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The Engineering Record has made more rapid advancement in the past twelve months than has any other technical journal during a similar period. This achievement is a guarantee of the purpose of the publishers to increase the usefulness of the paper and maintain its high character, so that it will be indispensable to the engineer. The annual subscription rate will be hereafter three dollars per year. Subscriptions at the old rate will be extended proportionately.

Economy of Superheated Steam.

In view of the growing use of superheated steam in this country, and the wide interest taken in the subject, it is surprising that there are so few data available regarding its actual economy in coal consumption. The advocates of superheating have claimed for it great economy, and they rely on the fact that, in European practice, compound engines have been run with superheated steam on a consumption as low as 9 pounds of steam per indicated horse-power per hour, and even lower, whereas, compound engines using ordinary steam seldom consume less than 13 pounds. The inference from such figures seems on the surface, to be decidedly favorable to superheating. Those who realize, however, that it takes coal to heat the steam to the required degree, look with suspicion upon any comparison based upon steam consumption alone, maintaining that it is no criterion whatever of the real economy. It is, therefore, gratifying to be able to refer to some pertinent data covering this important point, in the paper read by Professor Jacobus at the last meeting of the American Society of Mechanical Engineers, which gives the results of tests on a compound engine using superheated steam. An abstract of this paper appeared in The Engineering Record of December 12.

These tests were made on a plant having a boiler of the water-tube type, rated at 370 horse-power, with a superheater placed in an independent furnace, and a Corliss compound engine in which the cylinders were 16 and 28 inches in diameter by 42 inches stroke, the speed being 102 revolutions per minute. Reference will be made to two of these tests; one made with saturated steam, the engine indicating 407 horse-power, and one made with superheated steam, the engine indicating 420 horse-power. On the latter tests the temperature was 808 degrees Fahrenheit, which is 443 degrees above the normal temperature of the steam. Part of the steam was carried through a coil in the receiver, and by this means the steam was highly superheated for the low-pressure cylinder as well as for the high-pressure cylinder. On this test the consumption of steam was 9.56 pounds per indicated horse-power per hour. On the saturated steam test, the consumption was 13.84 pounds. There is a difference here of 31 per cent. in favor of the superheated steam, and this difference bears out the claims just noted. No such difference, however, appeared in the coal consumption, for it required a much larger quantity of coal to evaporate the water and superheat the steam than it did to simply evaporate the water. The actual evaporation per pound of dry coal without the superheater was 8.59 pounds. When the superheater was in use, however, the evaporation was only 7.09 pounds. Using these figures of evaporation in connection with the steam consumption of the engine, the actual amount of coal consumed was 1.35 pounds per indicated horse-power per hour, when the steam was superheated; and 1.61 pounds when it was saturated. The economy of superheating referred to coal consumption, therefore, is reduced to about 16 per cent. This economy was obtained by superheating the steam 443 degrees. If this result is used as an indication of what may be expected in practice for smaller amounts of superheating, it appears that about 5 per cent. economy is to be obtained for each 150 degrees, when the superheating is effected in an independent furnace.

How far it is desirable to carry superheating in practice, is a question that experience alone can settle, for whatever the economy realized, there is the offsetting effect of wear and tear, on both the superheater itself and the engine, which only time can measure. To be conservative in this matter, if the superheating is limited to 150 degrees, it is reasonable to expect from the results of these tests that the total saving in coal consumption will amount to only 5 per cent. and the net saving will be whatever is left after deducting from the cost of fuel, the interest on the additional investment and the cost of repairs and depreciation. As these items of expense must amount to a considerable sum, it must be allowed that the showing in favor of superheated steam is rather disappointing.

It is interesting to examine this subject from another point of view. As already stated, the actual consumption when the superheater was in use was 1.35 pounds per indicated horse-power per hour, and this result was obtained on a high-grade compound Corliss engine, equipped with a high-grade boiler and using highly superheated steam. Those who expect excellent results from superheated steam would naturally look for the best economy in such a plant; or, in other words, an unusually low consumption of fuel. It is disappointing, therefore, to find that the result obtained does not bear out these expectations. It is true that the plant did not have the benefit which would come from a feed-water heater in the exhaust pipe, and the boiler was fed with comparatively cold water. On the other hand, the steam used by the air pump of the condenser was not included in that supplied to the engine, and in this respect it was favored. However these things may be, the man who is paying the coal bills does not like to make allowances, and it is best to accept the figures actually obtained. There have been published in The Engineering Record the results of tests on two plants in which there were no superheaters, where the results were considerably better than the one in question. In these two plants, vertical boilers were used which, it should be stated, superheated the steam a few degrees. In both, also, the feed water was heated by means of economizers in the flues, which, no doubt, favored them to some extent; and in both the ratio of volume between the two cylinders was greater than in the engine using superheated steam, which, also, contributed in some degree to a more favorable result. Taking the result actually obtained, one plant gave a consumption of 1.21 pounds of coal per indicated horse-power per hour, and the other, 1.26 pounds. These figures of superior economy cannot, for the reasons given, be fairly compared with those obtained from the engine using superheated steam, but they cannot help having some weight with the layman, and possibly with the engineer also, in showing that the advocates of superheated steam have yet to prove that a high degree of superheating is always necessary for maximum efficiency in steam plants.

Municipal Trading.

The Citizens' Union of New York has under consideration a scheme of legislation for bringing about the municipal ownership of all plants for public service. A special committee of this organization reports in favor of laws permitting the city to undertake the control of railways, electric plants and similar undertakings now in the hands of private owners. While it is improbable that any important action will result from the report, the document is of some interest as indicative of the feeling of a certain class of public-spirited citizens, the same feeling which actuated Commissioner Monroe to advise the city of New York to build a plant for municipal electric lighting purposes. Theoretically it has much to commend it, but practically it is open to so many grave objections as to be of academic interest alone at the present time. Nevertheless the growing favor in which municipal trading is regarded renders it essential for all who take an interest in public affairs to keep in touch with the arguments advanced on both sides of the subject.

Speaking generally, it is doubtless true that municipal trading has its greatest foothold in Great Britain. There is a reason for this which is recognized by very few people. The obligation to take part in public affairs felt there by educated men is marked. The average American man of business or professional eminence shuns any political office as he would the plague. In Great Britain many of the members of a city council, for example, are successful merchants and professional men. Some of them have retired from active work and find in their official duties a certain measure of the enjoyment which comes with some regular employment. Councils of this class, having among their number men of exceptional sagacity, have been able to manage public service undertakings in a manner that is wholly beyond the capacity of the average council in the United States. But even in Great Britain municipal trading has often been unsuccessful. Everybody knows that it is an easy matter to juggle with figures which have been compiled without system, and thus produce a desired result which remains convincing only until these statistics are carefully analyzed. A parliament committee has been investigating this subject in Great Britain and has reported on the great lack of suitable bookkeeping in certain departments of municipal governments. The accounts of receipts and disbursements have been kept correctly enough, but in their final grouping there seems to be too little regard paid to such subjects as depreciation, sinking fund allowances and the like. It is largely time wasted to base arguments for or against municipal trading on figures that are not properly collected.

The purpose of the advocate of municipal trading seems to be a saving in money to the citizens, which will come from the public ownership of street railways, electric lighting plants and such enterprises. Little attention seems to be paid to the fact that such ownership can only result from very large expenditures for plant. Commissioner Monroe recommended but a few months ago the investment of a large sum for a lighting system for New York, and yet the city is too poor, according to its own authorities, to build and manage enough schools to give all the children of the city even elementary instruction. In most cities and small towns, the hospital service is a farce, the streets are largely unpaved, the fire department is a sort of social organization, and the sewerage system is in need of many additions. In the average city the accounts of such works as are now managed by public authority are kept in a manner which would reduce a private concern to bankruptcy. The legal tax limit is so closely approached that money absolutely essential for public purposes can be obtained only with difficulty. Under such circumstances the control of railways and lighting plants seems to be entirely beyond the capacity of the city.

Many of the enterprises of this nature undertaken in Great Britain have been paid for by an increase in the bonded debt of the municipal corporations which would horrify the average American tax payer. It is true that some of these British undertakings yield some return, but they are managed in a manner which it is hopeless to expect under the present conditions in most cities on this side of the Atlantic. The experience of certain Massachusetts and Ohio cities in building and operating lighting plants will doubtless recur to many readers. For some time these plants were held up to the public as examples of what could be done by municipal ownership when conducted by careful methods and public spirited men. An analysis of the accounts of some of these plants by competent accountants, which some strange figures on the balance sheets called for, revealed the fact that instead of being successful, the works were complete failures and the citizens would have to spend large sums to continue their ventures in municipal trading. Looking at the subject in a broad manner, it will be seen that its theoretical advantages can only be secured by the highest degree of business sagacity in planning and conducting municipal works, and with ample funds for carrying out the projects. With all respect to the many excellent men in municipal service, it is maintained that the time is not yet ripe for American cities, which need many public improvements, to enter upon this new field of public undertakings.

Railway Work in South China.

Railway engineering work in China has always offered considerable excitement to those taking part in it, and the accounts of the early construction of what is now the Imperial Railway have interested many readers. To-day the obstacles to be overcome are actually not much more serious than those presented occasionally by an independent Tennessee mountaineer, yet they may take a form which is unexpected. The work on the line of the American China Development Company from Canton to Hankow has presented few difficulties in Hunan, the province where the people were heretofore strongly opposed to foreigners, but in the province of Kwangtung there has been a certain amount of hostility and dilatory official action. This record is an encouraging one on the whole, for it shows that China can be developed by American methods without the serious opposition which we have been taught to expect. In view of the treatment accorded to Chinese in the United States the American engineers in Hunan and Kwangtung have little reason to complain.

Some months ago mention was made in the newspapers of an attempt to kill some of the surveyors of this enterprise. To show how little different was the attack on them from the experience any laundryman must expect in an American city it is worth while stating the facts of the encounter, as given in a correct report of them in the "China Mail," a Canton daily paper. It seems that some of the laborers near Yuangtang objected to the presence of the railway. An old woman succeeded in exciting them so deeply that they made an attack on the party, which retreated across a river and finally found refuge in a temple. It was merely an affair of a few ignorant field laborers, with which the villagers had no sympathy. Incidents just as serious are described in accounts of early railway surveying in Great Britain, and are comparable with the amenities exchanged between two American railway companies when one tries to cross the other's line at grade.

Tact is of course necessary in dealing with the Chinese people, particularly during the progress of surveying operations, but there seems to be little reason for believing that the difficulties are so great as reports of early explorers would lead one to anticipate. Even the graves of the ancestors cause little of the trouble which was anticipated; on this American line in South China large sums were demanded at first for moving a grave but the price has been beaten down to a nominal amount at present. The quotation is now about three dollars, which sum is paid to a relative who attends to the work. This subject, said at one time to be so important that a good railway location was impossible in thickly populated China, thus becomes insignificant.

A more important factor in Chinese railway construction proves to be the handling of labor on construction. This assumes an importance that surprises those whose idea of China is a country so overpopulated that daily wages for unskilled labor are nominal. The American China Development Company was forced to abandon its attempt to work through native contractors on some portions of its completed road. They had no apparent intention of completing their contracts at the agreed date, and so the company organized its own forces. The laborers were paid forty cents a day and were neither efficient nor cheap, when the result accomplished by a given expenditure was considered. Occasionally some of them struck, but on the whole such troubles were not of much moment. The fact that the company endeavored to get its labor from villages along the route may have had some effect in producing a favorable attitude toward the railway on the part of the people of the districts traversed.

Very little work outside of surveys has yet been done on the main line of this enterprise, but a short branch has been in operation for some weeks. It seems well assured, however, that the difficulties of location and of native opposition, about which so much has been said in some quarters, are really of little weight. Both engineering difficulties and the troubles which arise from work in localities where there is a prejudice against an enterprise can be surmounted if there is no open hostility shown, and fortunately this last does not exist.

Covered Reservoirs.

Concrete groined arch covers for reservoirs built to hold filtered water are connected in such a marked manner with the filtration of water in modern public water supply practice that they are considered wholly as a modern construction. This view is not to be criticised as a matter of substantial accuracy and yet there are some reservoirs with masonry covers that are at least as old as Spanish-American masonry in Porto Rico, if not Central and South America. Obviously such masonry designs were matters of convenience or for the purpose of securing a necessary water supply in fortresses or other similar locations, the matter of the preservation of water in good sanitary condition with light and air excluded not having been recognized at that time.

The introduction of filtration for the improvement of municipal water supplies has rendered absolutely necessary, in many locations at least, its preservation under conditions more or less similar to that of deep underground storage. It is not intended by this observation to imply that filtered water may not sometimes be properly stored in open reservoirs, for that has been done and is being done without materially prejudicial consequences under favoring conditions. As a broad and general principle, however, it may be stated that where the filtration of water supplies is contemplated, covered reservoirs must also be considered as an essential part of a properly designed system. The pressing need of proper storage of filtered water is forcibly illustrated by the report recently made by the Commission on Additional Water Supply for the City of New York, in which the distributing or equalizing reservoir for receiving filtered water at the northern limit of the city is recommended to be covered in the usual manner with concrete masonry arches, although the full capacity of the reservoir is over 2,000,000 gallons. Again, concurrently with the strong recommendation of immediate filtration of the present or Croton supply is the recognition of the advisability of covering not only the new Jerome Park reservoir, still uncompleted, but also those now in use in Central Park. These expressions of opinion by experienced engineers, based upon the best practice of the present time, show unmistakably that, as a general proposition, any public body devising plans for a supply of pure water should incorporate in them the masonry covered reservoir for the storage of filtered water to preserve the beneficial effects of filtration.

This particular field of water-works construction does not involve the formidable expense which a few years ago was associated with it, nor are there so many unknown elements as were supposed. Probably not less than twenty reservoirs covered with groined arches have been built in the United States within the last six or eight years, or are now being built, and the experience gained from these structures shows that under proper design and supervision of construction the groined arch covering above the springing line of the arches need not cost over about 50 cents per square foot of area, unless unusually heavy loads are to be carried. A considerable number of instances of less cost are on record. With further improvement in methods and materials it is practically certain that the present cost will be sensibly reduced.

The groined arch has ordinarily been used for this purpose, as it is admirably adapted for execution in concrete. Manifestly any improvement in the quality or resisting power of the concrete will correspondingly enhance the excellence of the reservoir covering. The spans have ordinarily ranged from 10 to 16 feet, or even more, and the size of piers from 18 to 30 inches square. The concrete used has seldom been leaner than one cement, three sand and five gravel or broken stone, the proportions of one, two and four having been used in a number of cases. With a thorough balance of the materials employed, however, the voids being reduced to a minimum, there seems to be no reason why concrete as lean as one of cement to ten of sand and gravel or broken stone should not be employed. There are instances where concrete as lean as one to ten and a half has been used for similar purposes with complete success, and without more care or a higher degree of inspection than is entirely practicable in ordinary work. As a matter of fact, the capacity, so to speak, of lean concrete when suitably mixed and placed in work is scarcely yet developed. A thorough mixture of well-balanced ingredients suitably wet will produce results in such applications as groined arch work surprising even to many experienced engineers at the present time. There is in this direction ample room for a higher degree of excellence and economy than has yet been attained in covered reservoir construction.

It is also probable that the development of re-enforced concrete as applied in covered reservoir construction has yet seen only its beginning. The carrying capacity of relatively thin rectangular plates of that material supported along their four edges is not yet fully realized. When such plates are made continuous, so as practically to render the masonry cover of a reservoir a continuous plate over its entire area, or over large portions of its area, and reinforced by relatively thin arch ribs springing between piers, the carrying capacity is so greatly increased as to reduce the required quantity of material sensibly below that necessary for the groined arch of concrete without the steel. It is clearly a question of the balance between the additional strength given by a small amount of steel, a relatively high-priced material, and the use of a larger amount of the lower-priced concrete. As experimental investigations are pushed farther into the field of reinforced or armored concrete its greatly increased carrying capacity becomes more apparent and the possibility of corresponding economy more clear.

Groined concrete arches, as they are at present constructed for reservoir purposes, are frequently and perhaps usually not more than 6 inches thick at the crown with the spans ranging from 10 to 15 feet. It is obviously impracticable to make even a re-enforced concrete plate much thinner than that amount for such spans, but there may be an economical gain in avoiding the masonry in the spandrels of the groined arches. At any rate, there are yet some undetermined elements in this particular line of construction in reference to which farther investigations will yield results, both interesting in character and of substantial economical value. Much progress has already been made, so that at present the construction of the masonry reservoir covering is no longer a formidable consideration and farther advances, bound to be made, will not only increase the excellence of the work but render still higher economy attainable.

Notes and Comments.

The Additional Water Supply for New York has attracted so much attention of late among engineers that it may be of interest to revert to the work done on this subject a good many years ago by Col. J. T. Fanning. Among those who have made a close study of the needs of the city in the matter of water, his predictions made twenty years ago concerning the growth of the city and its consumption of water are well known for their exceptional accuracy. When the new Croton aqueduct was planned, Colonel Fanning strongly advised making it capable of carrying water under sufficient pressure to supply the high service, the rapid growth of which he deemed inevitable. He had previously designed for a similar purpose a conduit made of brick of special form which adapted the masonry for tensile resistance. Had such an aqueduct been constructed for the Croton supply the execution of the proposed works for an additional supply would now be much facilitated. The reason for the development of this type of masonry conduit is worth mentioning. When Colonel Fanning was at work on his scheme for bringing water to the cities of the Hudson River valley from the Adirondacks, it was desirable to provide a masonry covering for portions of the conduit, as in the crossings through villages. For such places his idea was to construct an aqueduct of masonry, which could be laid on moderate grades and under moderate heads, so as to offer as much flexibility in location as a railway line. The system of construction he worked out permitted a material saving in length and often in tunnels and embankments.

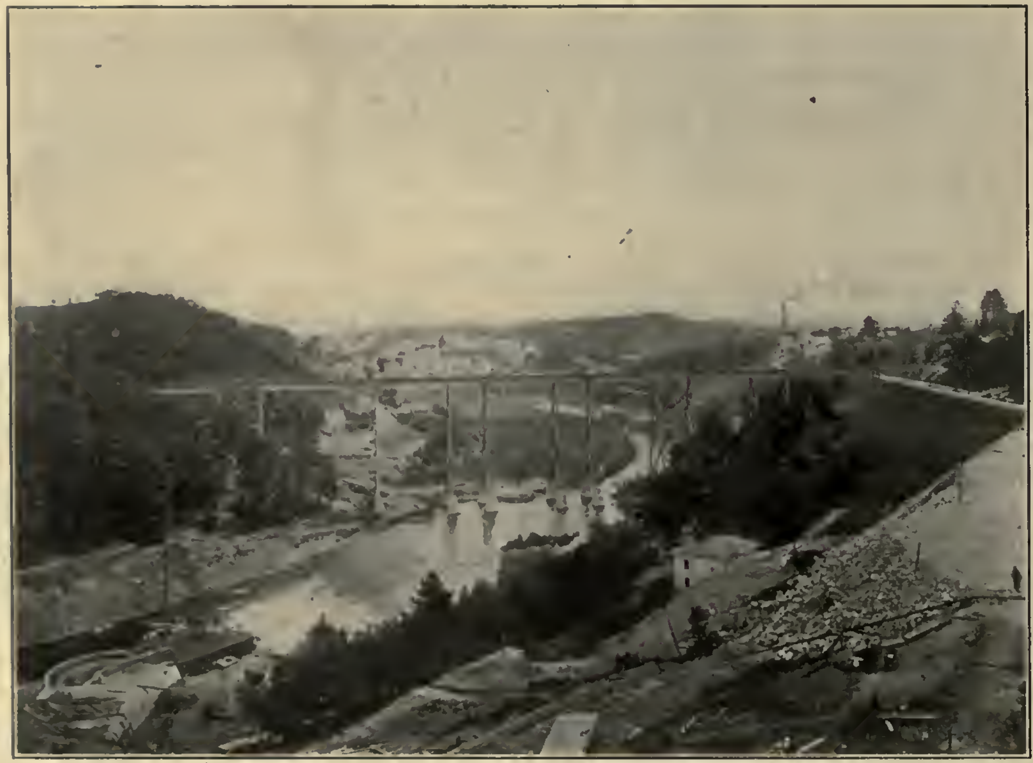
The Drainage System of New Orleans is the subject of an important report by Messrs. Hering, Harrod and Richardson, the advisory board of the commission originally in charge of this work. The drainage system as planned cannot be carried out with the money available for the purpose and the report has been made to indicate the best way of spending the limited funds which may be used on this great work. The completed drainage works are efficient and answer the purpose for which they were designed. Local areas are nevertheless flooded, and there is complaint that the drainage system is a failure. The report points out that this view has no basis in fact. The surface water must be conducted to the canals in suitable drains, which were planned so as to conduct the rainfall away without trouble. The construction of these street drains has not been kept in the hands of the commission entrusted with the construction of the drainage works, but has been delegated to another branch of the local government. Consequently it is found that the grades of these drains have been changed in some cases, so that the rainwater does not reach the canals as proposed. This tends to discharge into some of the canals a volume of water they were not proportioned to carry, while others do not receive enough. In addition, the inlets to the drains are not satisfactory, and there are not enough manholes to render the cleaning as easy as it should be in a city with as flat grades as New Orleans. The report of this committee of eminent engineers, coming so soon after a similar report on the plumbing of the city, ought to lead the city officials to a recognition of the importance of placing the entire drainage and sewerage undertakings in charge of one commission.

The Brooklyn Bridge Superstructure is the subject of a report recently made by Commissioner Lindenthal to Mayor Low. It concerns the reconstruction of the suspended system so as to increase its capacity while avoiding any overloading of the masonry or increase in the number of the cables. The old single-deck structure is to be changed to double-deck, with accommodations for four elevated and two trolley tracks, the latter entirely independent of the two 17-foot roadways. In the new designs the cables are to carry practically the entire live load and the weight of the floor construction proper, while the stiffening trusses will carry their own weight and that of the wind and lateral bracing. The trusses are designed to be continuous over the towers, with anchor posts under the middle of each end span. Expansion joints will be placed near these posts, which will act as supports for the live loads on the end spans. Nickel steel is proposed for use in the stiffening trusses. The reconstruction is estimated to cost about $5,500,000 and to afford facilities for double the present rapid transit traffic as well as a greater movement of vehicles and pedestrians. It is stated that the plans are submitted as a basis for more detailed studies, which can be perfected by the time the proposed Manhattan bridge is finished. The project is an interesting one, but to amount to anything it involves the improvement of the terminal facilities. At the present time these are beyond doubt the main cause of the congested traffic over the bridge during rush hours. Unless the terminals can be improved it is not worth while reconstructing the suspended system so extensively.

Relocation of the Central Massachusetts Railroad around the Wachusett Reservoir.

The breadth and variety of engineering operations involved in a water-works undertaking of the first magnitude can be fully comprehended only by those who have been intimately connected with such works. The Massachusetts Metropolitan Water-Works have been in an unusual degree an exemplification of this statement. Among the problems contingent upon the construction of the Wachusett dam and reservoir was the relocation of a portion of the single-track Central Massachusetts Railroad, one of the leased lines of the Boston & Maine system, about 6 miles of which were located in the bottom of the valley forming the main part of the reservoir. As the major part of this piece of track would be under a great depth of water—about 100 feet at the maximum—with the reservoir filled, a material change of location was necessary.

Owing to the number of interests concerned, some difficulty was experienced in reaching an agreement as to the most suitable route, and some thirteen or fourteen lines were surveyed and studied. The consequent delays consumed several years and an arrangement was finally reached only at a date uncomfortably near the time at which the storage of water in the reservoir and the resultant flooding of the tracks was to begin. Construction on the new location began in May, 1902, and was to have been finished last spring. Trains began running over the new tracks on June 15 and on the afternoon of that day the water was nearly up to the rail level on the old track. On the 17th of June the water was between 3 and 4 feet deep on the old roadbed. The needs of the Metropolitan district urgently required the use of all the storage available in the partially finished reservoir.


Viaduct across Nashua River, at Clinton, Looking Downstream from Wachusett Dam.

Departing from the old line at a bridge carrying the Central Massachusetts tracks over one of the branches of the New York, New Haven & Hartford Railroad, the new line swings northerly, crosses the south branch of the Nashua River about 800 feet below the Wachusett dam, traverses the north dike and in 4 miles reaches the double track of the Worcester, Nashua & Portland division of the Boston & Maine system, which is utilized for about 4½ miles, to Oakdale. Here connection is made with the undisturbed portion of the road, but short stretches of the tracks of both divisions, as well as the freight and passenger stations, have been relocated in order to avoid submergence to a depth of several feet and for the purposes of making suitable connecting curves. The new route is only one-third mile longer that the old. From near the easterly end of the north dike a Y-branch 4/5 mile long diverges to the Worcester, Nashua & Portland tracks leading to the Clinton station. The curved location of this line is almost wholly on the outer slope of the dyke at its widest part.

The new part of the relocation, although short, involves some heavy construction for that section of the country. Within a mile, near the Wachusett dam, there are a tunnel 1,110 feet long, a steel viaduct 917 feet long with a maximum height of 133 feet, a 1,500-foot rock cut with a maximum centerline depth of 56 feet and an embankment having a maximum height of over 30 feet. Grade crossings with highways are avoided by two bridges carrying the railroad and two carrying highways. The easterly end span of the viaduct also crosses one of the main highways leading into Clinton, and another highway will be carried across the easterly portal cut of the tunnel by a concrete arch between the rock abutments. The steepest grade is 1.10 per cent. and the sharpest curve 4 degrees.

In accordance with the agreement, the Board has done all engineering and construction work excepting the design and erection of the steel structures of the bridges and viaduct and the furnishing and laying of the ties and rails, and has borne the expense, except for the construction of the Y-branch. For construction purposes the line was divided into four sections. Section 1 embraces the first 7,740 feet and was let to the Crary Construction Company, of New York City. Section 2, being intimately connected with the Wachusett dam and so located as to interfere with the construction of the dam, an agreement was made with the McArthur Brothers Company, of Chicago, the contractors for the dam, thus taking advantage of the extensive plant already installed and available for the construction of the tunnel, heavy rock cut and viaduct masonry, making possible better disposal of some of the excavated materials and avoiding the complications which would have been inevitable with a second contractor in this territory. For similar reasons Section 3, on the north dike, was let to Messrs. Nawn & Brock, of Boston, contractors for the dike. Contract for Section 4, embracing the work at Oakdale, was let to Messrs. George M. Atkins & Company, of Palmer, Mass.

The tunnel excavation is 1,080 feet long, 790 feet at the easterly end being through hard close-grained granite, comparatively free from seams. For 200 feet of the next 290 the surface of the rock is slightly below the top of the tunnel, so that a part of the heading was in earth, and for the remaining 90 feet it is only a short distance above the top of the tunnel. This formation made this stretch of 290 feet difficult of excavation, requiring heavy timbering for 228 feet, and necessitating the use of a concrete lining. For a few feet at the easterly end also the tunnel is lined in order to prevent injury to the rock by frost. The lined portions are 22 feet high and 16 feet wide inside, and, where unlined, the excavated cross-section has been made large enough to permit lining if found necessary in the future. The lining masonry has been carried a few feet beyond the tunnel excavation and finished with portals of cut granite backed with concrete. The track is on an 0.8 per cent. grade through the tunnel. The headings, comprising the upper third of the cross-section, were excavated through practically before any bench was taken out, with an average progress of 60 feet per week at the easterly end and 16 feet per week at the westerly end where timbering was required.

Concrete for lining was mixed in the proportions of 1:2½:4½ in the arch and the interior facing and 1:3:6 in the backing. The work of placing concrete masonry began in the latter part of February. During the whole progress of placing concrete, the excavating of the lower two-thirds or bench of the tunnel was in progress and it was necessary to arrange the work so that the teams hauling out the rock could pass through the forms supporting the concrete masonry; consequently the arrangement shown in one of the illustrations was adopted. The car carrying the concrete ran on a track on the top strut of the framework, as is quite clearly indicated in one of the views, while another view shows the framework for supporting the forms erected to the mouth of the tunnel. At the time work was commenced on the concrete masonry, the weather was quite cold, and it was necessary to provide a building to mix the concrete in, also to provide steam for heating the water and taking the frost out of the sand and stone. This building was located at the portal of the tunnel on a level with the top strut of the framework.

The side walls were built to half their height at one operation, both sides being carried up at the same time; then the upper halves of the side walls were built, and finally the concrete arch. The concrete of the arch was built up on both sides on the centers, additional pieces of lagging being added as necessary, up to a key about 2 feet wide on top, the place left for key being finished to radial planes. After the concrete on both sides of the key had set somewhat, the key was filled in from the end, and this part of the work was very tedious. The stone packing above the concrete was filled in as the concrete progressed. All the lagging, placed when the tunnel was excavated, below the springing line was removed and the concrete extended to the ledge rock. Posts were removed if nearer than 4 feet on centers. Above the springing line, the lagging was removed where possible, although probably more than half was left in, but holes were cut through the lagging and concrete worked through the holes to the rock on both sides between the timbers of at least every second set. One of the illustrations gives a very good view of the timbering.

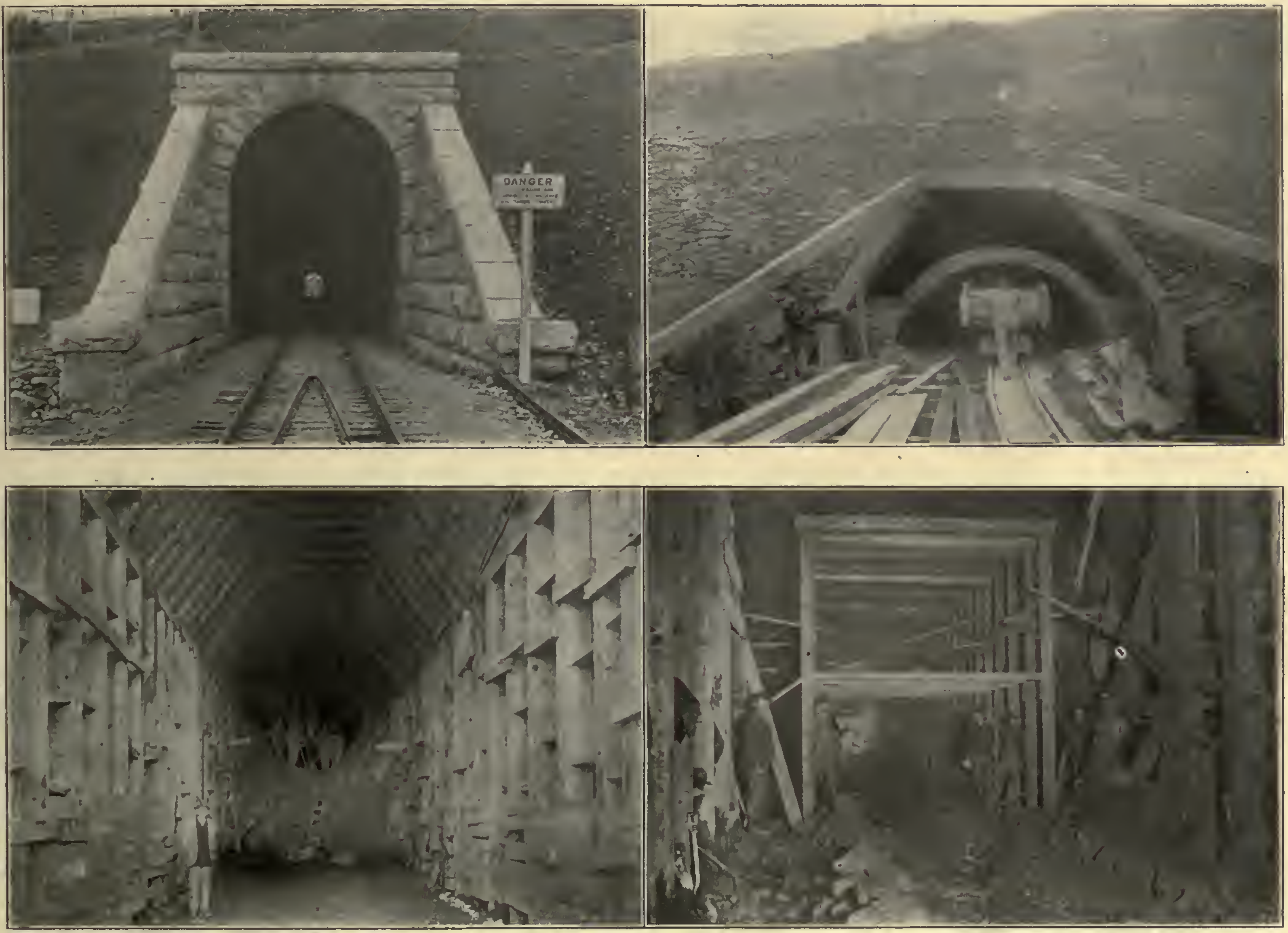
Emerging from the tunnel the trains go at once on to the viaduct, which crosses the river valley diagonally, approaching the Wachusett dam at the westerly end so that the track just beyond the viaduct crosses the waste channel from the reservoir and passes within a few feet of the end of the waste weir. A heavy skew arch of concrete faced with granite having a span of 62 feet and a rise of 20 feet 4 inches is proposed to carry the railroad over the channel when the dam is completed, but temporarily the track is laid on a modified location in order to avoid the towers of the Lidgerwood cableways used in the construction of the dam.

The viaduct has eight towers about 38 feet long between centers of posts, seven 72-foot intermediate spans, one 53-foot span at the west abutment and one 63½-foot skew span at the east abutment. It has but few unusual features. The spans are deck plate girders, excepting the one at the east abutment, which is a through girder span in order to afford head room over Boylston Street for trolley cars. There are expansion joints at the east abutment and at the west side of each tower. There is a 2½x3-foot safety landing, with railing, at the middle of each tower, at track level. The four middle towers are about 108 feet high above the granite caps of the pedestals; the pedestals in the river are about 25 feet high. The pedestals and abutments are of 1:3:6 Portland cement concrete, faced, where exposed above the surface of the ground, with quarry-faced granite ashlar. One abutment and six pedestals are founded on schist ledge, four pedestals on boulder clay, four on sand, and one abutment and eighteen pedestals on gravel. Several of the fourteen pedestals in the river bed had to be built to the height mentioned in order to have their tops above the surface of the mill-pond below the Wachusett dam, which is to be restored when the dam is completed. These pedestals are 7 feet square under the cap stones, which are 4 feet 6 inches square and 20 inches thick, the remaining eighteen pedestals are 6 feet square under the caps, which are usually 4 feet square and 20 inches thick. All pedestals are battered 1½ inches per foot.

The towers, with one exception, have four posts built of two plates and four angles, latticed, battered 1:6 transversely, with diagonal braces alone in the transverse planes and both X-bracing and horizontal struts in the battered sides. Each of the four post bases is anchored to its pedestal by two 1⅜-inch bolts, usually 10 feet long. Two diagonally opposite bases in each tower have ⅛-inch bronze sliding plates, and, to provide for expansion movements, the bolt holes in the shoe are made 2¾ inches in diameter, while in the shoes of the fixed bases the bolt holes are 1¾ inches in diameter. The legs of each transverse pair are connected at the top by two 30x⅜-inch plates with four 3x3x ⅜-inch flange angles. The ends of the tower girders rest on and are riveted to the post caps. The intermediate girders are pin-connected to the towers, with pins 4¼ inches in diameter, as shown in one of the detail drawings, which also shows the details of the pin shoes. Each pin shoe is fastened to the tower by four 1 13/16-inch turned bolts. In the shoes for the fixed ends these bolts pass through 1 27/32-inch drilled holes, and in those for the expansion ends, through slots 2⅝ inches long. The method of anchoring the fixed end of the girder at the abutment, used both for the viaduct and the other bridges, by notching the bottom flange of the girder to engage two projections on the cast-iron shoe, and the detail of the end of the girder for the viaduct are clearly shown in another drawing.

The most easterly tower, No. 8, is special. It stands close to Boylston Street and receives at one side the end of the through span over the highway and at the other the end of the first deck span, the tower girders also being deck girders, as usual. To accommodate both through and deck girders the easterly bent has vertical legs with web plates projecting inside having edges cut to the 1 to 6 batter of the regular towers and reinforced with 3x3x⅜-inch flange angles. Accompanying diagrams and detail drawings show the construction of this tower and the manner of connecting the two girders.

The method adopted for erecting the viaduct was to raise the posts of the towers by means of a very large derrick set on the ground, the three sections of each post being usually bolted together and raised as one piece and to place the spans by means of a traveler. After being raised, each post was secured temporarily by means of guy ropes until the remaining posts of the tower and the diagonal braces were in place, the derrick at one setting raising all four legs and filling in most of the braces. The traveler used was, essentially, a derrick with

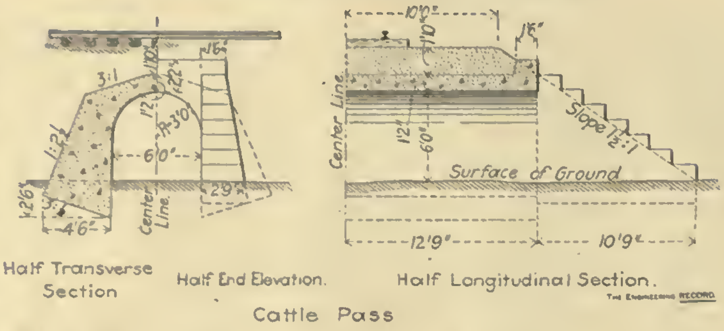


Central Massachusetts Railroad Tunnel: West Portal, Finished and During Construction; Timbering near West End; Staging for Concrete Forms.

two booms, one of which was 67 and the other 57 feet long, fastened by means of heavy bolts to girders already in place, and was guyed with two steel cables which were anchored about 200 feet on each side of the viaduct. All field rivets were driven by means of compressed air furnished by the compressor in use in connection with the Wachusett dam.

The other bridges have no unusual features. Two cattle passes were built entirely of Portland cement concrete according to the design shown. There is one large arched culvert 8 feet wide, 7 feet 6 inches high, of Portland cement concrete with granite ashlar head walls flared 1 to 6 from the direction of the axis and granite arch facings. There are also several smaller culverts.

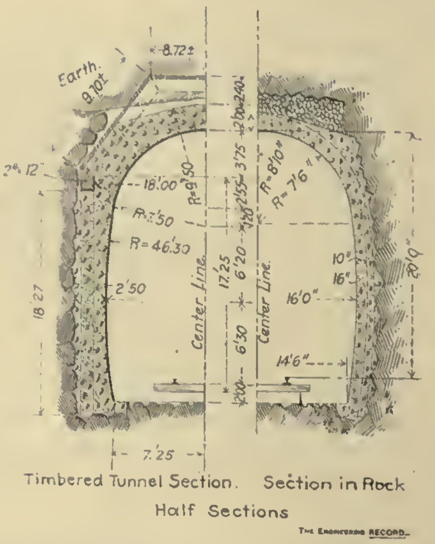
An interesting fea-



Half Transverse Section Half End Elevation. Half Longitudinal Section.

Cattle Pass

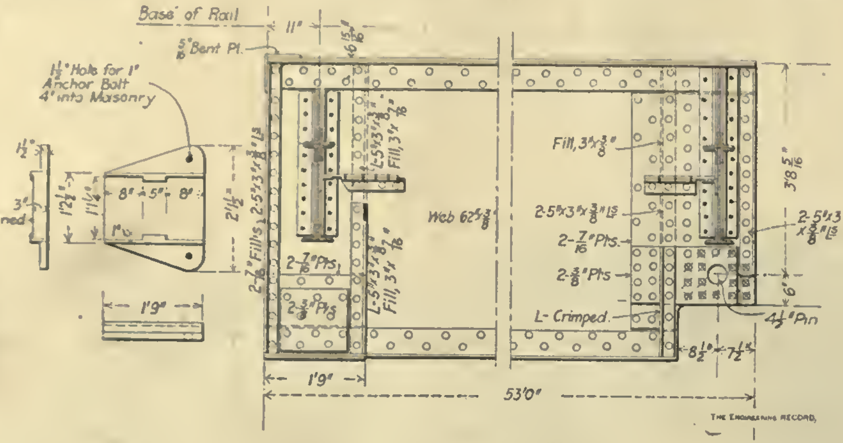
The Engineering Record.



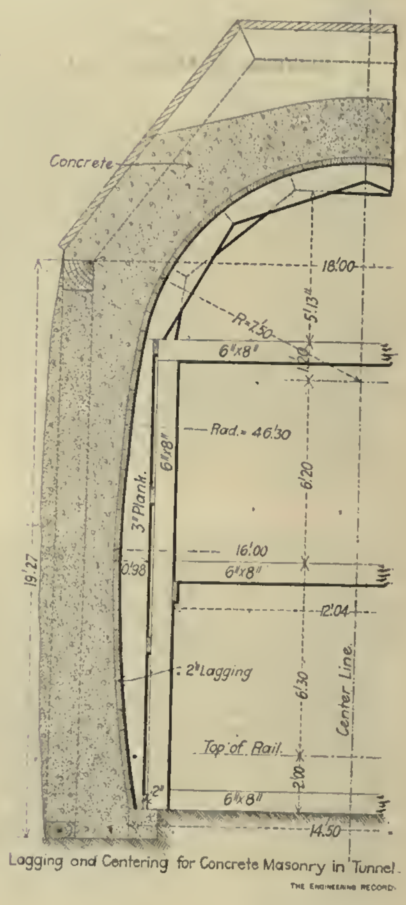
Timbered Tunnel Section. Section in Rock

Half Sections

The Engineering Record.



The Engineering Record.



Lagging and Centering for Concrete Masonry in Tunnel.

The Engineering Record.

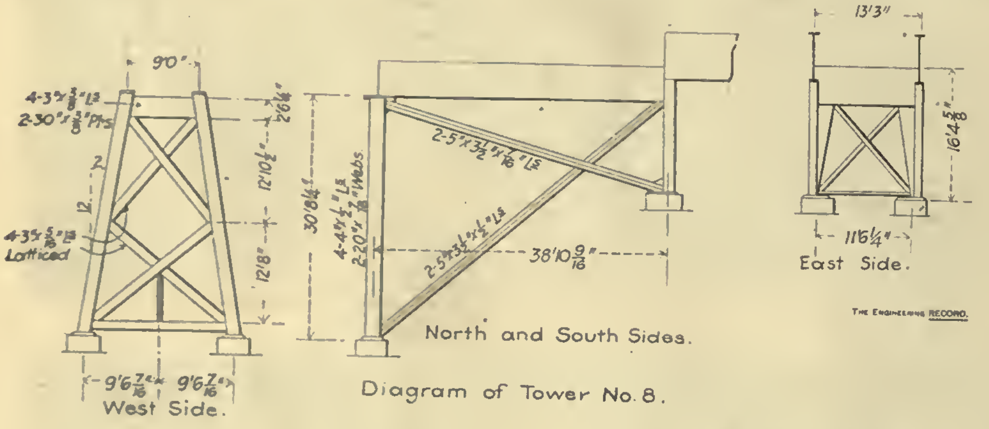
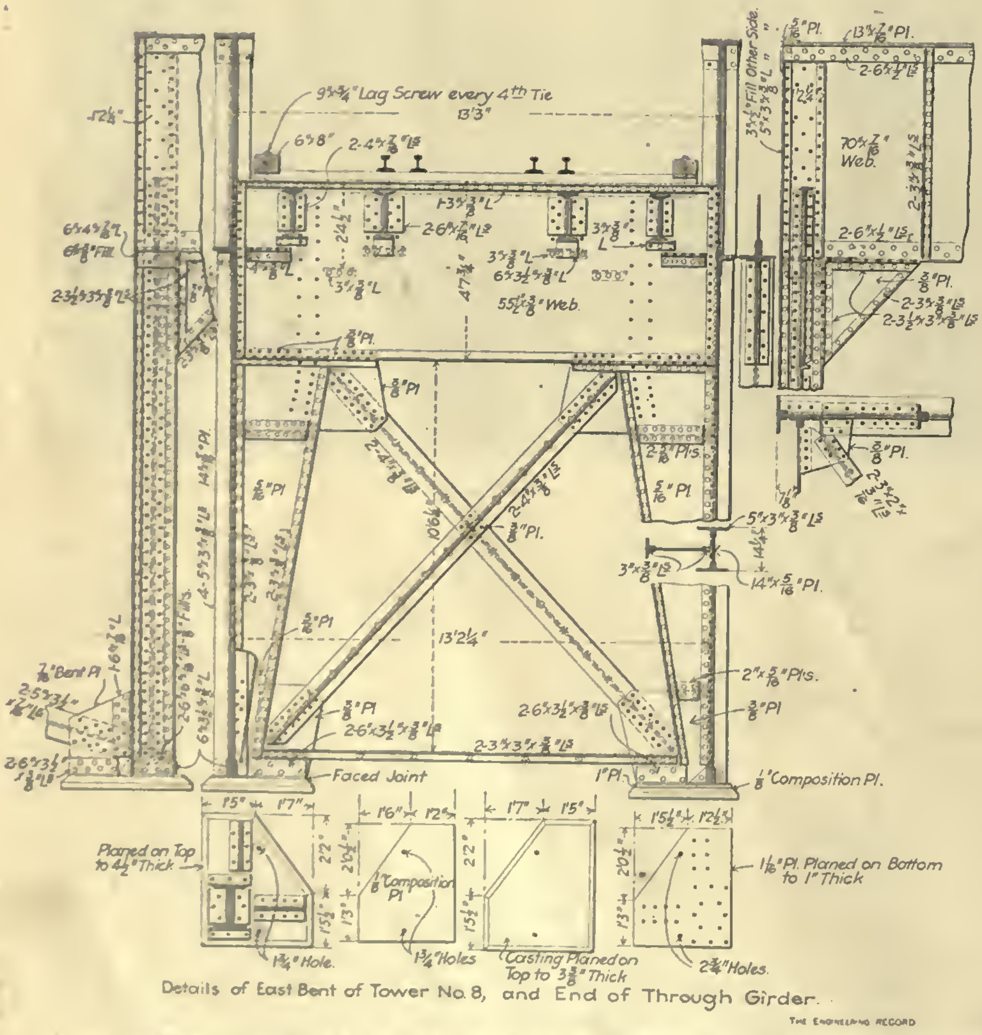


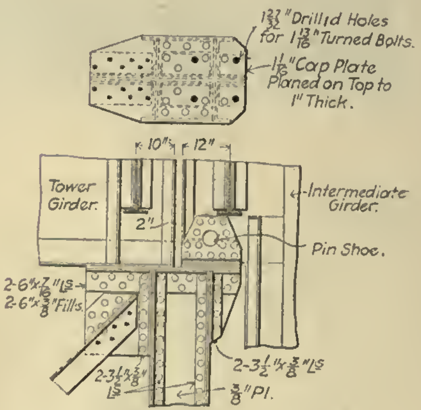
Diagram of Tower No. 8.

The Engineering Record.

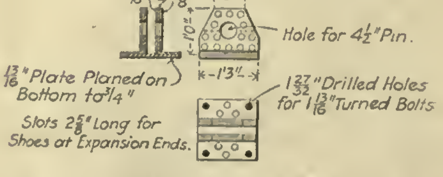

9/16"x¾" Lag Screw every 4th Tie
13'3"
55½"x⅜" Web
70"x 7/16" Web
13'2¼"
Faced Joint
1" Pl.
⅛" Composition Pl.
Planed on Top to 4½" Thick
1¾" Hole
1¾" Holes
Composition Pl.
Casting Planed on Top to 3⅜" Thick
2¾" Holes
1⅛" Pl. Planed on Bottom to 1" Thick

Details of East Bent of Tower No. 8, and End of Through Girder.

The Engineering Record


1 27/32" Drilled Holes for 1 13/16" Turned Bolts.
1½" Cap Plate Planed on Top to 1" Thick.
Tower Girder.
Intermediate Girder.
Pin Shoe.

Detail of Top of Post showing relative position of Girder and Post.


Hole for 4½" Pin.
1 13/16" Plate Planed on Bottom to 1¼"
Slots 2⅝" Long for Shoes at Expansion Ends.
1 27/32" Drilled Holes for 1 13/16" Turned Bolts

Detail of Pin Shoes.

The Engineering Record.

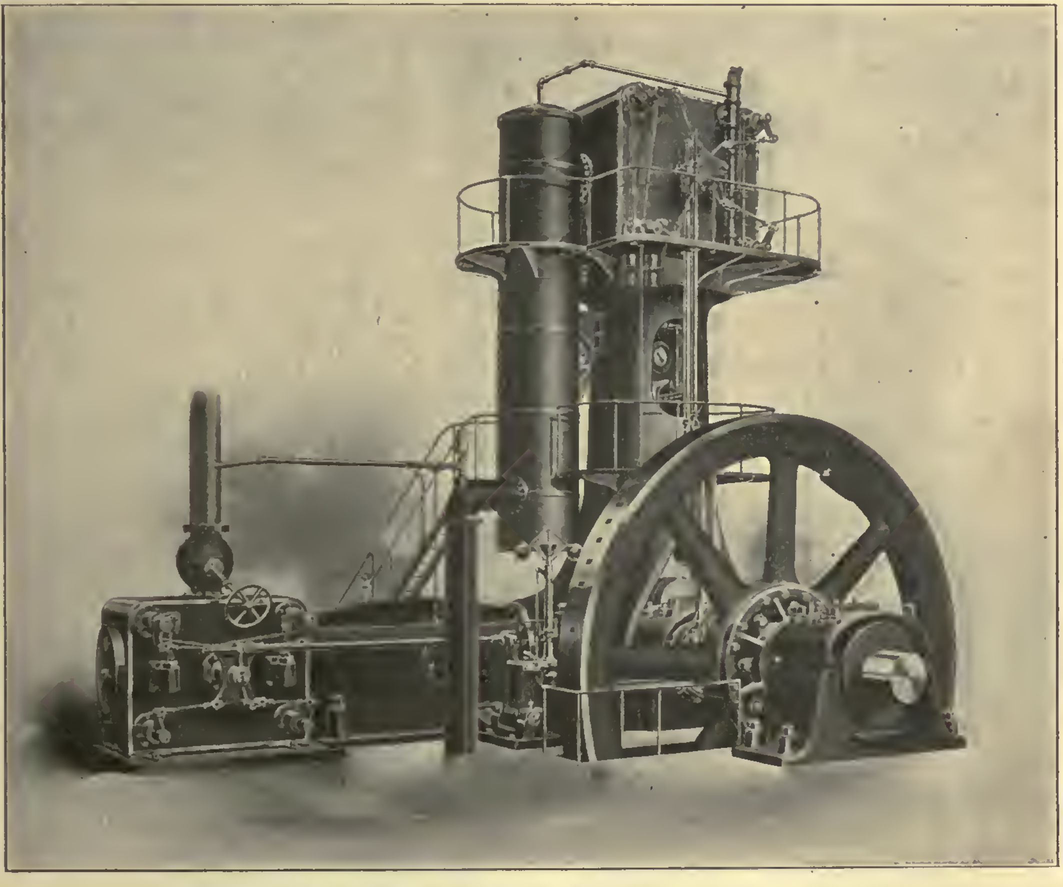
TUNNEL LINING AND SOME DETAILS OF VIADUCT ACROSS NASHUA RIVER, CENTRAL MASSACHUSETTS RAILROAD.

ture of the work was the use of the rock taken from the deep cut just west of the Wachusett dam to riprap the north dike. This dike, as has been previously described in this journal, is composed principally of the earth stripped from the bottom of the reservoir. It is protected on the water side by a thick layer of unscreened gravel on a 2 to 1 slope, on which has been placed a layer of broken stone or screened gravel 1 foot 6 inches thick at full reservoir level and 6 inches thick at a berme 13 feet below. On this have been dumped fragments of rock less than 1½ cubic feet in size to a horizontal thickness of about 16 feet at an elevation 4 feet below full reservoir level, with a face slope of about 1⅓ to 1. As the final layer, exposed to the waves, the larger fragments of rock were dumped and roughly placed, by the aid of a little barring, to a slope not steeper than ¾ to 1. It was required that the face of the larger stones should have a steeper slope than that of the smaller fragments at any given place, so as to afford a greater thickness of the large stones at the top of the riprap. All these protective layers, including the gravel, were carried to an elevation 5 feet above full reservoir level. The excavated rock was loaded into skips having a capacity of about 1½ yards of solid rock, which were lifted by derricks to flat cars. The cars were hauled to the place desired at first by mules and later by a locomotive, and the skips were hoisted by a traveling derrick, swung over the slope and dumped. This very heavy protection has been built because of the importance of the dike, its exposure to waves where the reservoir is about 2 miles wide, and because of the ice action.

The steel structures required for the relocation of the railroad were designed by the bridge department of the Boston & Maine Railroad, Mr. J. P. Snow, engineer, and were inspected and erected under Mr. Snow's direction. The bridge and track work was done under the general supervision of Mr. H. Bissell, chief engineer of the Boston & Maine Railroad. The American Bridge Company was the contractor for the construction and erection of the viaduct and the two plate-girder bridges. The work on Sections 1 and 2 was in charge of Mr. T. F. Richardson, engineer of the dam and aqueduct department and that on Sections 3 and 4 in charge of Mr. Hiram A. Miller, until recently engineer of the reservoir department. Mr. Frederic P. Stearns, as chief engineer of the Metropolitan Water and Sewerage Board, had supervision of the whole work.

The Clairton Twenty-eight-Inch Three-High Steel Billet Mill.

The Clairton Steel Company has recently built a new open-hearth steel plant at Clairton, a few miles above Pittsburg on the Monongahela River. The product of the plant is intended at present to consist of steel billets and blooms which will be finished by the purchasers. A 28-inch mill designed by Mr. Julian Kennedy and Mr. G. G. Thorpe, manager of the Clairton works, and built by the Mesta Machine Company, has just been installed to roll billets from 7x9-inch blooms delivered to it directly from the roller table of the blooming mill. The mill has a three-high train of rolls 28 inches in diameter arranged for seven passes and designed to deliver four sizes of square billets and one size of flat billets if required, thus being adapted to furnish material suitable for any finishing mill that may be hereafter erected in connection with it. The mill is driven by a compound non-condensing engine built by the Mesta Machine Company. Its design combines standard features and improvements and is especially intended to secure durability and accuracy and to endure rapid and continuous operation. It is capable of receiving a second and third billet before the first one has received its last pass, and when rolling two 5,200-pound billets simultaneously, can finish them in one minute. Allowing for ordinary delays and interruptions, the mill has a capacity of 2,000 gross tons every 24 hours, and is now in satisfactory operation.



Compound Non-Condensing Engine at the Clairton Billet Mill.

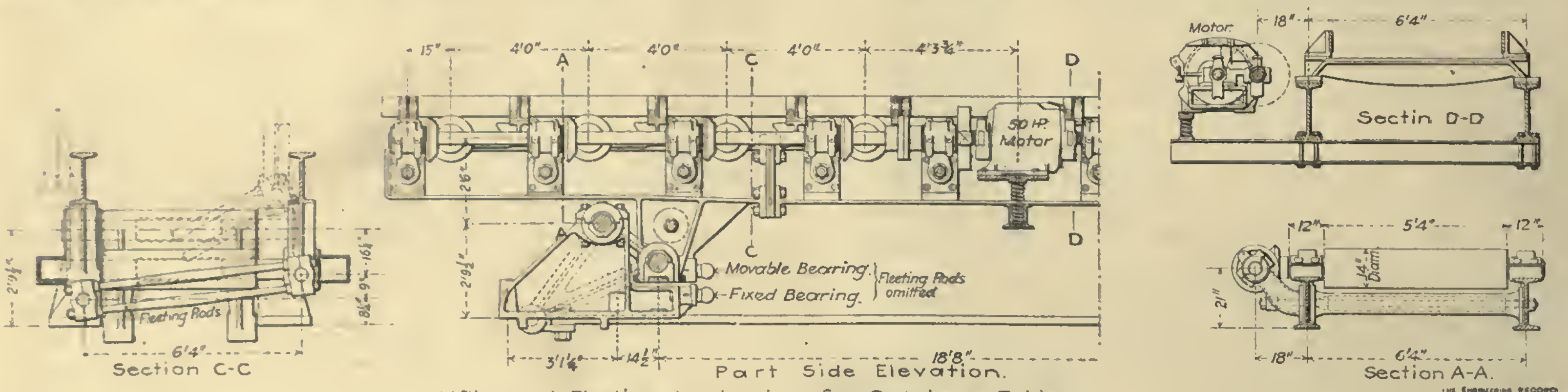
The construction of the mill is massive and the details are carefully finished to secure accuracy and smooth operation. It is provided with hydraulic lifting tables on both sides carrying electrically-driven roller beds. Special devices are provided for the fleeting and turning of the blooms; the pinion bearings are flooded in oil and the housings are made in sections with finished joints and special anchorages.

The roller's and the catcher's tables are substantially alike, excepting that the former has special fingers for turning the billets 90 degrees at each pass and transferring them laterally. The tables have rollers on cast-steel frames and driven through miter gears by a Westinghouse 50-horse-power motor of the street-car type, which is seated on springs on the cantilever ends of transverse beams bolted across the under side of the table bed, as shown in the cross-section. A pair of heavy cast-iron brackets are bolted to the under side of each table and have full length bearings for horizontal shafts which engage double bell-crank steel castings. These castings have a fixed upper pivot through cast pedestals seated on the floor. The long arms of all four bell cranks under both tables are pivoted to eye-bars connected with the hydraulic operating cylinders. These cylinders are double as shown in the detail of the catcher's table. A constant pressure is maintained in the one nearest the table sufficient to about half balance the weight of the table. The pressure in the other cylinder is regulated by a valve and suffices to operate the cranks and raise the table. The table descends by gravity and pulls the piston back to its initial position ready for another stroke.

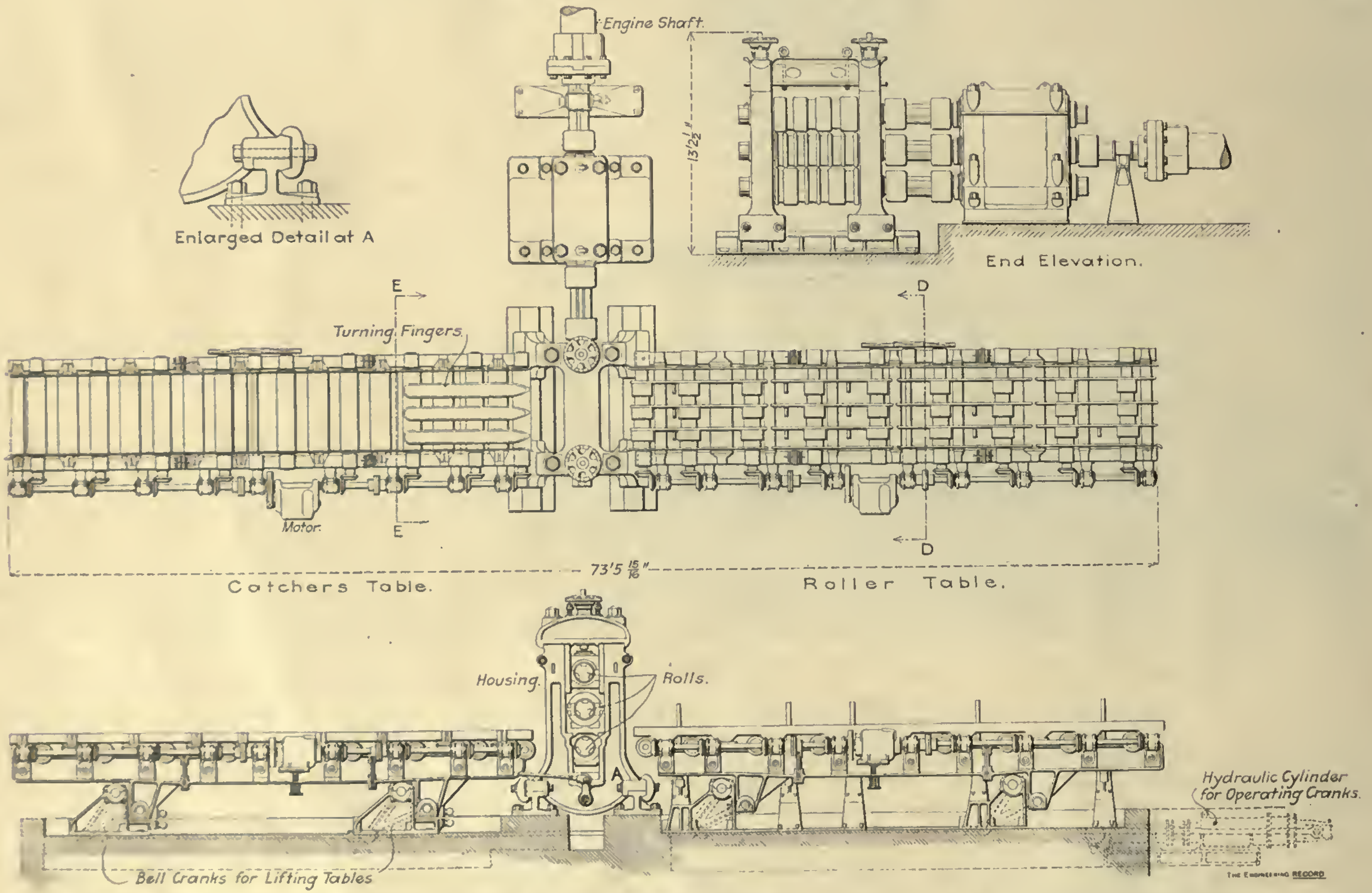
The catcher's table is similar to the roller's table, except that it has no fingers for turning the billets, and that it is arranged to move transversely so as to fleet the billets from one pass to the next. This motion is secured by a pair of connecting rods shown in the transverse section CC. At each end they have cross-heads engaging spherical bearings. That at the lower end is fixed to the bed plate and that at the upper end is fixed to the frame of the table. The bearing of the table on the bell-crank shaft is loose and as the table rises vertically, the connecting rods revolve about their lower fixed pivot into the oblique upper position shown by dotted lines. This gives the table a positive fleeting of 9 inches and restores it to its original position as it descends, thus making the operation entirely automatic and providing for the transfer of the billet to a new set of grooves at every second pass.

The pinion housings are made in four sections separated on the center lines of the rolls. The horizontal contact faces are machine finished and a sheet of paper is inserted between them when the bearings for the pinions are bored. Afterwards the paper is removed and the pinions are thus provided with a pinch fit. The bearings are lined with bushings bored to receive oil pipes, through which a constant supply of oil is automatically pumped to flood the bearings. The sections of the mill housing are bolted together by twelve vertical bolts 5 inches in diameter, and are seated on a pair of heavy shoes, to which they are secured by improved clamps which, as shown in the detail, have a C-shape cross-section with faces engaging the flanges of the housing and of the rails. The contact faces are machined so that when the clamps are bolted up they engage a large area very tightly and secure adjustment and perfect solidity of bearing. The rolls reduce the billets from 7x7 to 7x6, 6x6, 6x5, 6x3½, 5x5, 5x4 and 4x4 inches successively, thus giving at the back of the mill four square sizes varying 1 inch.

The engine is shown in an accompanying reproduction from a photograph. It has a high-pressure cylinder of 40 inches diameter, a low-pressure cylinder of 68 inches diameter, and a stroke of 60 inches. It is of the compound type, one cylinder horizontal and the other vertical, and is operated non-condensing, a condition which is not regarded as the most favorable one for an engine working with an extremely variable load. It runs at 90 revolutions per minute with steam varying from 135 to 150 pounds pressure. It is intended to drive two mills, the first of which is that described. The valve gear is of the Corliss type; a single eccentric actuates the valves of the high-pressure cylinder, while separate eccentrics are employed for the steam and exhaust valves of the low-pressure cylinder. The engine can be reversed by simple means. The fly wheel is 22 feet in diameter and weighs 180,000 pounds. The total weight of the engine is 630,000 pounds.



Lifting and Fleeting Mechanism for Catchers Table.



Billet Mill with Improved Housings, Hydraulic Lifting Tables and Electrically-Driven Rollers, at the Clairton Steel Plant.

The Substitution of Steam Wagons for mule teams in the transportation of mine products to the railroad, in connection with the big borax mines of Calico, San Bernardino County, Cal., is reported by the "Pacific Coast Miner" to be entirely successful.

Gas-Power for Central Stations.

Abstract of a paper presented by J. R. Bibbins to the American Institute of Electrical Engineers.

Heretofore the interest taken in gas-engine plants seems to have been confined chiefly to those operating in foreign countries, but as there are a number of successful installations of this kind in the United States, it might be of interest to present a few facts about their operation.

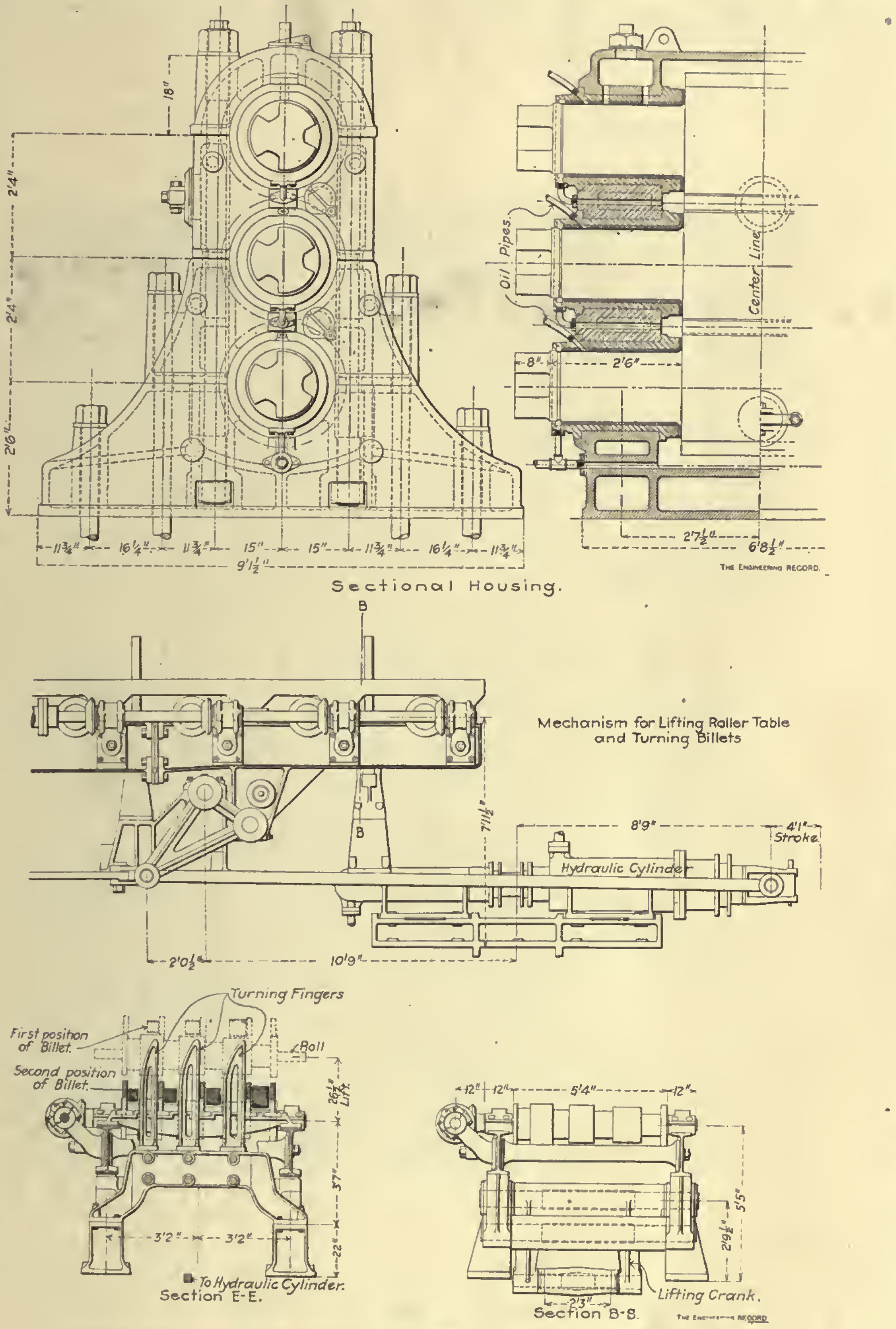
It is intended to offer testimony upon four contentions, viz.: (A) That present gas-power machinery is suitable for central-station service. (B) That a well-equipped gas-power electric-plant can operate with far better economy than a steam-plant under similar conditions. (C) That its operation is much simpler and requires less running expense for the same results. (D) That gas works, laboring under low load or output-factor, can profitably install a gas-power electric generating station, and become its own largest customer, selling both gas and electricity at competitive rates.

The basis of this paper consists of data collected from various electric light and power-plants in the United States using gas-engines as their principal motive power. Table 1 presents the most important data upon the general equipment and service rendered by the first twelve plants considered. The identity of the exhibitors is withheld, in most cases by request, thus making available more complete and valuable data. These plants are located in centers ranging from 2,000 to 20,000 inhabitants, and, in most cases, where the cost of fuel is high. The equipments average about 315 brake horse-power capacity and operate every standard form of generator for arc and incandescent lighting and for railway or general power service. All the generators are belted, the majority directly, but a few through a medium of a jack-shaft.

Plants 13 to 15 are somewhat larger and generate polyphase power for industrial works. These three plants average approximately 570 brake horse-power and the units are all direct-connected and run in parallel. Operative results have been obtained from plants 1 to 11 inclusive, the first and last furnishing excellent data upon the comparative economy of the present gas-engines and the steam-engines which were replaced.

In considering the subject in hand from an unbiased standpoint, it is important to enumerate the qualifications imposed upon the gas-engine, in order to determine its actual merits. (1) Continuity of service at any cost. (2) Simplicity of operation. (3 Reasonable cost of equipment. (4) Economy of fuel and supplies.

A 65-horse-power two-cylinder vertical engine of the type employed in the plants here considered has made the following record: Load, fan blower; total elapsed time, 8,472 hours; hours run, 97.0 per cent. Hours shut down, changing igniters, 38 hours; taking up bearings, 13 hours; painting, 179 hours; repairing blower, 5 hours; changing gas supply, 7 hours. Total 242 hours. The total amount chargeable to the engine was 0.6 per cent. During this period the engine ran, without stopping, 1,157 hours, and was then shut down to repair a broken belt. In a pumping station located on the Allegheny, a short distance from Pittsburg, five 85-horse-power engines of the same type operate regularly at full load through the week without stopping, except on Sunday, when the units are shut down in rotation for inspection and repair. Each engine operates from 96 to 98 per cent. of elapsed time.



Housing and Lifting and Turning Mechanism of the Clairton Billet Mill.

The skill required for operating a gas plant is apparently no greater than for steam plant. In several instances where the latter have been replaced, the old employes have been retained. In plant No. 11 weekly inspection of bearings, igniters, and valves were at first carried out. This was found to be unnecessarily frequent and is now done once a month. The cylinders are inspected occasionally throughout the year. This plant, 800-horse-power capacity, is operated by three day men and one night man, ten hours to a shift.

In cost, the gas-engine equipment is quite comparable with that of a steam plant. The engine itself costs more than a steam-engine of corresponding size, on account of the increase in metal required by the higher pressures dealt with. With the cost of condensing machinery charged to the steam-engine, however, this disparity is much reduced. With natural or illuminating gas supply available, the equipment cost would fall considerably below that of a steam equipment of boilers, engines, condensers, heaters, pumps, etc. In the case of a producer gas plant installed to supply the gas engines, the cost of the respective equipments, each of 1,000-horse-power is at a parity, although depending somewhat upon the gas-storage capacity provided. This, however, amounts to much less than electric storage. For producer-gas the former costs in the neighborhood of $7.35 per horse-power-hour ($100 per 1,000 cubic feet capacity), and the latter $100. Considering the increase in productiveness of labor which is stated by a prominent gas engineer to be fully 100 per cent. (owing to the fact that one man can handle twice the amount of coal), the advantage, if any, held by the steam plant, disappears.

In economy of fuel, the gas-engine admittedly has no rival. The present limit of steam-engine practice is 10 pounds water per indicated horse-power, or 11 pounds per brake horse-power. With an evaporation of 10 pounds of water per pound of good coal (14,000 thermal units per pound) a performance of 1.1 pound coal, or 15,400 thermal units per brake horse-power is realized. The gas-engine at present delivers, at full load, a brake horse-power upon 10.5 to 11 feet of gas (of 900 to 1,000 thermal units per cubic foot, calorific value) which is equivalent to 10,000 to 11,000 thermal units per brake horse-power.

Table 1.—Gas-Power Plant Equipment.

	Engines.			Generators.	
		Transmission.			
Plant No.	Full load B. H. P.	Character.	Efficiency.	Total kilowatts	B. H. P. Gen. ÷ B. H. P. Eng.
1......	685	Belt	82.5	370	.845[1]
2......	170	Belt	80	112	1.00[2]
3......	110	Jack-shaft	75	75	1.2
4......	90	Belt	80	40	0.93
5......	320	Jack-shaft	75	232	1.18[3]
6......	340	Jack-shaft	75	215	1.14
7......	305	Belt	82.5	260	1.38
8......	280	Belt	80	152	0.91
9......	..	Belt	...	..	...
10......	85	Belt	80	60	1.17
11......	803	Belt	82.5	476	0.97[4]
12......	255	Belt	80	116	0.78[5]
Av'ge.	314				
13......	375	Direct-connected	85	75	0.94[6]
14......	491	Direct-connected	85	75	0.96[6]
15......	840	Direct-connected	85	150	.85[6]
Av'ge.	568				

[1] Largely railway load—running 15-18 hrs. per day. [2] Exclusively arc. [3] Monocyclic system—runs 24 hrs. per day. [4] Plants operate 24 hrs. per day. [5] Natural gas. [6] Operates in parallel, natural-gas. Plants, generally, incandescent load. Plant 11, natural gas.

An important source of economy in gas plants is the fact that as soon as an engine is shut down all heat-losses cease, and the plant is not hampered by inefficient auxiliaries such as steam-pumps, condensers, return-traps, etc. Steam-pipe and cylinder-condensation losses, radiation, leakage in piping and fuel-loss in banking fires, have no parallel in the gas plant. The only auxiliaries required are the igniter-generators and air-compressors. The former are negligible as affecting the economy of the station, and the latter operate at full capacity at regular intervals.

In quick starting, the gas-engine fulfils every requirement. The 280-horse-power pumping units of the Philadelphia high-pressure fire system have been repeatedly started cold, brought up to speed and the pumps loaded to the required pressure (300 pounds per square inch) within a period of 40 seconds from the starting signal. In plant No. 11, employing 133-cycle high-speed generators, the units are regularly started in two minutes, and this may be reduced to one minute in case of necessity.

A number of plants make use of hot jacket-water for heating offices and buildings, ordinary cast-iron or coil-pipe-radiators being used for this purpose. One station supplies a municipal heating system resembling the Yaryan, thereby deriving direct revenue from a waste product. Part of the return-water is sent again through the jackets, the temperature being lowered to the proper degree by adding fresh water from the station supply-main. Station No. 14

returns hot jacket-water to a large cistern where it partially cools and is again pumped through the jackets emerging at a temperature of 200 degrees Fahr. before being discharged into the sewer. As return water from a heating system is also discharged into this well, a small amount of cold water from artesian well or city water system is added from time to time to reduce the general temperature of the circulating system. In another plant, the jacket-water is utilized in winter for warming the water in the gas holders to prevent freezing. This was formerly done by using live steam from a boiler used in making water-gas. It is estimated by the manager that a saving of $250 per year is effected. In locations where water is expensive, a small cooling tower may profitably be installed to cool the jacket-water which may then be saved.

Several distinct fuel-gases suitable for gas-engine use are available. When reduced to calorific values per foot of explosive mixture of proper constituency, the ratings are nearly equal as shown in the accompanying table:

Approximate Number of Heat Units per Cubic Foot.

	Gas.	Mixture.
Natural-gas	1000	91
Coal-gas	650	91.7
Water-gas	300	88
Carburetted water-gas	600	92
Producer-gas	120—145	60—68
Coke-oven gas	600	90
Blast-furnace gas	90	53

The power to be developed by an engine of given proportions does not therefore vary within appreciable limits, except on producer-gas and blast-furnace gases, when larger engines are required, or larger cylinders on the same engine frames. The rate of combustion is, however, less rapid with these than with other gases, and the compression may also be carried much higher without risk of pre-ignition or "back-firing," thus increasing the efficiency of the cycle. With water-gas the high percentage of hydrogen occasions quicker combustion and higher flame temperatures with so considerable a tendency to pre-ignition and back-firing that this gas is not well adapted to gas-engine work.

Table 2.—Cost of Operation—Fuel Only.

Plant No.	Kind of gas.	Per cent. of gas generated used for engine.	Charged to engines.	Gas per kilowatt-hour.	Gas per kilowatt-hour.
			Cts.	Ft.	Cts.
1......	Mixed	54	37.57	43.75	1.65
				28.40	1.07
				46.57	0.84
2......	Coal	..	18	33.64	0.61
3......	Coal	31	62	53.2	3.3
4......	Water	30	59.3	41.6	2.46
5......	Mixed	37.5	34.6	...	...
6......	Coal	26	39.8	48.4	1.93
8......	Coal	5	33	28.5	0.94
9......	Mixed	19.5	29.5	41.7	1.22
10......	Coal	15.0	20	41.9	0.98
11......	Natural	100	15.0	12.4	0.18
			16.0	21.5	0.34
Average....			33.9	39.0	1.4

Cts.
Average cost per kilowatt-hour at 20-cent gas (excluding No. 11).......................... 0.828

Manufacturing cost of gas, per 1,000 cubic feet: Nos. 1 and 2, 18 cts.; No. 8, 19 cts.; No. 11, 10 cts.

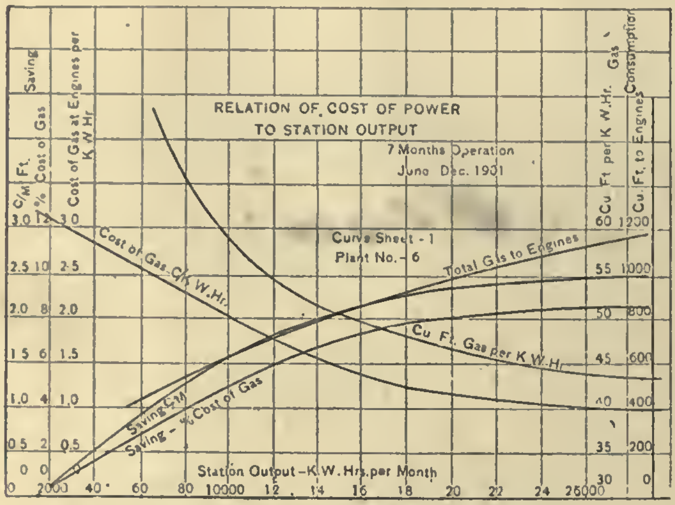
Cost per cent. of steam station, per kilowatt: No. 1, all day run, 81; gas at cost, 63.5; No. 2, 24.5; No. 11, average of six months, 26.

In Plant No. 1, the figures of the first line are the average of 6 months; those on the second the results of an all-day run; those on the third for gas at cost. In Plant No. 11, the first line gives figures of special test.

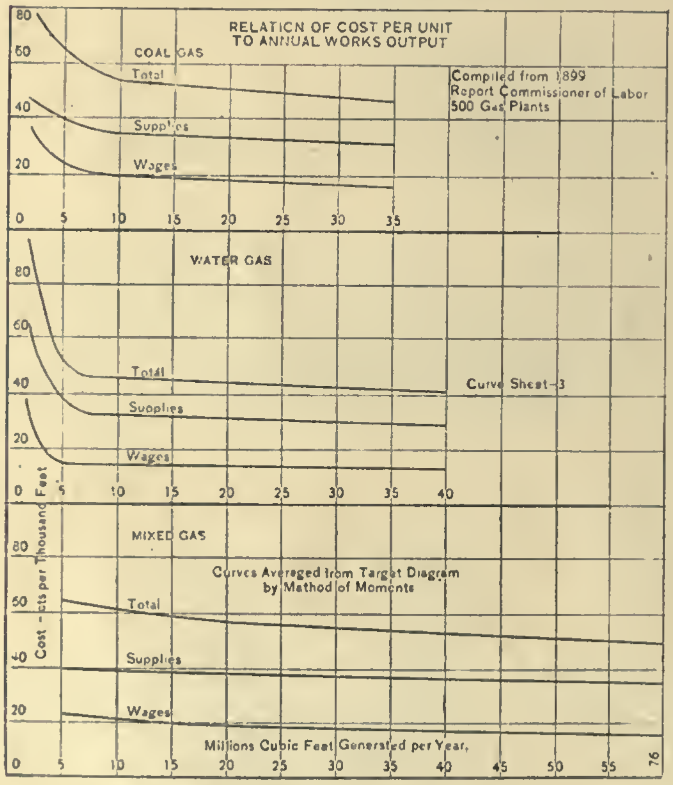
In water-gas plants a great saving may be made and the gas rendered much more suitable for the operation of gas-engines by providing additional holders for the air or blast-gas made during the period when the producers are under blast. This gas is equivalent in calorific value to blast-furnace gas—90 thermal units—and is generally allowed to go to waste. It may be used alone or mixed with a proportion of water gas, which it renders less snappy.

Leaving out of consideration the by-product, or waste coke-oven and blast-furnace gases, as occupying a field of power-development somewhat foreign to the subject in hand, producer-gas offers at present the greatest possibilities in the field of power for use in manufacturing centers. This is due to its comparative cheapness, simplicity of installation and general efficiency when gas for power purposes is alone considered.

A comparison of the approximate thermal efficiencies of the various processes gives the following results: Coal-gas (without coke), 0.24; coal-gas (with coke), 0.60; water-gas, 0.60; water-gas, special quick-blast, 0.75 to 0.80; producer-gas, 0.80 to 0.85. Assuming the calorific value of coal as 14,000 thermal units per pound, and the efficiency of the gas-making process 80 per cent. the heat available at the engine is 11,250 thermal units, which is equivalent to about one brake horse-power. This duty, one brake horse-power per pound of coal, should be expected from a well-equipped gas-power plant.



Cost of Gas Power in Plant Number Six.



Cost of Gas Production in Relation to Output.

The average station economy observed is shown in Table 2. Averages for several months' operation have in most cases been given so that the results represent the efficiency of the entire station, day in and day out, with various generating outfits running at varying load-factors and including errors of measurements encountered in every-day operation. The average gas consumption per kilowatt-hour is 39.0 cubic feet. Assuming an average calorific value of 625 thermal units per foot for coal-gas, water-gas, or mixed-gas, the heat consumption is 24,400 thermal units per kilowatt-hour, 18,200 per electrical horse-power, and 14,500 per brake horse-power-hour. The average cost of gas charged to the engine is 33.9 cents per 1,000 cubic feet, which is in nearly all cases considerably above the cost in the holder to companies operating both plants, with the result that the gas works realizes a handsome profit from the electric station in addition to the decrease in cost per unit with increased production. Assuming an average production-cost of 20 cents per 1,000 cubic feet, the average cost of power is 0.83 cents per kilowatt-hour, equivalent to 0.495 cent per brake horse-power-hour at 80 per cent. combined efficiency.

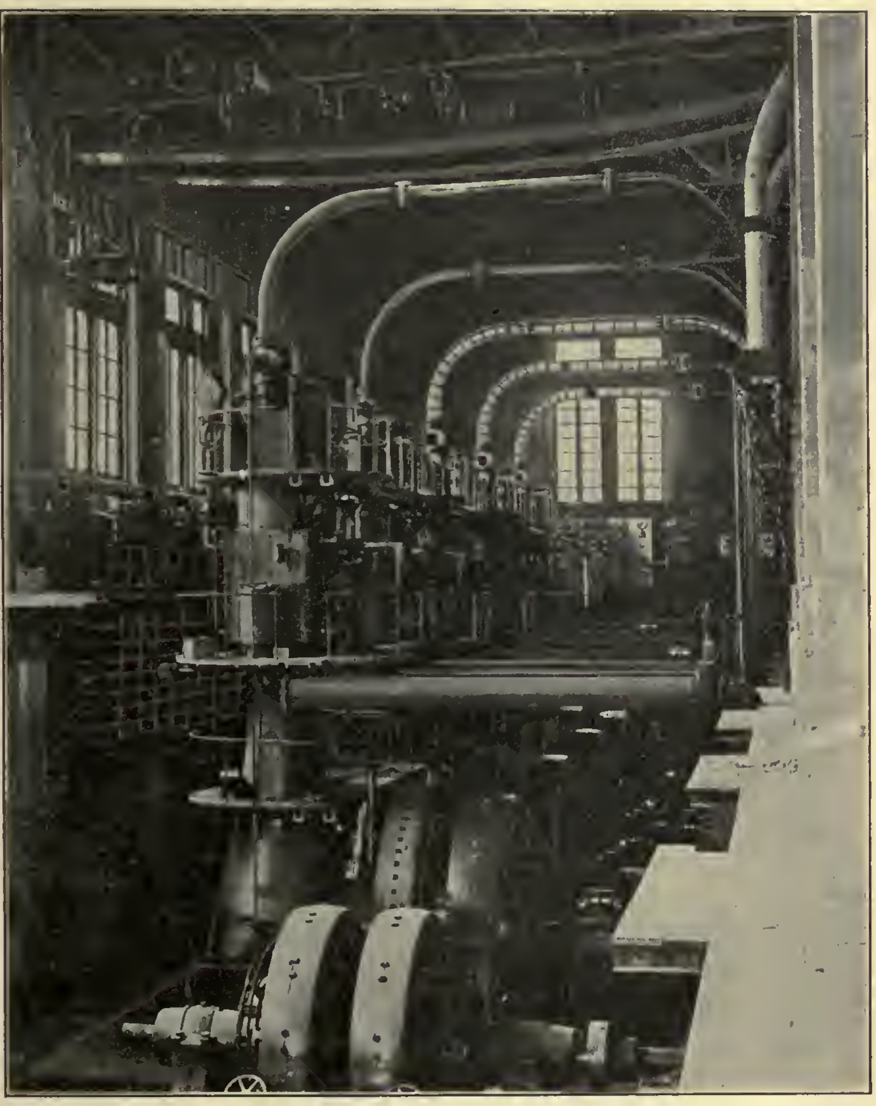
The comparative cost of steam and gas-power is well shown in Table 3. Two independent stations were operated during 1902, together with the gas works. The cost of coal in the steam plant was 1.38 cents per kilowatt-hour against 0.75 cent in the gas plant, representing a saving of 45.5 per cent. although the cost per 1,000 thermal units of gas was 3.4 times that per 1,000 thermal units of coal.

In plant No. 11 a steam plant that was formerly operated, employed horizontal tubular boilers fired by gas. The saving in total operating cost effected by change to gas engines amounted to 40.5 per cent. In the face of a 30 per cent. increase in station output, the gas consumption has been reduced by 93 per cent. Previous to the replacement of the steam-equipment an economy-test was run on the station, throughout 24 hours. The gas consumption at the boilers was 51.09 cubic feet per indicated horse-power developed at the engines, equivalent to about 86 cubic feet per kilowatt-hour. All engines were of the simple high-speed type running non-condensing. During the six months ending August, 1902, the total gas consumption of the station, including heating, was 23.8 cubic feet per kilowatt-hour. Deducting approximately 7.5 per cent. for heating, the net consumption was 21.5 cubic feet, which is about 24 per cent. of that recorded on the steam station. It is equivalent to a duty of 14,100 thermal units per brake horse-power.

The gross station economy in the case of plant No. 6 is shown on curve sheet No. 1. These observations were taken when the station was first started and operating under an extremely low load-factor. The results may be considered as representative of conditions about as unfavorable to high economy in the prime mover as is usually encountered. In plant No. 9 the average cost of gas is 1.22 cents per kilowatt-hour, and the total operating cost 3.18 cents per kilowatt-hour. Considering this to be a plant of but 135 horse-power capacity, these results are good.

Curve-sheet No. 3 shows the cost of coal-gas, water-gas, and mixed-gas for approximately 500 gas plants in the United States. These figures were taken from a report of the Commissioner of Labor on gas and electric plants, 1899. The curves were determined by the method of moments from a "shot-gun" diagram, and bring out the following points: (1)

Cost per unit decreases as output increases, most rapidly in coal-gas plant and less rapidly in water-gas plants. (2) Decrease in cost per unit in small plants of two to ten million per year output is very marked, being greatest in water-gas plants and least in mixed-gas plants. (3) The greatest opportunity for increasing revenue from combined gas and electric stations appears to be in the case of small coal and water-gas plants under ten million output. The smaller the plant the greater the profit.


Engine Room, Showing Generators and Shafts from Turbines, at Richmond.

In Table 2, plants 1 to 10, inclusive, operate combined gas and electric works and all successfully. Although production-cost (net cost after deducting value of residuals), of gas is not in all cases available, in most cases the power-gas is charged to the engine at such a rate as to insure a handsome profit to the gas works. Plant No. 1 the electric plant was charged with gas at twice the cost of production. The gas works also realized a saving of 8.5 cents per 1,000 feet nominal, or 10.3 cents actual, as a result of the increased output due to the gas-engines, which is 60 per cent. of the present production cost. The total saving amounted to 20.8 cents, nearly twice the production cost, and but little under that charge to engines.

Table 3.—Comparative Operating Economy—Plant No. 1.

Steam, 1250 IHP 6 mos.		Gas, 685 BHP 5 mos.	
Load.	Ry. Incan. arc.	Load.	Railway.
KWH per Mo.....	122733	KWH per Mo.....	39508
Lbs. coal per KWH	6.55	Cu. ft. gas per KWH	43.75
Cost coal per ton..	$4.02	Gas charged per M ft.	$.3767
Handling	.19	Gas per KWH.....	.0165
Total	4.21	Cost gas. actual...	.18
		Actual cost KWH..	.0075
Cost coal per KWH	.01375	Per cent. saving per KWH	45.5
Watt-hours per lb. coal—A. M....	134.65	Watt-hours cu. ft. gas—A. M......	24.33
Do—P. M.......	166.02	Do—P. M........	21.40
Do—24 hours...	159.08	Do—24 hours.....	22.23
		BTU per cu. ft., est.	625
BTU per lb., est..	14000	Watt-hours per M BTU—24 hours..	35.6
Watt-hours per M. BTU 24 hours...	11.35	BTU per KWH....	29100
BTU per KWH....	92000	BTU per EHP.....	21700
BTU per EHP-hour	68600	Per BHP at 85%...	18400
BTU per BHP-hour	55000	Per cent. saving heat	66.5

Both plants run 15 to 18 hours per day.

In plants Nos. 1, 2, 3, 6 and 10, the average saving recorded, due to gas-engines, was 5.2 cents per 1,000 cubic feet, or 6.8 per cent. of works-cost (gross cost, including maintenance and without deducting residuals). This, however, is less than the actual saving by reason of the general increase in cost of coal at the time the last observations were taken, due to general stringency of fuel.

BETTER BUILDING LAWS FOR INDIANAPOLIS were discussed at a meeting of architects called recently by Building Inspector Stanley to consider plans for securing better laws governing architecture and building. The meeting was well attended and an organization effected with Mr. O. D. Bohlen, president, and Mr. J. T. Johnson, secretary. Mr. Stanley asked the co-operation of architects in the consideration of ways and means of making what he considers greatly-needed changes in the Indianapolis building laws, to conform with improved ideas in architecture and the growth of the city. All present were greatly pleased with the plans presented and the interest shown by the architects is evidence of their willingness to assist in bringing about the desired change. The council will be asked to pass a new building ordinance providing that all applications for permits to build structures large or small shall be made to the building inspector instead of to the comptroller. Factory Inspector McAbee was present and commented on the movement for better building laws.

The Steam-Hydraulic Plant of the Virginia Passenger & Power Company, Richmond.

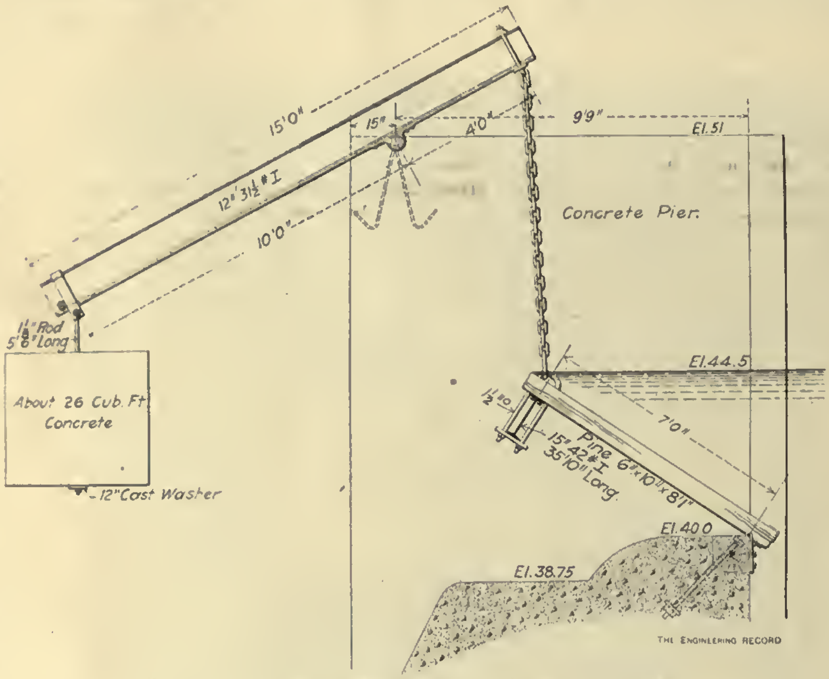
On November 9, 1901, The Engineering Record printed a description of the plant of the Virginia Electrical Railway & Development Company, at Richmond, Va., now the property of the Virginia Passenger & Power Company. Since that time the plant has been extended under its new ownership, and in its enlargement some departures have been made from the plans as outlined at the beginning. It was originally laid out for an ultimate development of 10,000 horse-power and the initial installation, which was the subject of the account two years ago, was 4,000 horse-power. The work was started in 1898 to furnish electric power for all classes of service, in competition with companies already established. On account of the variable supply of water in the James River, an auxiliary steam plant was arranged for, with the full capacity of the hydraulic development. The passage of the property into the hands of the Virginia Passenger & Power Company, which is the title of the corporation now controlling the electric railway, power and light business of Richmond, was early followed by arrangements for the completion of the plant to the full 10,000 horse-power; and the promising demand for electric power influenced the extension of both the hydraulic and steam plants to the same capacity. Changes were made in the canal and the intakes to the wheel chambers, but the most interesting innovations are the new type of dam that was built in completing the old dam, which had not been entirely extended across the river, and a rack-cleaning mechanism for clearing the intakes of obstructions.

The power house and the hydraulic features of the original plant were designed and constructed under the supervision of Mr. Reuben Shirreffs, M. Am. Soc. C. E., as chief engineer. The contractors for the dam, canal and power house foundations were Messrs. Winston & Company, of Chicago, Mr. J. H. Apsey, superintendent. The steam and electrical details were designed by Mr. Edward J. Willis, M. Am. Soc. M. E., of Richmond, who resigned in the spring of 1900 and was succeeded by Mr. J. P. Pope. Messrs. Sargent & Lundy, of Chicago, were consulting engineers on the steam plant. After the consolidation of interests, of which Mr. Frank Jay Gould, of New York, is now in control, Mr. Wm. C. Whitner, of Rock Hill, S. C., was retained as chief engineer of the water-power developments of the company, which include both the enlargement of the James River property and the development of 20,000 horse-power on the Appomattox River.

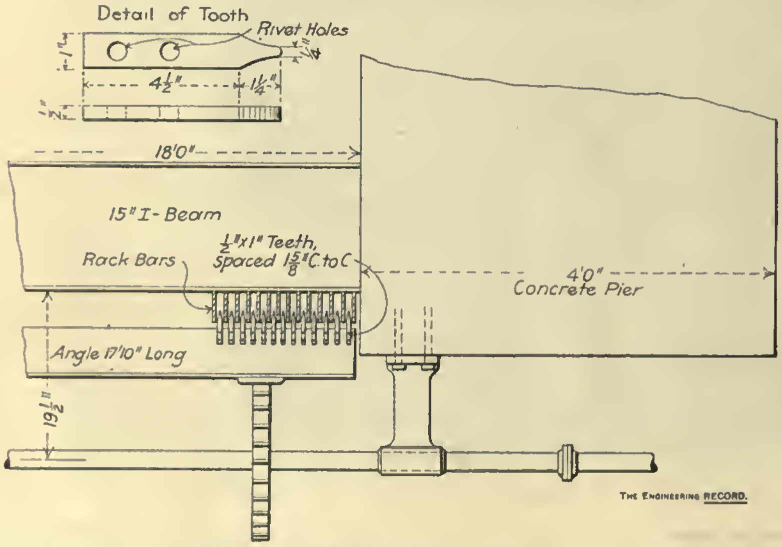
According to Mr. Whitner, the average rainfall for the watershed of the James River, which comprises 6,900 square miles, is 42 inches per annum, but it is not advisable, on the basis of the records of the Geological Survey, to figure that the minimum flow of the river at Richmond exceeds 700 cubic feet per second, or 0.1 cubic foot per square mile of the catchment basin. It will be remembered that a diversion of the water takes place through the Chesapeake and Ohio Canal, amounting to about 100 cubic feet per second, which is not available for power, and also that on the opposite side of the river from the power station there is a power canal, known as the Manchester Canal, along which there are several tenants depending on hydraulic power. This canal has been acquired by the Virginia Passenger & Power Company, but the contracts under which the water is furnished cannot, practically, be changed. It is estimated that 600 cubic feet are ordinarily disposed of in this way, under a head of 19 feet, but at periods of low flow, the Manchester Canal tenants are only entitled to half the water in the river. On the aforementioned minimum flow basis, and on the operating head of 25 feet, for which the station is designed, the following schedule of available power has been prepared by Mr. Whitner, assuming a combined efficiency for the wheels and generators of 75 per cent. and allowing for the diversion to the Manchester Canal: for 5 months of the year, 8,846 horse-power; for 6 months, 6,242 horse-power; for 8 months, 4,012 horse-power; for 9 months, 2,982 horse-power; for 11¼ months, 1,065 horse-power; minimum, 639 horse-power. This summary shows the necessity, if it is desired to supply 10,000 horse-power continuously from the plant, for the steam engine adjunct. It shows, for example, that if 9,000 horse-power is the demand, the engines would not have to be operated at all for 5 months, that for one month they would have to supply 2,758 horse-power, for 2 months they would have to supply 4,988 horse-power, and so on. For 15 days they would have to meet practically the entire demand. It must be remembered that these results are based on the minimum flow, which is not necessarily an annual occurrence.

As was described in detail in the former article, the power development is of the type in which the water is diverted by a dam into a canal and passed through wheel chambers in a power house, this being located parallel to the axis of the canal and at its end between the canal and the river proper. A particularly interesting feature of the work was the restriction as to the height to which the dam could be extended. Owing to the probable damage to property above the dam in times of freshets which are of no inconsiderable magnitude, contracts covering the water rights stipulated that the dam proper should not rise above an elevation of 40.5, which gives the dam an average height of 5 feet above the granite bed of the river, but further provided that flashboards could be employed to maintain a level in the impounded pond at 44.5. Corresponding to this is the normal tail water level at 17, but in the design of the canal restrictions as to its width called for a comparatively high velocity, 9 feet per second, and it was calculated that the head water level at the power house would be reduced 12 or 15 inches, dropping to 43, so that the gross head is 26 feet. It may be remembered that these flashboards consist of heavy timber gates attached at each end to a lever and arranged to be swung upward and fastened in a position above high water level. For this purpose at intervals of 40 feet concrete piers 4 feet wide rise upward from the concrete dam and spanning them a continuous bridge extends the length of the dam. The bridge carries a narrow-gauge track on which a hand car can be pushed from gate to gate and utilized to haul up the gate by means of a motor mounted on the car. The flashboard is fastened in its uppermost position and the car moved on to the next flashboard.

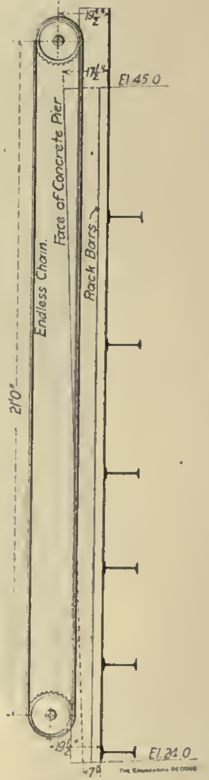
About 1,200 feet of the dam had been completed on these lines, leaving about 560 yet to be built. For this work, the type of movable crest shown in one of the accompanying illustrations has been substituted. It was designed by Mr. Whitner and is planned to be automatic, consisting, as shown, of a hinged apron inclined in the direction of flow so that there is a downward pressure of water on it, which pressure can be counterbalanced in such a way that when the weight, that is the height, of water reaches a sufficient amount, the downward pull of the counterbalance is overcome and allows the apron to drop and thus lowers the rollway crest. This type of flashboard has also been calculated to maintain the elevation of 44.5. The concrete dam proper has a different shape top to that of the old portion, on account of the clearance required for the new type of flashboard. The apron consists of 6x10-inch pine timbers 8 feet long, bolted together between iron plates at the bottom and top and strengthened at the top by a 15-inch 42-pound I-beam. There are two levers, one at each end, from which the apron and the counterweights are hung, and these consist of 12-inch 31½-pound I-beams 15 feet long, with lever arms of 4 and 10 feet. The apron is suspended from each lever, as indicated, by a heavy chain. Each counterweight is a mass of concrete measuring about 26 cubic feet. A signal station is maintained at Columbia, Va., about 50 miles up stream, from which reports can be sent to Richmond by telephone of the water level at that point. By this means notices of floods are received 12 hours in advance of a rise at Richmond, and men immediately start raising the gates in anticipation of the high water. Of course with the automatic type of flashboard this is unnecessary, and it was to do away with this work on the new part of the dam that it was designed.



Automatic Flush Boards on the James River Dam.



Part Plan. The Rack-Cleaning Device at Richmond.



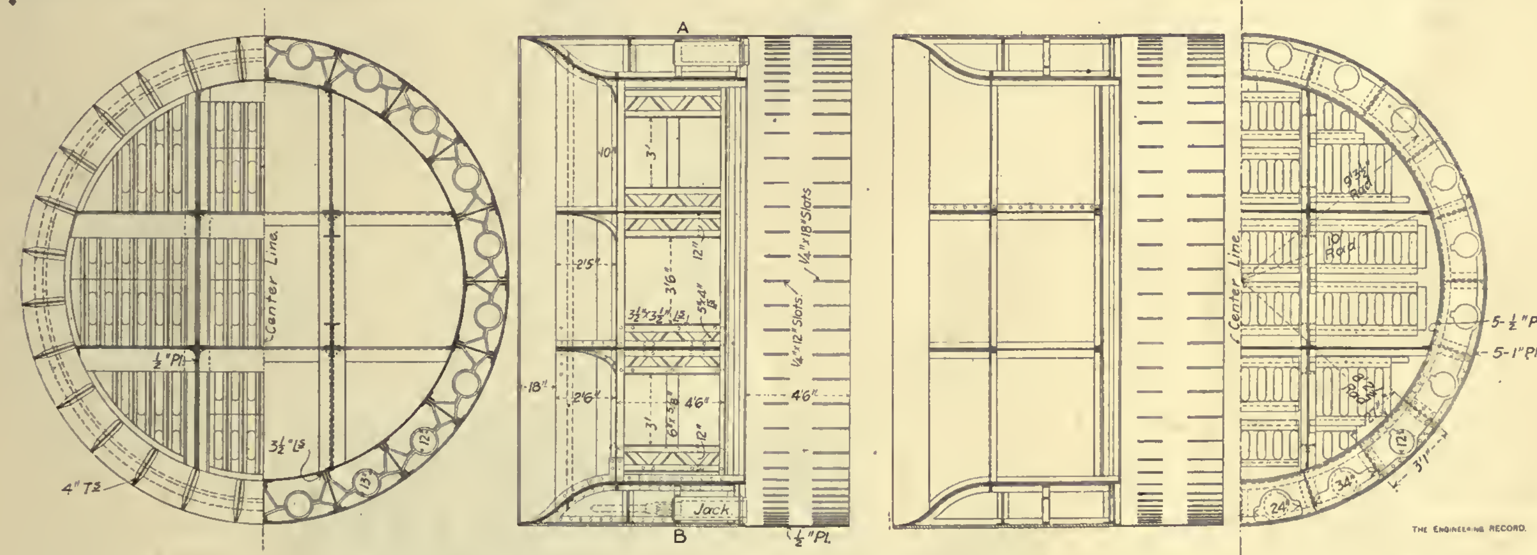
Elevation.

At the power house, the end of the canal has been enlarged as much as the width of the property would allow so that as large a forebay as possible could be obtained. Formerly the racks were set across the canal, but now they have been placed immediately in front of the wheel chambers and in that way the area of flow through them has been increased 3½ times, it is stated. The racks are composed of 3½x⅜-inch steel bars spaced on 1⅝-inch centers and each rack structure protects an opening 18 feet wide, which is the mouth to the wheel chamber. In the interest of preserving as high a head as possible at all times, a mechanical rack-cleaning device has been provided, as already stated, to keep the spaces between the racks free from obstructions and to give the largest possible free waterway. The cleaning device comprises a number of large combs, so to speak, the projecting teeth of which fit in between the bars of the racks, and of endless chains on which the combs are fixed, and by which they are moved upward along the rack bars. The comb consists of an angle-bar with teeth of ½x1-inch iron riveted to the angle on 1⅝-inch centers and pointed. The chains pass over sprocket wheels which are carried by a shaft at the top, driven by a 10 horse-power motor.

One of the striking features of the power house, it may also be remembered, was the large use that was made of concrete in its construction. Not only were the foundations of the building formed of concrete, but the walls and the roof, the switchboard gallery floor and even the outer shell of the chimney. Owing to the high floods the foundation work of the station had to be very heavy and these are monolithic. The walls of the superstructure, however, were formed of concrete blocks, previously moulded in boxes and laid up in the walls like stone ashlar. It is said that the stone from the excavations was unsuitable for stone masonry and this was one of the reasons for the choice of concrete. Incidentally, it made architectural effects possible at a comparatively low cost. In the extension of the superstructure of the building the walls consist of brick, but to have it conform with the earlier portion, the brickwork is faced with concrete, marked off to represent the block work already existing.

The generating equipment of the station as now enlarged includes six pairs of water wheels of the Victor cylinder gate type, built by the Stilwell-Bierce & Smith-Vaile Company, and the remainder of pairs of Hercules turbines built by the Holyoke Machine Company. Each wheel is 51 inches in diameter and the pair is designed to develop about 1,200 horse-power under the 25-foot head. They are all controlled by Lombard governors. To recall the general arrangement of the station, it may be worth while to state that each pair of turbines is submerged in a wheel chamber and the wheel chambers are arranged side by side and over them is located the boiler room for the steam plant. From the wheels the draft tubes extend to the tail-race underneath the generator room. As usual in plants of this type, the wheel chamber ends in a metal plate in the partition wall, and the shaft from the pair of turbines extends into the generator room, where it is directly attached to the electric machine. Each generator is of 700-kilowatts capacity, of the General Electric make, six of the continuous-current type and the remaining unit installed, of the alternating-current type. On the other side of the generator, in each case, as explained in detail in the former article, the crank shaft of the steam engine is located and connection can be made so that the generator can be driven from either source or both. The engines, which are of the Allis steeple tandem compound type, arranged to be run condensing or non-condensing, are noteworthy from the fact that while capable of delivering 1,500 horse-power their economical rating is 750 horse-power. The reason for this is that they are not depended on to operate alone for very much of the year. Instead they are intended principally to supplement the wheels in times of low water and to maintain the proper speed in the turbines at high water. The boiler installation now consists of four 1,000 horse-power batteries of Babcock & Wilcox water-tube boilers, but the general characteristics of these, together with the interesting Worthington condenser installation and the steam piping system, were described in the account already mentioned.

The officers of the Virginia Passenger & Power Company are as follows: President, Mr. F. Sitterding, of Richmond; first vice-president, Mr. Frank Jay Gould, of New York, who holds the controlling interest; second vice-president, Mr. Augustus Wright, of Petersburg; secretary and treasurer, Mr. Guy Phillips, of New York; assistant secretary and treasurer, Mr. William Northrop, of Richmond. The late construction work, except the extension of the power house, which was erected by Mr. John Mann, Jr., was done by the company's own forces.



Half Front Elevation. Half Cross-Section A-B Vertical Section through Axis Horizontal Section through Axis Half Rear Elevation

An Improved Shield for Tunneling through Soft Materials in Submarine or Land Work.

An Improved Tunneling Shield.

In an article on the intercepting sewers of Chicago printed in this journal August 12, 1899, there was a description of a shield used in constructing the Thirty-ninth Street conduit, but no illustrations of this shield were given in that issue. This shield was designed by Mr. Cornelius G. Hastings, of Chicago, who since that date has developed this type of shield for application to tunnels of a considerable range of sizes through various classes of materials, seeking to produce an apparatus that will successfully overcome the numerous difficulties encountered in submarine tunneling as well as in some land tunneling, particularly beneath streets lined by heavy buildings whose stability may be imperiled by the tunneling. Several improvements have been made in details since the Thirty-ninth Street shield was built, and besides improving the shield, Mr. Hastings has designed a system of tunnel lining consisting of segmental concrete blocks and steel reinforcement. These designs are the result of long practical experience in difficult tunnel work.

Each shield is essentially a double tube having an outer shell of heavy plate and an inner shell of plate of about half the thickness of the outer shell, with a bell-shaped reducing plate extending from the beveled cutting edge to the forward end of the inner shell, bulkheads and controlling gates of special design and interior partitions and framework which can be left out if desired. The two shells are concentric and are connected and rigidly braced apart by radial steel plates with steel angle connections, so spaced and proportioned that the tube of the shield is strong enough to resist without sensible deformation all pressures from without as well as the force of the hydraulic jacks used to drive it ahead. These jacks are carried in the cells formed between the shells by the stiffening plates by means of bent plate carriers connected to the shells through the same angles as the stiffening plates, as shown. The cutting edge has a small bevel outward so as to cause a slight compression of the earth against the outer surface of the shield, while the bell-shaped reducing plate, as indicated in the drawings, can produce a very considerable compression of soft materials in reducing the diameter of the intercepted cylinder of earth from that of the cutting edge to that of the inner shell. This consolidation is intended to render such materials much easier to excavate and also to increase their resistance to the escape of compressed air at the working face. Thus if the soft matter has a tendency to move in advance of excavation the forward movement of the shield, owing to the provision just explained, causes it to be deflected against the bulkhead and held intact until excavated, it is claimed.

In shields of large size this reducing or compressing space in front of the bulkhead can be subdivided by vertical and horizontal partitions extending part way from the bulkhead to the cutting edge, and, as these partitions are designed to have curved plates on one or both sides, they accomplish still further compacting of the soft earth. These partitions are placed to correspond in position with vertical and horizontal partitions inside the shield, which carry the working platforms. These interior vertical and horizontal dividing walls are of heavy steel plate held in position by suitable framing of steel angles, and are arranged to divide the space inside the shield into as many working chambers as the size of the tunnel may require. This interior framework and the partitions, however, are so attached to the inner shell that they can be readily adapted to any condition of tunneling or size of bore, without impairing the strength and rigidity of the double tube. Of course in small shields such partitions would not be required as the excavating could all be done from one level.

The bulkhead is pierced by one or more doors, according to the size of the shield, corresponding to the working chambers, hung on heavy hinges and arranged to swing back against the interior partitions, or in small shields, against the inside of the shell, so as to cause the least practicable obstruction in the working space. These doors are provided with strong latches so that they may be securely fastened shut when necessary, in order to exclude inflowing soft materials or for other purposes, and each has several narrow vertical slots, as shown, controlled by a sliding gate. By these means, when passing through soft running material, the inflow can be well regulated, while the wide opening of the doors makes possible the more rapid excavation of compact earth or an effective attack upon a boulder, a buried log or other troublesome obstructions. Over one or more slots in each working chamber nozzles may be fitted into the sliding gate to provide for the attachment of a centrifugal pump, which can be brought into play in case a considerable amount of water or very soft flowing material is encountered.

To aid in breaking up strata of tough clay or similar more solid formations, when met, a number of radial 4-inch steel tees, bent to the proper curvature, are riveted to the face of the bell-shaped reducing plate, from the cutting edge to the plane of the partitions in front of the bulkhead. These tees also serve to stiffen this plate and to reinforce the cutting edge. Wherever the tunnel is in a formation sufficiently stiff to be self-sustaining, the bulkhead may be entirely removed to permit of blasting, if this should be necessary, and is so arranged as to be easily and quickly taken out and replaced. The shield is followed by an apron or hood made of steel plates of one-half the thickness of the outer shell, so attached as to make the outer surface flush. This apron is pierced by numerous narrow slots, as shown, which give it a slight degree of flexibility. The jacks are designed to be connected to the main hydraulic pressure feed in such a manner as to permit each jack to be operated independently or all the jacks to be operated in unison. By means of a special group of cocks supplied with a gauge the pressures exerted on individual jacks may be ascertained, thus making it possible to so direct the application of pressure as to keep the shield to line and grade.

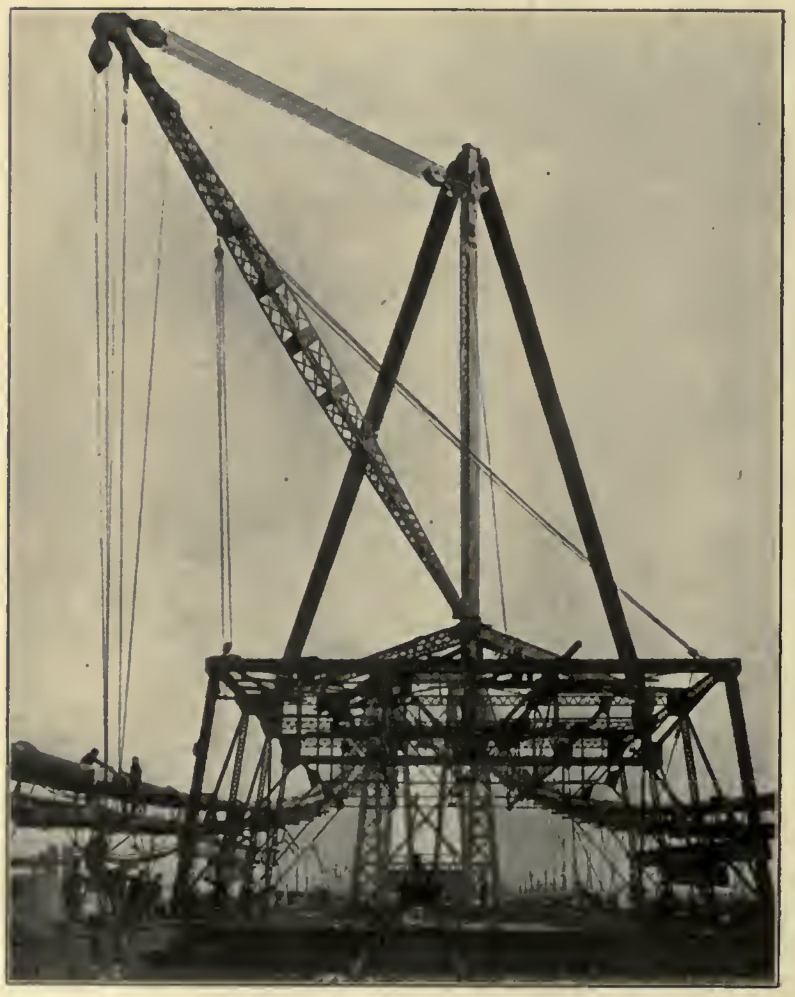
The tunnel lining previously alluded to, consists of segmental concrete blocks, reinforced with steel rods or expanded metal, cast in molds and allowed to set thoroughly before being taken into the tunnel. These blocks will be placed so as to break joints at the middle of a block. In each course there will be a key block at the crown. The joints between the blocks will be made with asphalt or some other suitable elastic waterproof substance. By this method of construction it is expected that the blocks as rapidly as placed in position will be able to receive the pressure of the shield jacks, and, indeed, this pressure is to be utilized to assist in retaining the blocks in position until the key is set and the ring completed. As the blocks will be large and heavy a power device has been designed for placing and forcing them into position. There are placed in each block, when the concrete is put into the mold, two steel lugs with pinholes through them for the purpose of attaching circular steel rails or beams, and, inside these, a cylinder of expanded metal or other suitable steel fabric. Concrete mixed with small crushed stone or gravel is then to be applied to any designated thickness.

Strength to resist great external pressure, not only ultimately but immediately after the placing of the blocks, or to withstand considerable bursting pressure, as in a conduit carrying water, as well as great permanence are claimed for this type of lining. Furthermore, by using blocks of concrete molded and set under favorable conditions outside the tunnel, the difficulties incident to the use of fresh concrete under pneumatic pressure are, to a large extent, avoided. The finish inside the blocks may be applied at any convenient time after the blocks are placed, and in many cases would preferably not be put in until after other parts of the work were done and the air pressure dispensed with. The type of shield described can also be adapted, it is claimed, to cross-sections of the horseshoe or similar shapes. United States and foreign patents have been granted to Mr. Hastings covering broadly the features of this type of shield and system of tunneling, and other patents are pending. The drawings and notes for this brief description were kindly furnished to this journal a few weeks ago.

The Main Span of the Williamsburg Bridge, across the East River, New York City.

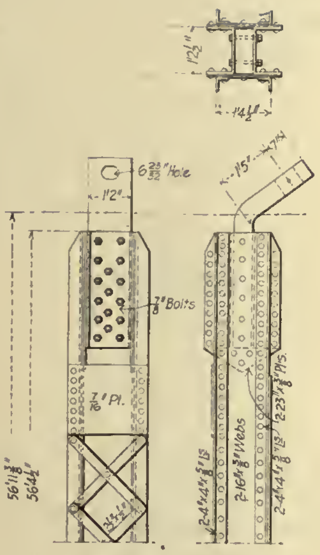
Part III.—Tower Derricks and Main Travelers.

Details and Rigging of Steel Hoisting Derricks.—The stiff-leg derricks in the main towers were of special construction designed for this work, but intended for future service in any heavy erection. They have a capacity of 30 tons at the extremity of a 52-foot boom. The mast was about 45½ feet high seated at the intersection of a 36½-foot sill parallel to the bridge axis and a 36-foot sill perpendicular to it. These sills were supported outside the tower face on steel cantilever beams parallel to the bridge axis and carried across the tops of the main portal girders. The top of the mast was braced by heavy steel struts which were pin-connected to the ends of the sills. Each derrick was rigged with twenty-nine 18-inch sheaves including the snatch blocks for the leads to the hoisting engines. The hoisting and topping-lift tackles were rove with 1,745 feet and 1,053 feet respectively of ¾-inch plow steel cable with an ultimate strength of 50,000 pounds. The sheaves were arranged, as shown in the diagram, so as to provide two hoisting tackles at the end of the boom. Each derrick had a total weight of about 28 tons, including the rigging and excluding the cantilever beams and the extra 62-foot boom which was provided for special service.

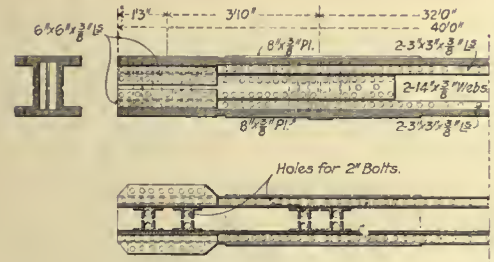

Williamsburg Bridge: Main Traveler without Small Derricks in Rear.

The two lead lines were carried down in the usual way through the center of the mast, and thence were run in an approximately horizontal plane, diagonally to the bridge axis, to snatch blocks attached to one of the cantilever beams, thence down vertically about 43 feet to the floor level and through another snatch block to the hoisting engine. The hoisting tackles commanded a height of 182 feet at the Brooklyn tower and 167 feet at the New York tower with the boom at an angle of about 45 degrees and lifted a 25-ton chord section about 130 feet in three minutes. The mast has a ¾-inch horizontal base plate, and riveted to it there is a 2½-inch cast-iron bearing plate and a phosphor-bronze disk 1 inch thick which has a spherical polished bearing surface ground to a radius of about 6 feet. This is seated in the concave top of a cast-steel base plate to which the mast is secured by a hollow vertical pin with a collar at the upper end engaging the base plate and a nut at the lower end engaging the base casting, which is seated on the apex of the sills to which it is securely bolted. A pair of jaw plates ½ inch thick project from the side of the mast just above the base plate, and are stiffened with heavy horizontal angles to receive the boom pivot pin. Vertical sheaves are placed inside the mast near the lower end to guide the fall lines through the bottom pin, and boxes are built up on the outsides of the mast near the upper end to receive the sheaves, over which the lead lines are run from the tackles. The upper end of the topping-lift is connected to the mast 5 feet below the top with a link made with a pair of 4-inch bent eye-bars 1¼ inches thick and the mast is reinforced to resist bending from this connection. The top of the mast is stiffened by a horizontal diaphragm about 22 inches from the end and by a heavy U-plate and flange angles at the end. Both are bored to give upper and lower bearings for the 7 7/16-inch gudgeon pin 3½ feet long which is notched at the lower end to prevent it from twisting. The pin engages two 14x5½-inch annealed cast - steel goose necks, which are bolted to the upper ends of the stiff-legs and take bearing on a convex washer plate on top of the mast.

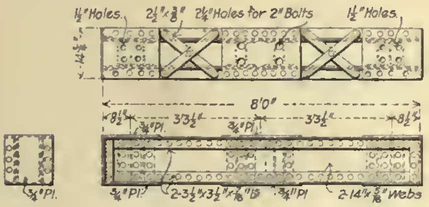
The boom has a rectangular cross-section made with four 4x⅝-inch angles with their flanges turned inwards and latticed on all sides. It is 2 feet square in the center and tapers to 1 foot at the outer end, where the sides are covered with long tie plates. At the heel two of the plates project to form jaws for the pivot pin. At the point there are two small sheaves on the outside of the boom and one large sheave inside with an axle which also engages a pair of 5x¾-inch bent links for the connection to the auxiliary hoisting tackle. The main hoisting tackle and the topping-lift tackle have shackles engaging pins through vertical jaw plates riveted across the point of the boom. The sills are 18x24-inch horizontal struts about 38 and 40 feet long and have rectangular cross-sections made with four 3½x3½-inch angles with their flanges turned out and latticed on all sides. They are connected at one end by horizontal gusset plates bolted to the upper and lower flanges. Near the intersection of their center lines one strut is stiffened by a pair of reinforced vertical trans-



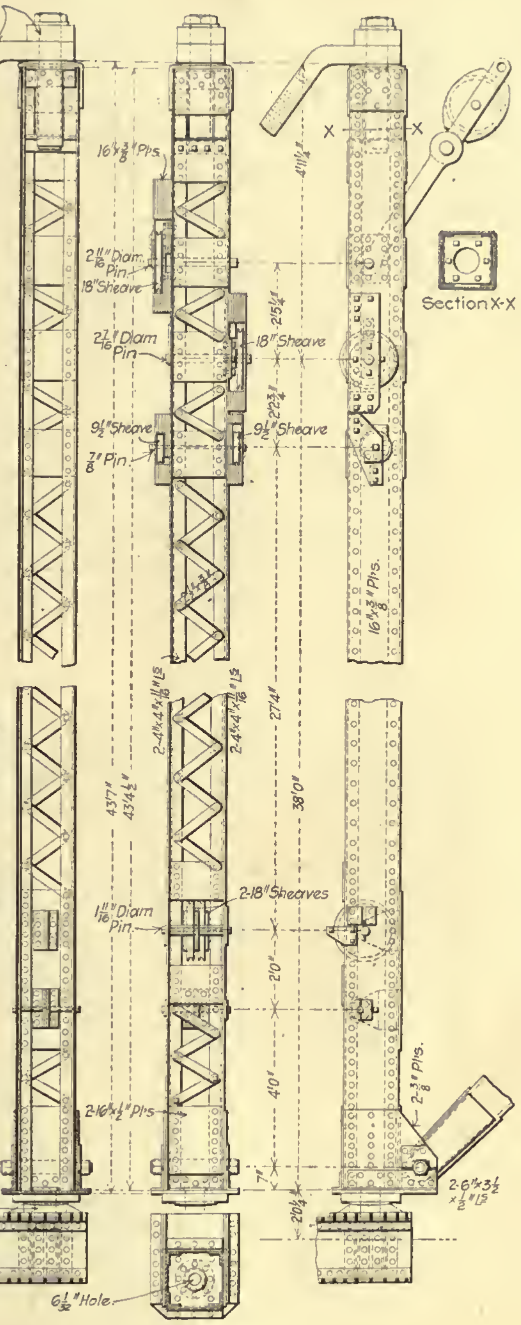
Stiff Leg for Tower Derrick.



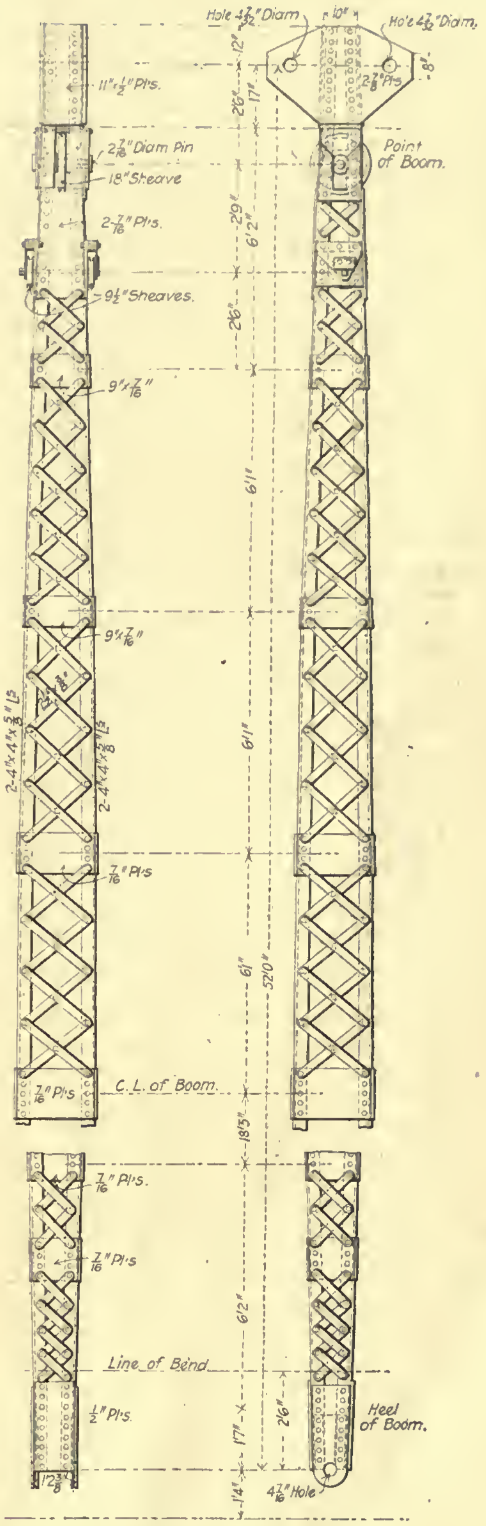
Cantilever Beam.



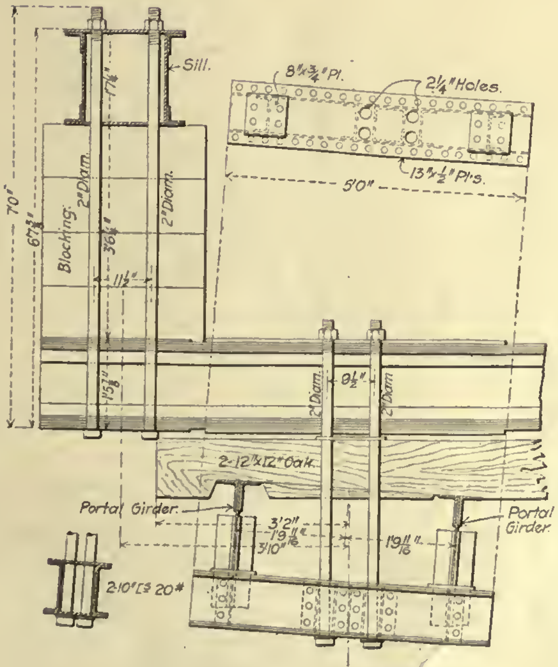
Yoke Beams.



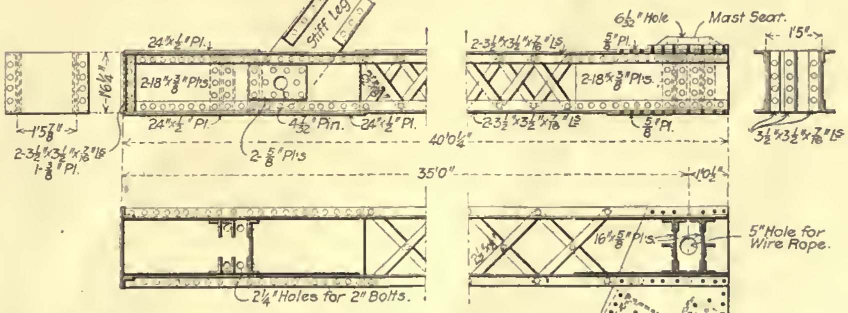
Mast of Tower Derrick.



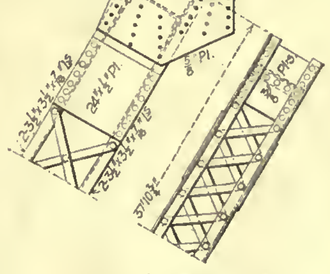
Short Boom for Tower Derrick



Tower Derrick Anchorage.



Sills for Tower Derrick.



THE ENGINEERING RECORD.

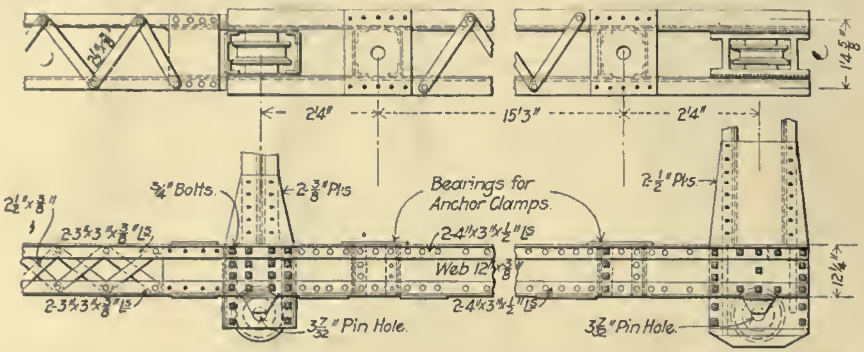
DETAILS OF THE STEEL DERRICK USED FOR ERECTING THE TOWERS OF THE WILLIAMSBURG BRIDGE.

verse diaphragms which at the upper ends are milled to bearing for the lower base casting of the mast. At the opposite ends long web end flange plates make a closed cross-section, and the top and bottom horizontal plates are bored for four 2-inch anchor bolts which secure the sills to the permanent tower girders or to the temporary cantilever beams. At these points the strut is stiffened by vertical transverse diaphragms and vertical bearing angles fitted against the upper tie plate which receives the bearing of the nuts on the anchor rods.

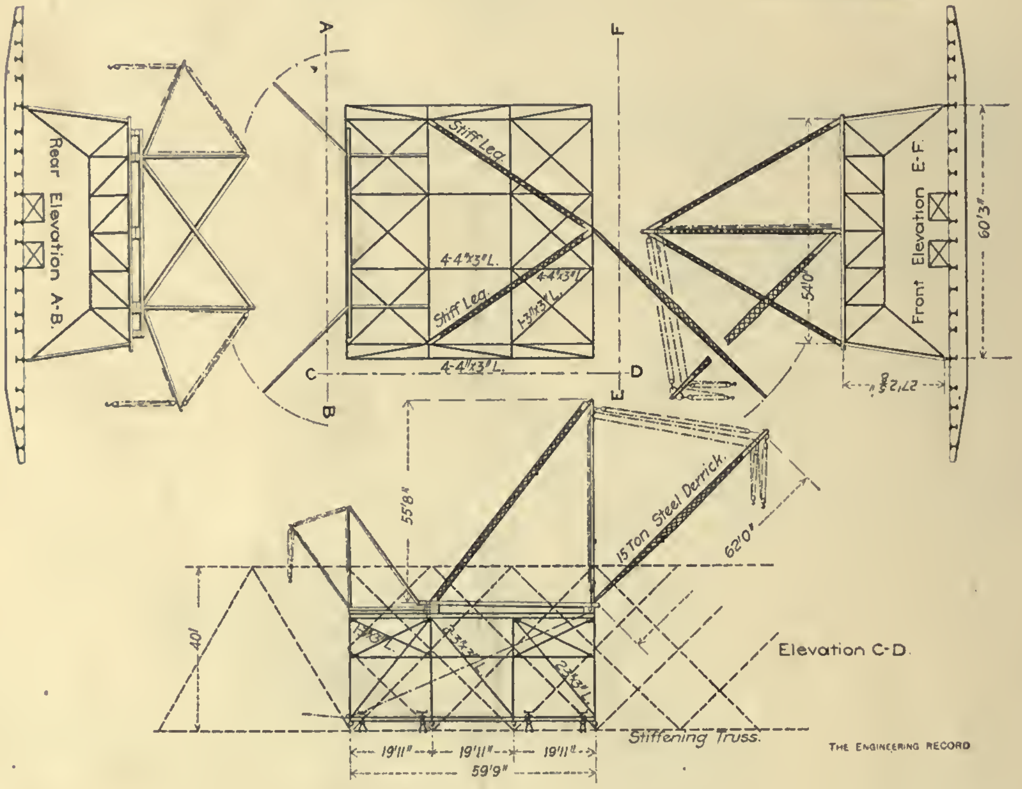
The web plates are bored for the horizontal pins through the ends of the stiff-legs. The trough-shaped stiff-legs are about 57 feet long over all and are made with two built channels with latticing on the top and a cover plate on the bottom of the flanges. The webs of the channels are in vertical planes and between them at the upper ends are fitted the cast-steel goose-neck plates which are secured by sixteen ⅞-inch turned bolts passing through them flatwise and screwed up on heavy bent plates riveted to the stiff-leg. The beams which carry the derrick sills on the tower girders have closed rectangular sections and are made with four 3x3x⅝-inch flange angles, two 14x⅝-inch web plates and several 14-inch cover plates of different lengths and thicknesses. The cover plates are bored for groups of four 2-inch anchor bolts and are reinforced by vertical angles riveted to the insides of the webs to form pockets, through which the bolts pass. The connection of the sill A to the cantilever beam 2 and the support of the latter across the permanent portal girders is shown by the detail marked "tower derrick anchorage." This anchorage is typical of the other anchorages connecting the beams and sills to the framework of the tower.

Details and Rigging of Steel Travelers.—The duplicate travelers for the main span erection each weighed about 50 tons and consisted of a rectangular tower about 60 feet square and 30 feet high which carried one stiff-leg derrick in front and two behind. The frame was made as indicated in the general diagram, with four transverse bents with horizontal struts and diagonal braces, in the longitudinal faces and in the horizontal upper face. Each bent consisted of two inclined posts and kneebraces supporting an overhead transverse truss with a clearance of about 14 feet above the track. The travelers were first assembled with only the large derricks in front. The two smaller derricks in the rear were not erected until the traveler commenced the fourth movement. The transverse bents in the traveler were lattice-girder trusses with battered end posts, which were continued beyond the lower chord line and bolted at the lower ends between jaw plates projecting from the upper sides of the longitudinal sills. The ends of the top chords were connected by longitudinal horizontal struts, and the panels thus formed were braced by diagonals so as to practically form longitudinal lattice girders in the side faces of the tower. The top chords were X-braced in a horizontal plane and supported the sills of the derricks. All the tower members were shipped separately and bolted at connections. Most of the members had rectangular cross-sections made up of four angles or of two channels latticed, and were connected by pairs of jaw plates shop-riveted to one of the members. The lateral diagonals were single angles.

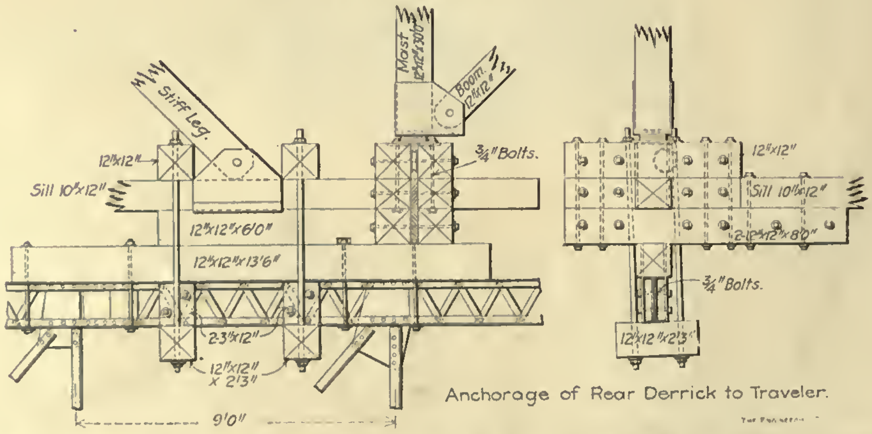
The large derrick had a 62-foot boom, 30 inches square at the center, which, with the mast, stiff-legs and sills, were similar in design and detail to the tower derricks. The small derricks were built of timber with riveted and forged steel fittings, and were arranged as indicated in the diagram elevation of the rear of the traveler. The stiff-legs were lapped and spliced with fourteen ¾-inch bolts and two 4x6-inch oak keys. The lower ends of the stiff-legs were pin-connected to vertical plates with angle flanges which enclosed the lower corners of the sill. The sills were blocked up from the top chords of the traveler trusses, to which they were anchored by yokes made with transverse wooden beams and vertical tension rods, as shown in the detail for the front sills. The anchorage of the rear sill was similar, but consisted of two pairs of 1½-inch rods 5½ feet long which had bottom nuts engaging transverse bearing angles under the flanges of the traveler chords. The derricks were proportioned for a load of 10,000 pounds with the boom in a horizontal position. This gave a computed maximum reaction of 30,000 pounds at the foot of the mast and an uplift of 20,000 pounds at the extremity of the longitudinal sill. At the extremity of the transverse sill the uplift was 13,500 pounds when the boom was horizontal in the same plane.



Bottom Chord of Traveler.



Main Span Traveler.



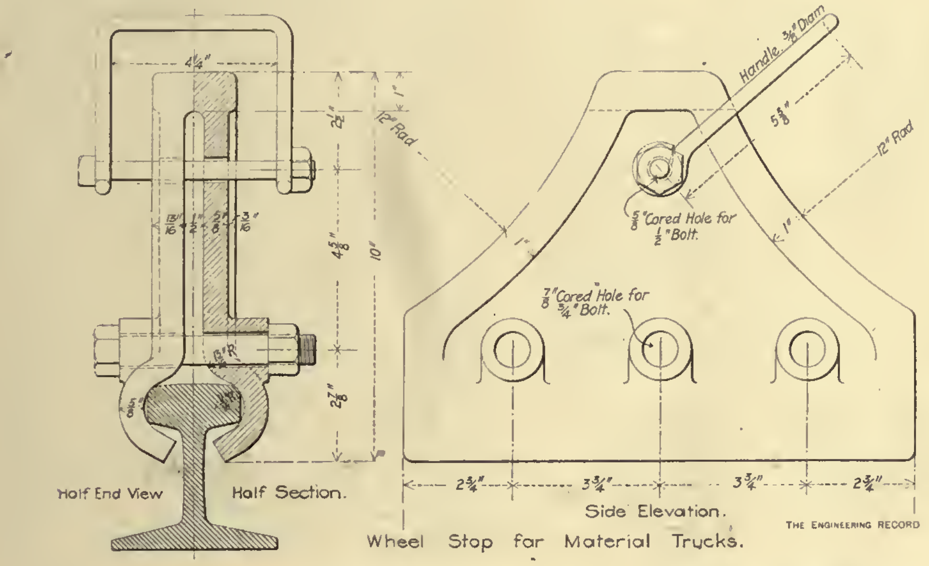
Anchorage of Rear Derrick to Traveler.

The Williamsburg Bridge across the East River: Some Details of the Main Traveler.

Each of the steel derricks on the travelers had twenty-seven 18-inch sheaves including those attached to the traveler to lead the lines to the hoisting engines. The main hoisting tackle had a total length of 1,725 feet and the topping-lift 1,620 feet. The lines were led from the foot of the mast to a double-sheave snatch block attached to the sill or lower chord of the traveler at the foot of the rear bent, and were thence carried through the suspended span near the lower chord to the hoisting engine at roadway level in the tower adjacent to the engine which operated the tower derrick. At intervals of about 50 feet the lines were intended to be supported in hangers made with a hinged horizontal latch and a gas pipe roller, as indicated in the sketch, but it was found unnecessary to use them. Riveted steel boxes about 3 feet long, 2 feet deep and 2 feet wide, similar to those mentioned for the tower derricks, were made of thick plates and angles and bolted to the sills of the steel derricks at the foot of the mast to receive pairs of oblique 18-inch sheaves, around which the fall lines were led to the snatch blocks at the rear ends of the travelers. These snatch blocks had eyes engaging I-bolts through wooden yokes clamped to the traveler sills as close as possible to the anchors which secured the latter to the track stringers. These clamps had wooden cushions carefully fitted to the sills so as to give solid bearing and avoid any distortion, as shown by the detail sketch. Equal precautions were taken wherever snatch blocks or lines under heavy strain were attached to the steel work and various special drawings for these connections were detailed in the office for the use of the erectors.

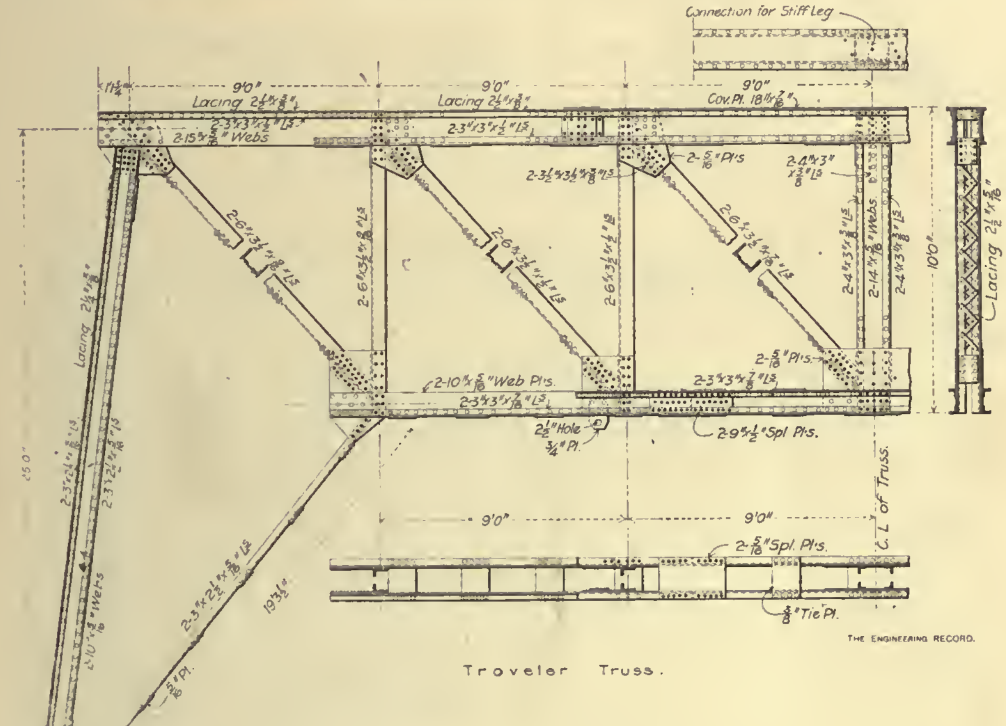
Each traveler was mounted on eight double-flanged cast-steel wheels with 2¾-inch tread 12 inches in diameter. These wheels were bushed with phosphor bronze ¼-inch thick, and had a driving fit on 3 3/16-inch axles which took bearing in the vertical side plates of cast-steel blocks bolted to the insides of the web plates of the traveler sills. The horizontal lower edges of the side plates of the wheel boxes were planed to engage the surfaces of pairs of folding wedges which were driven under them to raise the traveler bearings off from the wheels when hoisting was being done. Each traveler was anchored to the track stringers by eight sets of hook clamps, which engaged their top flanges and were adjusted by the ordinary vertical screw rod operated by a lever nut with bearing on a cast-iron pedestal washer seated across the top flanges of the traveler sill.

As the traveler was required in the first movement to advance to the last floorbeam erected, it was necessary to provide a reliable stop at that point to prevent danger of the forward



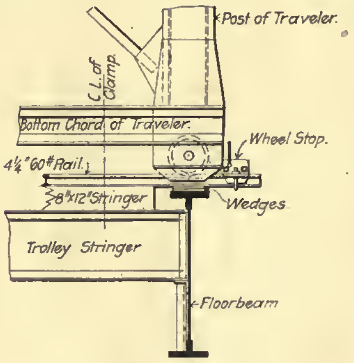
Wheel Stop for Material Trucks.

THE ENGINEERING RECORD



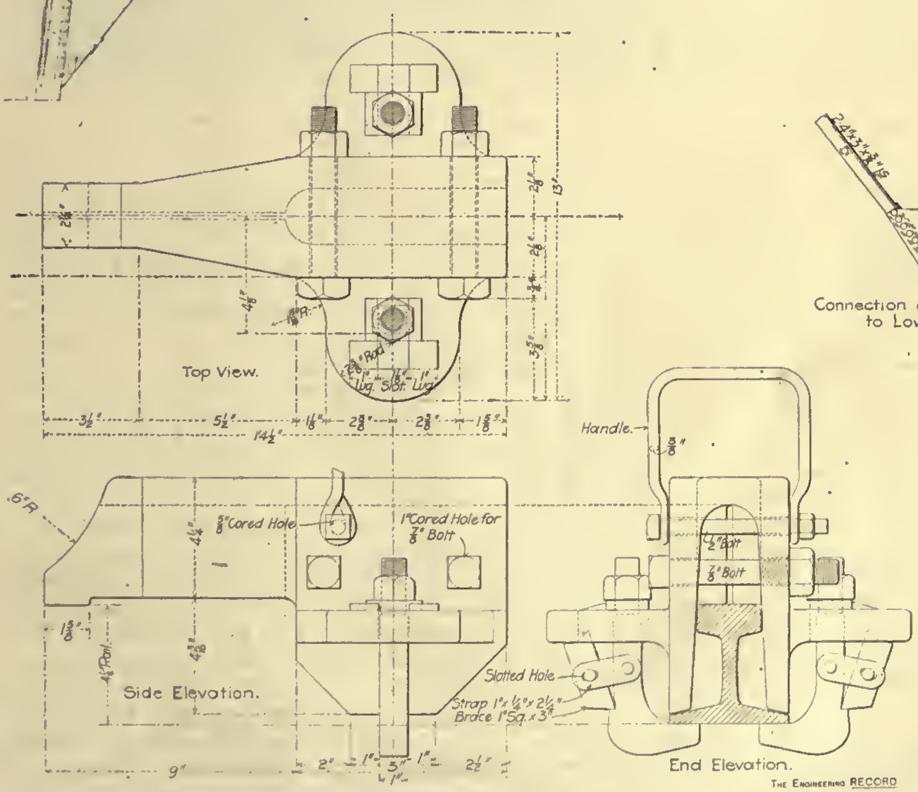
Traveler Truss.

THE ENGINEERING RECORD.



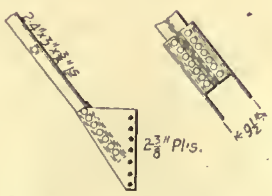
Position of Traveler Stop

THE ENGINEERING RECORD.

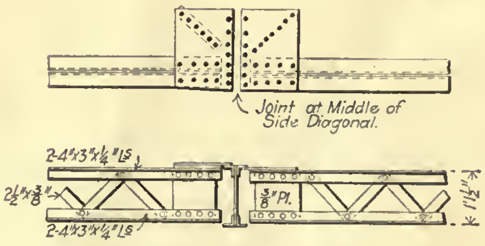


Rail Stop for Traveler Wheels

THE ENGINEERING RECORD

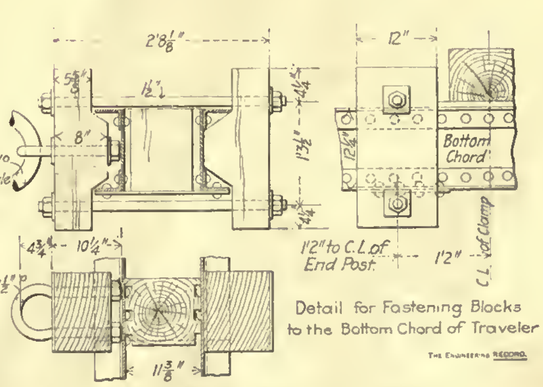


Connection of Foot of Diagonal to Lower Chord.



Details of Traveler Bracing

THE ENGINEERING RECORD.



Detail for Fastening Blocks to the Bottom Chord of Traveler

THE ENGINEERING RECORD.

SOME DETAILS OF THE MAIN TRAVELER USED FOR ERECTING THE RIVER SPAN OF THE WILLIAMSBURG BRIDGE.

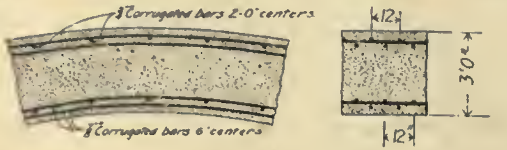
wheels running off from the end of the track. This consisted of a set of four castings bolted together, as shown in the detail drawing, and having vertical screw hooks to engage the under side of the flange. These hooks were seated in heavy brackets to which their heels were braced. The stops were provided with handles pivoted through the center of gravity, and simpler stops, composed of pairs of cast-iron plates were provided for material tracks.

(To be continued.)

THE WESTON AQUEDUCT of the Metropolitan Water Works, Boston, was formally put into commission by the Board and its engineers on Tuesday, December 29. This aqueduct, which was described and illustrated in this journal May 4, 1901, and October 18 and 25, 1902, has a nominal capacity of 300,000,000 gallons per day, and is designed to deliver from the impounding reservoir to the Metropolitan district a large additional supply, supplementing the now outgrown Sudbury and Cochituate aqueducts. Furthermore, this additional quantity will be delivered at a sufficient elevation to dispense with a part, and perhaps ultimately all, of the low-service pumping now done at one of the Chestnut Hill pumping stations. For the present about 35,000,000 gallons will be sent through the Weston aqueduct and delivered into the distribution system through a 60 and 48-inch pipe line. Contract construction work was begun in the spring of 1901 and the aqueduct with its appurtenances is now substantially completed, having been built in all details practically in exact accordance with the designs. It is said that the total payments to the contractors will exceed by only some ten to twenty thousand dollars the sum of the contractors' bids as computed on the basis of the engineers' estimated quantities. This is a noteworthy result in such large works. Mr. Frederic P. Stearns is chief engineer of the Metropolitan Water and Sewerage Board, and these works have been designed and executed under his supervision. Mr. Horace Ropes, engineer of the Weston Aqueduct Department, has had immediate charge of the work, and the pipe line from the terminal chamber was laid under direction of Mr. Dexter Brackett, engineer, Distribution Department.

Big Rock Creek Concrete-Steel Arch on the Chicago, Burlington & Quincy Railway.

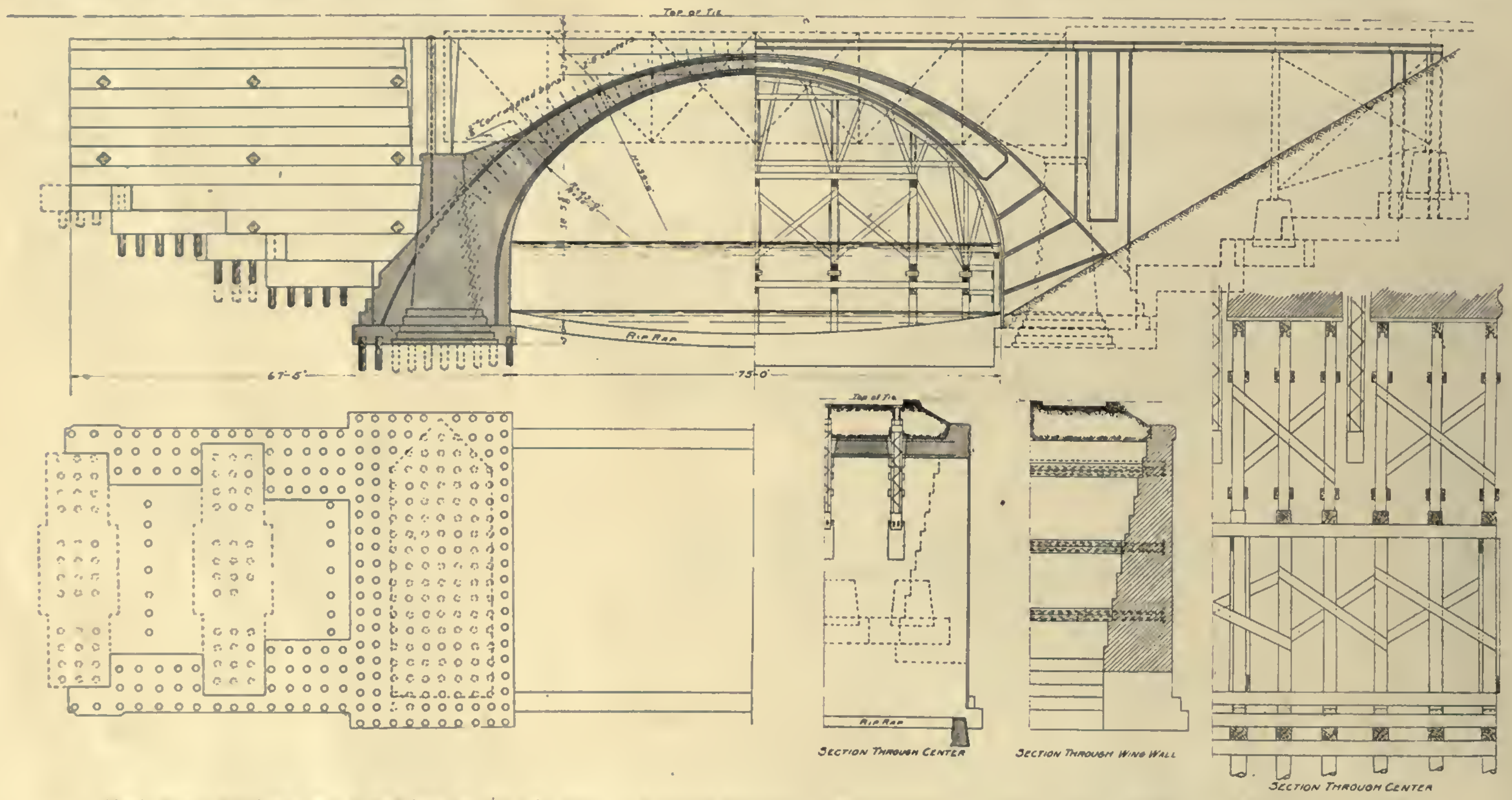
The Chicago, Burlington & Quincy Railway is replacing a steel bridge on its main line near Plano, Ill., with a concrete-steel arch which will be the longest structure of its kind on the line. The bridge which is being displaced is a 95-foot double-track steel deck truss span on masonry piers, with two approaches each consisting of two 32-foot and one 24-foot deck girder spans on trestle bents resting on small caissons. The old stone piers founded on grillages of piles are retained and incorporated in the abutments of the new arch. The trestle bents and caissons will not be removed, although the girders will be used elsewhere. The foundations have been extended, new piles being driven as shown in the accompanying drawing. The drawing also shows the use of riprap beneath the arch but this possibly will be dispensed with as the bed of the stream is solid gravel. The concrete abutments are built around the old masonry piers, every other course of which has been notched, although not across the entire face of the pier in every case. To prevent any tendency of the concrete to separate from the piers, ⅞-inch corrugated steel bars 4 feet long have been set in cement in holes drilled 2 feet into the masonry on 4-foot centers. The bars have been set approximately in the direction of the lines of stress in the arch. Four expansion joints have been provided between the wing and the spandril walls, as shown. These are about ½ inch in width and filled with asbestos, and head caps are provided at the tops and sides for the protection of the joints. The wing walls extend back from the abutments parallel to the tracks in the manner shown, this being the most economical arrangement. Steel rods are embedded at their ends in the concrete of these walls to tie them together as an aid in resisting the tendency to move outward.



SECTIONS OF ARCH AT CROWN

The new structure is a 75-foot three-center arch 3 feet thick at the crown and 44 feet wide. The stresses were computed by Prof. C. E. Greene's method for a circular segmental arch with fixed ends. A segment of a circle with a radius of 50 feet very closely approximates a neutral axis and was used as the elastic line, with a limiting angle of 45 degrees. The portion of the arch ring below a section cut by a radial line making an angle of 45 degrees with the vertical, was considered abutment. The neutral axis was divided into segments of 10 degrees and the loads due to the filling and the weights of segments of the arch ring were computed and considered concentrated at those points. The dead load was computed considering the weight of concrete as 140 pounds and of the filling as 125 pounds per cubic foot. The live load was assumed at 1,000 pounds per linear foot per foot of arch ring. Stresses were computed for two conditions of loading, one a full live and dead load and the other a live load from abutment to crown. The pressure line for a partial load was found to be inside the middle third at the critical section, thus giving no tension at any point in the arch due to live and dead load. The pressure line for the latter was continued to the foundation course by an approximate method and the latter was designed so that the resultant pressure fell inside the middle third.

As the concrete in the structure is of such volume as to take care of temperature and other stresses, the corrugated steel bars introduce an additional factor of safety. They are disposed in lines around the barrel of the arch and transverse to the same. The latter are ¾-inch bars laid 6 inches from the intrados and 4 inches from the extrados on 2-foot centers. Parallel with the barrel of the arch at distances of 4 and 6 inches from both the intrados and the extrados, on 6-inch centers but staggered, are ⅞-inch bars. The spandrel walls are tied to the arch by ⅞-inch bars set into the latter radially on 2-foot centers. The corrugated steel bars were made by the St. Louis Expanded Metal Fireproofing Company and were furnished by Mr. T. L. Condron, Chicago agent.



Half Plan, Sections and Elevation of the Big Rock Creek Concrete-Steel Arch Bridge on the Chicago, Burlington & Quincy Railway.

The concrete in the foundations, wing walls and spandrel walls was mixed in the proportions of 1 part Portland cement, 3 parts sand and 6 parts crushed stone, although in part of the wing walls the mixture was 1 cement, 3 sand, 2 gravel and 4 crushed stone. For the arch concrete of 1 part cement, 2 parts sand and 4 parts crushed stone was used. The cement was of the Marquette and Owl brands and the mixing was done by machine, Drake and Olsen mixers being used.

The arch is being erected with the present structure in place, the traffic being interrupted in nowise. The bottom laterals of the trusses were removed and for such members as intersect the arch, openings have been left. These are of radial wedge-shaped form and, when filled with concrete, will not detract from the strength of the arch. After the latter is completed, the top chords of the trusses will be supported on falsework resting on steps on the arch ring at points directly over posts in the centering. The truss members intersecting the arch will then be taken out as well as the remaining parts of the trusses. The falsework under the arch will be kept in position until the concrete is thoroughly set. The filling at the crown of the arch will be 6 feet in depth, on which the usual rock ballast of the line will be laid. The plant of the contractor, Mr. Gilbert H. Scribner, Jr., of Chicago, presents no unusual features other than the use of center dump, drop-bottom steel cars of 1½ cubic yards capacity. These permit of a most economical handling of concrete.

Building Concrete-Steel Arch under Existing Steel Span, at Big Rock Creek

Mr. W. L. Breckinridge is the chief engineer of the Chicago, Burlington & Quincy Railway, and Mr. C. H. Cartlidge, the bridge engineer, in charge of the design and erection of the arch.

Chinese Railway Construction is now being carried on somewhat more actively than hitherto, according to "Engineering." The line from Pekin southward to Canton, which will be about 1,300 miles long, was opened in September for 242 miles from Pekin and work is progressing on further extensions. Other connecting lines are under construction and it is hoped that unbroken communication will be established from Pekin to Hankow, a distance of about 750 miles, by the close of 1905.

Structural Details of the Kuhn-Loeb Building, New York.

The 73x91-foot Kuhn-Loeb building at the corner of Pine and William streets, New York, is a twenty-story steel cage structure which rises to a height of about 275 feet above the curb. The basement, cellar and first story occupy the whole of the nearly rectangular lot, but part of two of the walls is offset in the upper stories so as to provide for a 32½x18-foot air shaft at one corner, as indicated by the general floor plan.

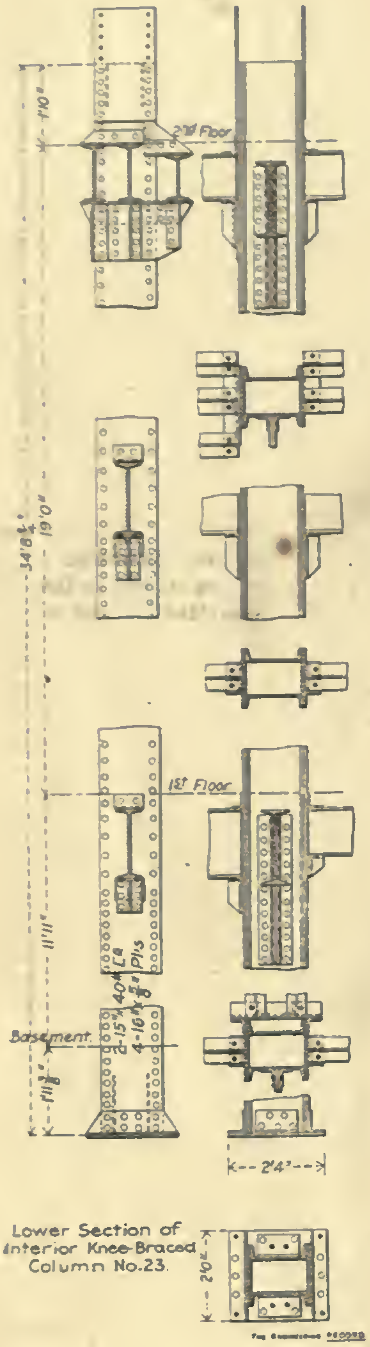
The main columns are seated on I-beam grillages which cover about half the total area of the lot and are proportioned to diminish the foundation loads to about 3 tons per square foot on the fine sand above ground-water level. The lot was enclosed by sheet piling and was excavated to a depth of about 20 feet below the curb. On the level surface of the bottom, planks were braced edgeways to divide the limits of the separate footings; and in the moulds thus formed, concrete was rammed to a uniform depth of 15 inches, extending continuously under certain groups of columns and the adjacent wall footings and forming separate foundations for interior columns. On these footings a second course of concrete, 12 inches or 15 inches thick, with its edges set back from those of the lower course, was laid for some of the interior columns and most of those in the street walls. The upper surfaces of these footings were made with pairs of transverse concrete ribs 5 inches wide which projected 1 inch above the general surface of the footing and resembled chipping pieces left on castings to concentrate the bearings. These ribs were arranged, as shown in the sketch, to support the grillage beams near the ends and leave their lower flanges generally clear of the footing. The beams were set in place, bolted together and carefully leveled on these ribs. A clay dam was then built around the edge of the footing enclosing the grillage, Portland cement grout was poured inside it to fill the space between the top of the concrete and the lower flanges of the grillage beams and afford a solid continuous bearing for the latter. The grillage beams were painted two coats of graphite paint, and the interstices between them were filled with concrete and grouted and the concrete was extended 4 inches beyond them on the ends and sides.

Ten of the columns have extended bases seated on cast-iron pedestals, wide enough to reach across the distributing beams which form transverse tiers across the centers of the single column footings and are made stiff enough to distribute the column loads equally on the centers of all of the grillage beams. The columns adjacent to the lot lines were required to be supported wholly inside the building, so that it was impossible to provide for them concentric symmetrical center footings which would have projected into the adjacent buildings. They are therefore carried at the extremities of distributing girders perpendicular to the wall and supported on the centers of transverse grillage beams covering the continuous footings of two or more columns.

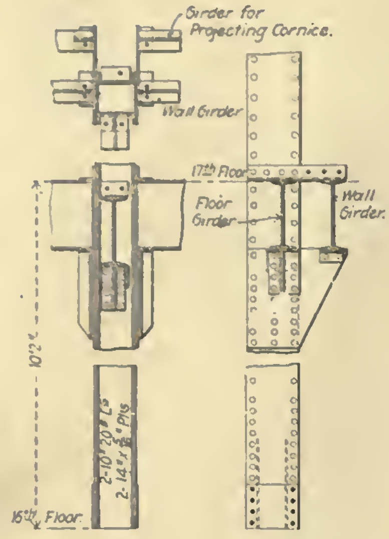
One or two other columns are seated on each distributing girder, and the loads and dimensions are such that the center of gravity of the girder and its combined loads coincides with the center of gravity of the footing, while the plane of the girder web is in the longitudinal axis of the footing. In some cases the girders are only as long as the footings and carry two columns, one at each end. In other cases the girders carry one column at each end and a third one near the center, but do not require footings of as large area as would be provided by extending them full width to the ends of the girders. It was therefore considered more satisfactory to make the footings of the full width and terminate them inside the inner ends of the girders, thus leaving the latter to act as cantilevers with overhangs of from 4¼ to 5⅓ feet on centers, and having their lower flanges uniformly supported by the remainder of their lengths.

The two-column girders, about 22½ feet long, were each made with three 60x¾-inch webs and have two 6x4x¾-inch and two 6x6x9/16-inch angles and three 24x½-inch cover plates in each flange. The webs are stiffened by vertical angles and fillers from about 3½ to 4½ feet apart, except under the columns where double pairs of them are placed close together to resist the concentrated shear. The inside web has stiffening angles on both sides, the outside webs have them on the outside only. The three-column girders are about 5 feet deep, 32 inches wide and 38½ feet long. They have three webs 9/16 inch thick in the middle and reinforced to 13/16 inch at the ends, where the flange angles are riveted between the double thickness of the web, and the reinforcing plate is fillered out from the main web so as to leave a space between. The outside webs are reinforced on the outside only; the center web reinforcement plates are riveted together with single vertical lines of rivets through narrow filler plates about 2 feet apart, as indicated by dotted lines in the elevation. Each flange consists of two 8x8x⅞-inch and two 6x6x⅝-inch angles and three 32x 13/16-inch cover plates. The chord angles are continuous for the full length of the girder, and the webs are spliced by single vertical rows of rivets through narrow cover plates over the center of support on the grillage beams where the shear is minimum. These splices are arranged to come just beyond the stiffening angles and to be independent of them.

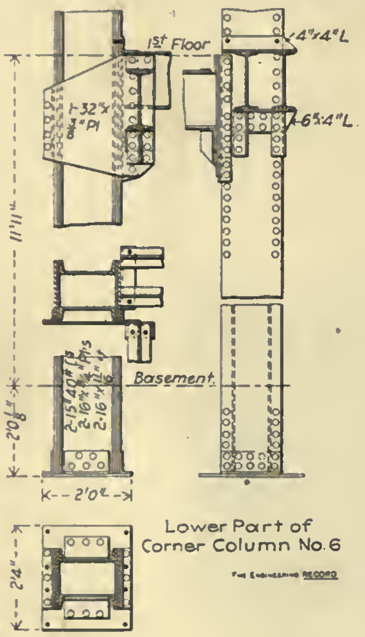
The columns are seated on bearing plates countersunk-riveted to the top flanges, and the girders are reinforced at each of these points with eight pairs of angles riveted together back to back and riveted to the girder webs and milled for bearing against the insides of the horizontal flanges, thus virtually extending the column sections through the girder to the grillage beams. In both the two-column and three-column girders the bottom flange cover-plates are all full length and none of their rivets are



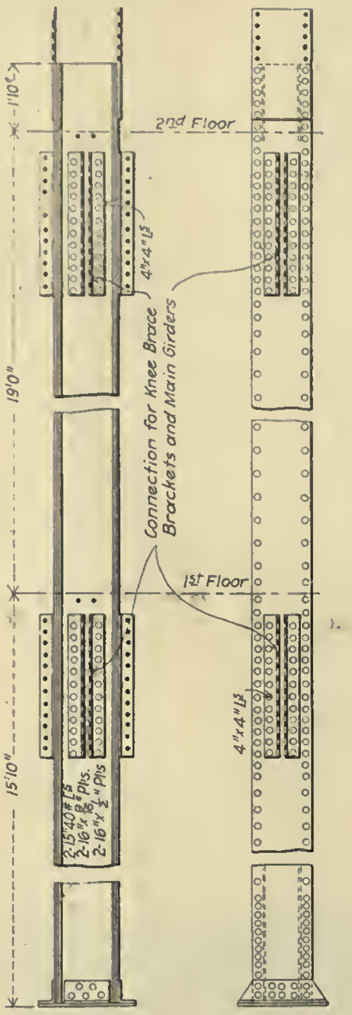
Lower Section of Interior Knee-Braced Column No. 23.



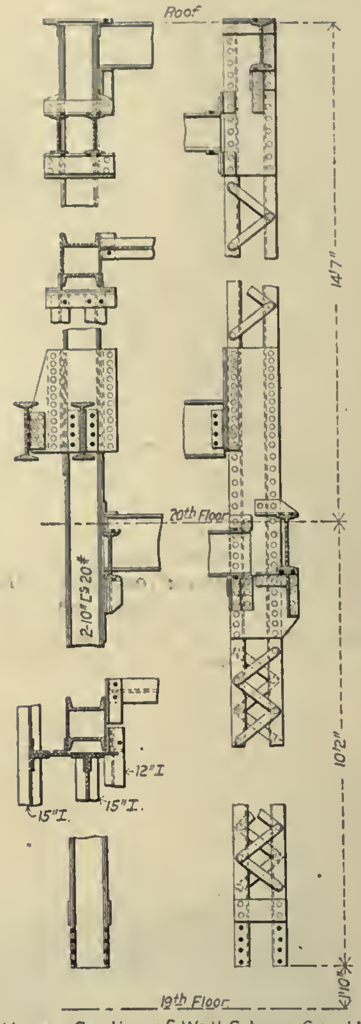
Part of Wall Columns 7 and 13



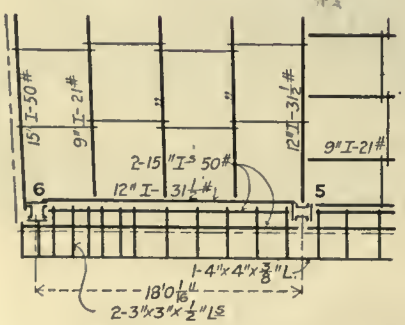
Lower Part of Corner Column No. 6



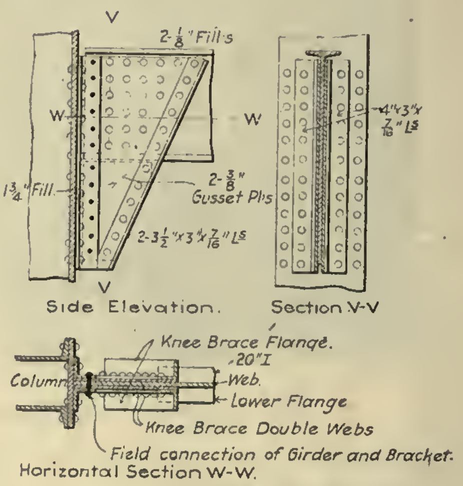
Bottom Section of Column No. 8.



Upper Section of Wall Column 6 and 19.



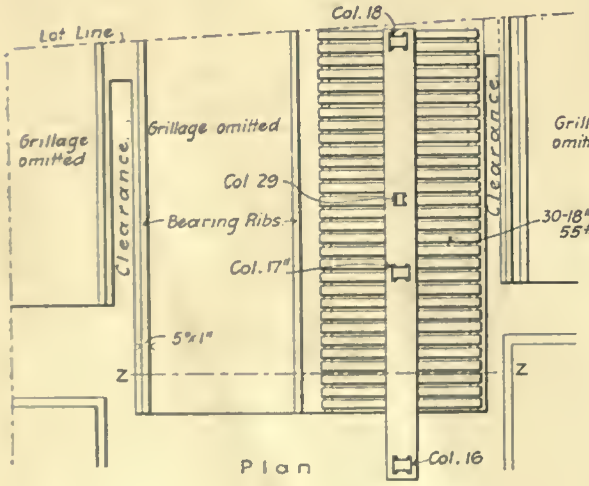
Arrangement of 20th Floor Cornice Beams.



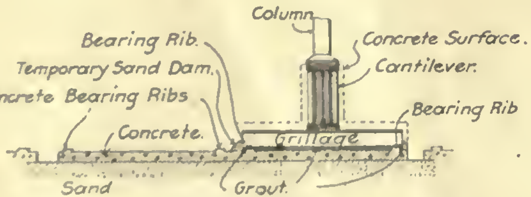
Side Elevation. Section V-V

Horizontal Section W-W.

Wind Brace Bracket.

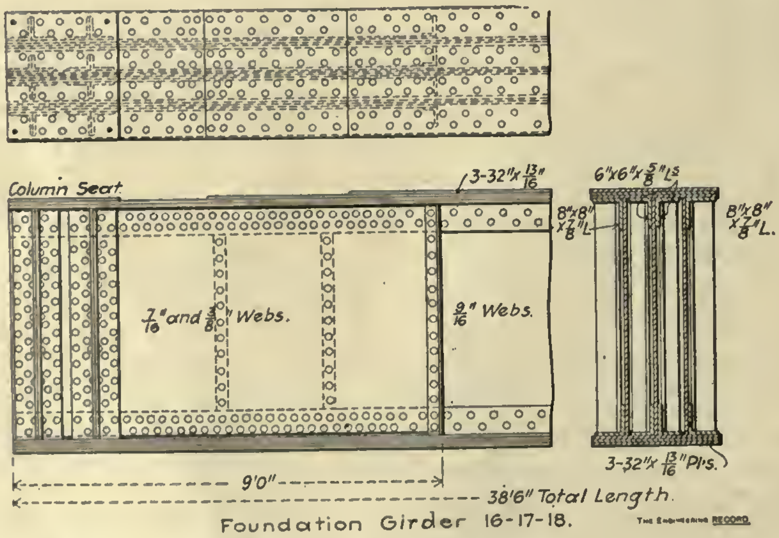


Plan



Section Z-Z.

Part of Concrete Footing with One Set of Grillage Beams and Cantilever Girder

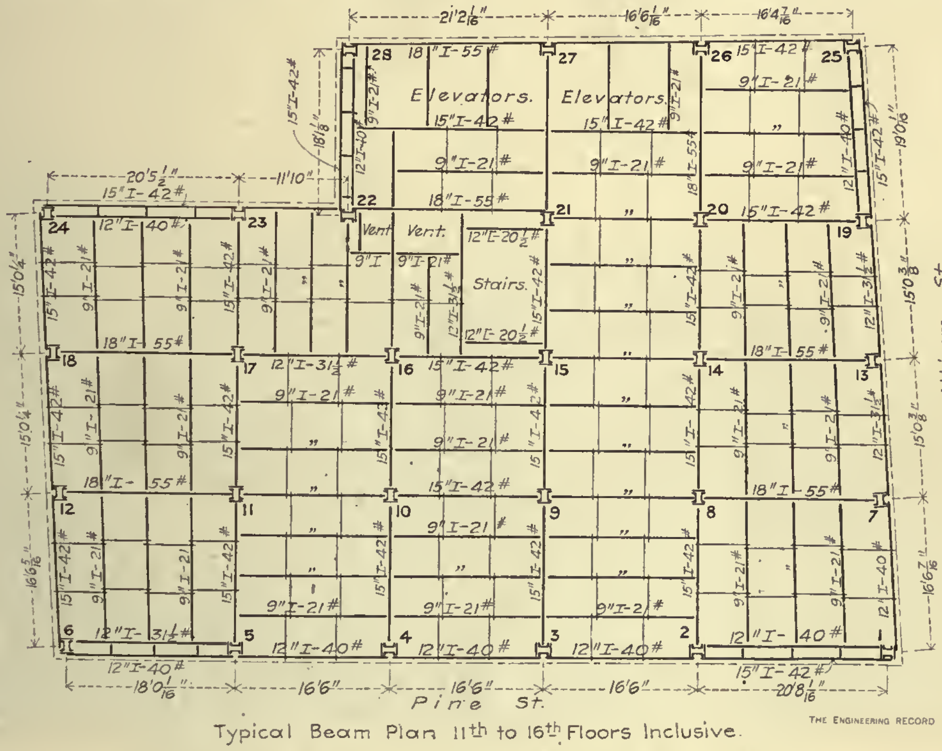


Foundation Girder 16-17-18.

SOME STRUCTURAL STEEL DETAILS OF THE KUHN-LOEB BUILDING, NEW YORK CITY.

countersunk. The bearing on the grillage beams was secured by grouting, the flanges of the girders, being large enough to reduce the load to a safe unit pressure on grout. The distributing girders are painted two coats of graphite paint, filled with grout and concrete and plastered on their outer surfaces with cement mortar in which hollow terracotta blocks are set to enclose them where they project above the cellar floor. After the grillages, column pedestals and distributing girders were set, back-fill was rammed and leveled to the required height and the concrete cellar floor was laid on it, covering all the space between the footings.

The walls, floors and roof are carried by twenty-eight main columns about 275 feet in total height, uniformly built with pairs of 15, 12 and 10-inch channels and 18, 16 and 14-inch cover plates, making closed rectangular cross-sections. They are spaced from about 15 to 20 feet apart on centers and carry I-beam girders, beams and joists, arranged as shown in the typical plan, which gives the framing for the 11th, 12th, 13th, 14th, 15th, and 16th floors. The other floors correspond in general, except that at the 17th story the walls recede inwards and the wall girders are nearly on the center lines of the columns instead of being carried beyond their outer faces, as in the lower stories. At the 17th floor, 4x4-inch transverse horizontal angles 22 inches apart are cantilevered out from the wall girders to carry a projecting terracotta course. At the 20th floor, a similar construction is provided to carry the terracotta cornice, which projects about 3 feet beyond the face of the wall. The first floor is essentially different from the typical floors in the sizes of the I-beams, and their connections to the wall columns and from the fact that it is extended beyond the limits of the upper stories to cover the sidewalk vaults and the back corner of the lot occupied by the air shaft. These variations do not, however, materially change the character of the construction or the details of the connections.



A Floorbeam Plan for the Kuhn-Loeb Building, New York City.

The floors throughout the building are built with hollow terracotta flat arches of from 4 to 5 feet span leveled up above the beam flanges with cinder concrete. The first story is calculated for a total dead and live load of 225 pounds per square foot, the other floors for 150 pounds. The columns are calculated according to the regulations of the building law to provide for the full roof load of 50 pounds live and 75 pounds dead per square foot, and have the estimated floor loads diminished by successive increments of 5 per cent. of live load each, going down until the 10th floor from the top, which, with those below it, was assumed to transmit only 50 per cent. of the live loads plus total dead load to the columns. It is assumed that the lower faces of the building will be protected from the wind up to the 4th floor, above which a wind pressure of 20 pounds per square foot is assumed. The wind stresses are provided for by making very deep and rigid connections between the floor girders and the columns in the four transverse rows below the 17th floor. Similar connections are also made for the intermediate columns in the two narrow ends of the building. In the corner columns these braces are omitted.

The kneebrace connection is virtually a double-web gusset plate, with inclined flange angles, which is shop-riveted to the end of the I-beam girder. The lower flange of the I-beam is coped to clear the plates and the vertical edge of the plates is field-riveted between a pair of vertical connection angles shop-riveted to the web or cover plate of the column on its center line. In the lower stories some of the interior columns have this connection on three sides and have no other connection, excepting horizontal shelf angles to receive a floor-beam on the fourth side, as shown in the elevations for the lower two stories of column 8. The upper and lower sections of all columns are two stories in height, the intermediate sections are three stories in height, all splices being made with pairs of cover plates shop-riveted to the upper end of the lower section of the column just above the finished floor line.

Where the cross-sections of adjacent column sections differ materially, horizontal diaphragm plates are inserted between the milled ends of the columns so as to distribute the bearing uniformly from the less to the greater section. Where there is no material difference in cross-section, these bearing plates are omitted. All floor-beams and girders are at right angles to the faces of the columns, and in most cases they are located on the center lines of the interior columns and loaded symmetrically. In some cases, as in the first floor, the girders are made with double I-beams which require special connections offset from the center line, and in the wall columns there are various irregularities caused by the use of double I-beams to carry the floor, wall and projecting courses and to provide for the special beams at the corners. In the 16th, 17th and 18th stories of the wall columns 7 and 13 regular beams are connected to the columns by horizontal transverse shelf angles engaging the top and bottom flanges of the beams and riveted to both webs and cover plates of the columns with vertical reinforcement angles under the beam seats where required. This constitutes the standard method of connections and is modified as necessary to provide for special positions of the I-beams, as at the 17th story where wall girders are carried beyond the outer face of the column to support the projecting course. These beams are seated on brackets riveted to projecting tie-plates, which form short cantilevers on both sides of the column. In other cases where it is necessary to carry beams beyond the face of the column and they would interfere with beams in the opposite direction, which are carried on the bracket shelves riveted to the flange plates, a tieplate is provided parallel with the channel web and projects beyond the column flange, as shown in the drawings of column 8. This detail distributes the weight of the beam over both sides of the column and avoids the intersection of the floor girders. These details and those shown for other columns illustrate the principal variations in the methods by which the connections are made, and with their combinations provide for all the different cases encountered in this building. All connections of beams and girders to columns are riveted; all other beam connections are bolted. Beam connections are made to conform to the standards of the American Bridge Company. Field rivets were driven by hand and were twenty per cent. in excess of the number which would have been required if shop driven.

Mr. James B. Baker was the architect of the building, and Thompson-Starrett Company was the general contractor. The structural steel weighs about 2,000 tons, including 400 tons of grillage beams and foundation girders. It was fabricated at the Pencoyd shops of the American Bridge Company, and was erected by the Thompson-Starrett Company. Mr. S. C. Weiskopf was the consulting engineer and Mr. Geo. Simpson, assistant engineer in charge of detail designs.

THE ASPHALT DEPOSITS OF TRINIDAD were recently examined by Prof. Henry Louis, of Newcastle, England, who is reported as declaring that the celebrated pitch lake is not inexhaustible, as sometimes stated, but that its surface has sunk correspondingly to the quantity taken from it.

THE INDIANA ENGINEERING SOCIETY will hold its annual convention in the Commercial Club's rooms, at Indianapolis, Ind., January 14 to 16. An excellent program has been provided including enjoyable social features. Papers will be presented on the following subjects: The Sewer System of Connersville; The Pollution of White River; Sewage Purification at Jackson, Milwaukee and Easthaven; Railway Construction; The Central Power and Heating Plant of Purdue University; Brick Tests; Timber Tests; Strawboard Refuse Purification; Economy in Road and Street Construction; Surveys for Electric Railroads; Curves and Pavements for Interurban Tracks; Bridge Abutments and Piers; Specifications for Bridge Masonry; More Light on the Theory of Concrete; Interurban Railways in Small Cities. Mr. Charles C. Brown, of Indianapolis, is the secretary.

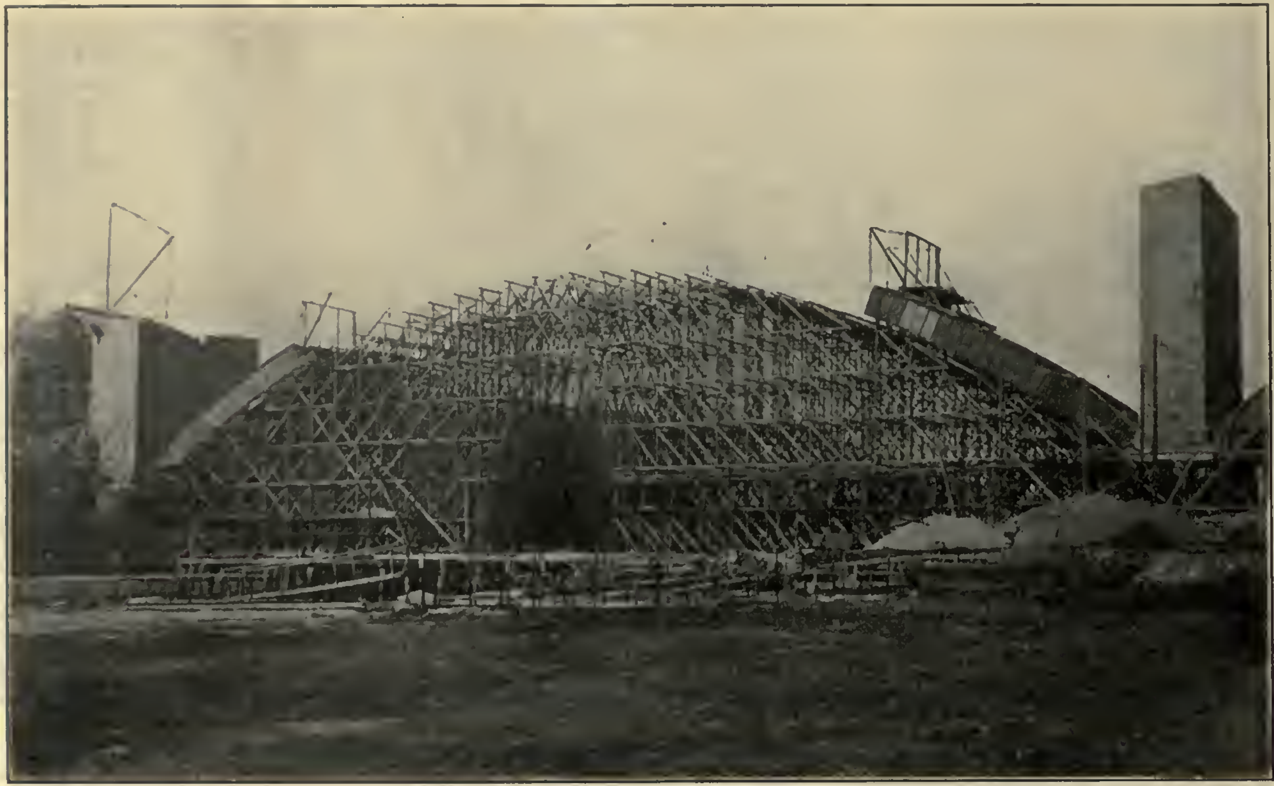
Types and Details of Bridge Construction.—XVI.

By Frank W. Skinner, C. E.

Plate Girder Arches (Continued).

The Washington Bridge carries 181st Street, New York, across the Harlem River on two two-hinge plate girder arch spans about 133½ feet high in the clear, above mean high water. The bridge is notable for its handsome and massive design, the symmetry of outline, and especially for the dimensions of the arch spans, which are the largest of their kind yet constructed. It is also interesting as one of the first long-span steel plate girder arches, and for the excellent character of the details and workmanship, which are typical of advanced practice and modern methods. The design is an admirable combination of masonry and steel which gives mass, beauty and dignity to a monumental structure and still preserves structural efficiency in a measure seldom found in large American bridges. Nineteen competitive designs were submitted by eminent American bridge engineers and contractors, and two prizes were awarded to them, although none of them met all the requirements or were adopted. They included two designs with 800-foot suspension spans; four designs with cantilevers of spans up to 560 feet; three designs with steel arches; three designs with steel arch trusses of spans up to 545 feet, and three designs with stone and concrete arches with spans up to 280 feet. A design having three 198-foot full-centered masonry arch spans over the river and a series of smaller shore spans on slender piers was considered the most meritorious, but was not accepted because it failed to meet the requirement that the main span should be of metal.

Another plan was subsequently submitted for a bridge with two 508-foot plate girder arch spans, heavy masonry piers and solid masonry wall approaches. This was modified to have 510-foot spans and masonry arch approaches and the contract was awarded for $2,055,000 for a structure having a total length of 2,373 feet, which carries a 50-foot carriage way and two 15-foot sidewalks at a grade of 1.33. The three main piers are founded on solid rock, the center one being sunk in the river channel by the pneumatic caisson process to a depth of about 41 feet below mean high water. The end piers and the abutments have arched interior chambers enclosed with face walls 8 feet thick at the base. Each approach has three full-centered 60-foot arches and there is one 56-foot flat elliptical arch over the roadway. The ends of the piers, cornices and parapets are granite; the side faces of the piers, spandrel and abutment walls are of light gray gneiss, and the face masonry is backed with concrete.



Washington Bridge across the Harlem River, New York City: Falsework for Erection of Channel Span.

The bridge is proportioned for a dead load of 225 pounds per square foot and a distributed live load of 100 pounds per square foot or a 20-ton road roller. The steel arches are proportioned for an assumed dead load of 15,000 pounds per linear foot of arch and 18,000 pounds per linear foot of floor system and paving, for a live load of 8,000 and a wind load of 1,200 pounds per linear foot. Allowance was made in all parts of the structure for a variation of 75 degrees Fahrenheit in the temperature. The arch rib flanges were proportioned for maximum stresses of 15,000 pounds per square inch of gross section in compression, and for 18,000 pounds per square inch of net section in tension. The arch ribs are made principally of open-hearth steel with an ultimate tensile strength of from 62,000 to 70,000 pounds and an elastic limit of 32,000 pounds per square inch. The computed rise of the crown due to maximum temperature variation is about 2½ inches. The computed maximum deflections are 2.3 inches vertical and 1.3 inches horizontal.

Each main span has six two-hinge plate girder arch ribs of 510 feet clear span, and about 91.8 feet clear rise on centers of skewback pins. The ribs are spaced 14 feet apart on centers and are braced by horizontal transverse struts at the panel points of the top and bottom flanges. There are pin-connected sway-brace rods in the transverse planes through the struts, and single zig-zag lateral angles in each panel of the struts and arch ribs in the planes of the top and bottom flanges. Each rib is divided into 34 equal horizontal panels of 14 feet 11¾ inches. At each panel point there is a floor-beam supported on the caps of six vertical spandrel posts, each of which has an oblique base plate riveted to the top flange of one of the arch ribs. The spandrel posts are braced by longitudinal and transverse horizontal struts and have pin-connected sleeve-nut diagonal sway-brace rods. There are no spandrel posts at the seven panel points at the crown of the arch, and the floor-beams there are seated on short pedestals riveted to the arch ribs.

Each arch rib has a uniform depth of 13 feet and is made in 34 nearly equal segments with lengths varying slightly to give equal horizontal projections. The segments have straight sides, and their center lines are chords and their ends are parts of radii of a parabolic curve.

The web plates are ¾ inch thick in the end segments and ⅜ inch thick elsewhere. The flanges are double with an H-shaped cross-section composed of six 6x6-inch angles and 12-inch and 20-inch cover plates, with varying thicknesses, which have a maximum of 3 1/16 inches for the 20-inch plates. Each segment is divided into three equal subpanels by pairs of 5x3½-inch radial web-stiffener angles, which at the ends serve as splice flanges. The web plates are shop-spliced with two vertical rows of rivets at each intermediate stiffener and the stiffener angles are slightly crimped at the ends and have their web flanges turned in opposite directions on opposite sides of the girder web so that their combined cross-section is Z-shaped. The field splices of the arch segments are made with 20-inch flange plates and with 58 rivets through the end web angles.

In the end sections the flanges are curved so that their center lines intersect on the center of the 18-inch skewback pins. The webs are also reinforced and, with the ends of the flange angles, are planed to a semi-hexagonal bearing for the cast-steel socket which has a pin bearing of about 170 degrees, 34 inches long. Triangular extensions of the web plates with their upper and lower edges stiffened with narrow flange angles are riveted to the curved ends of the girder flanges to carry the parallel lines of the flanges to the pedestals which continue them to the pier masonry so that the effect is that of a square ended rib with a full width base on the masonry. The lower pin-bearing casting has a rectangular seat against the reinforced quadruple webs and inclined stiffener angles of the pedestal.

The inner webs of the pedestals are triangular plates, but the outer webs are rectangular plates extended beyond the inclined flange angles to maintain the full width of the arch rib, and correspond with the web extensions of the end segments to which they are spliced by bolts in slotted holes through jaw plates shop-riveted to the girders. The 4½x13-foot pedestal bases are made of double ¾-inch plates seated on felt packing and anchored to the granite with four 2-inch expansion bolts.

In the shops great care was taken to plane the ends of the segments to the exact angles of the radial joints of the parabolic arch curve, which differed for every segment in the semi-arch. Each segment was put on the planer with its web horizontal and one end was planed to the approximate angle. The segment was reversed and the edge of the finished end was carefully aligned with a fixed point several hundred feet away, outside the shop, at the intersection of the two radii through the ends of the segment, the other radius being drawn through the cutting line of the tool.

The horizontal transverse struts between the arch ribs are composed of two pairs of angles riveted back to back and latticed, one pair of web flanges being turned in and the other pair turned out. One pair is riveted to horizontal connection plates on the outer flange of the girder and the other pair is riveted between a pair of vertical plates riveted to the outstanding flange of a vertical web stiffener angle. These plates form jaws to receive the loop end of the sleeve-nut sway diagonal rod, which is pin-connected to them. The wide base plates of the spandrel posts project beyond the top flanges of the arch ribs and are field-riveted to the lateral diagonal angles. The bottom flange connection plates for the lateral struts also receive the ends of the lower lateral angles. The spandrel posts are made with pairs of 10½-inch channels, latticed, and the longitudinal and transverse struts between them have I-shaped cross-sections made with two pairs of angles riveted together back to back and latticed.

General View of the Washington Steel and Masonry Arch Bridge, New York City.

The plate girder floor-beams have a center section 42 feet long and two cantilever end sections about 20½ feet long. The center sections are 30 inches deep, and the end sections are 48½ inches deep and overhang the spandrel posts about 6 feet. The three sections are spliced together on the center lines of the spandrel posts by field rivets through their end vertical web stiffener angles. The asphalt pavement and flagstone sidewalks have a concrete foundation on buckle plates carried by I-beam stringers seated across the top flanges of the floor-beams. At the piers the floor platform slides longitudinally between guides on a beam grillage anchored to the masonry so as to transmit the lateral stresses to solid reactions. At the outer edges of the sidewalks there is a wide cast-iron cornice on a foundation of 5/16-inch steel plates, bolted to the ends of the floor-beams and to two intermediate brackets in each panel. The massive cast-iron parapet has bronze ornaments and lamp posts.

The arch segments were shipped from the bridge shops with the webs vertical and suspended through slots cut in the floors of flat cars so as to clear the tunnel roofs. The arch spans were erected on trestle falsework with bents having six vertical posts supported in the river by piles and on land by transverse sills. The falsework was seven stories high in the middle and had sway bracing between the first and second, the third and fourth and the fifth and sixth posts. Every panel had a single longitudinal brace except the two panels under the crown. Each semi-arch rib also had two raking braces from the haunches to the ground near the center. The land span had three openings to clear intersecting railroads and streets spanned by plate girders about 45 feet long, which supported the upper bents of regular falsework. The channel span had a center opening of about 80 feet for navigation spanned by two inclined bents on each side and short timber trusses at the top.

Materials were delivered by a balanced cantilever revolving tower derrick to an elevated distributing platform at skewback level alongside the falsework and from there was hoisted and erected by two overhead travelers. Each traveler consisted of a movable platform with two adjustable braced masts and two booms which commanded the full width of the span. The travelers were seated on the arch ribs and erected them from the skewbacks to the crown, then moved backward from crown to piers at roadway level erecting the spandrel posts and floor platform. The arch segments were supported during erection by blocking on the falsework caps, and were swung by jackscrews inserted between the girders and caps alongside the blocking. Most of the field splice rivets were driven by pneumatic yoke riveters suspended by differential hoists from grooved wheels rolling on round steel bars which in turn rolled on the flanges of the horizontal spandrel struts. The two spans weigh about 3,342 tons. Their erection was commenced September 1, 1887, and finished May 11, 1888, by an average force of about 200 men. Work on the foundations was commenced in May, 1886, and the bridge was substantially completed in December, 1888, at a total cost of $2,857,684.55. The erection was described in The Engineering Record of July 21 and 28, August 11 and September 1, 1888. Acknowledgment for data of the design is made to Mr. Theodore Cooper, consulting engineer.

(To be continued.)

The Ambridge Plant of the American Bridge Company.

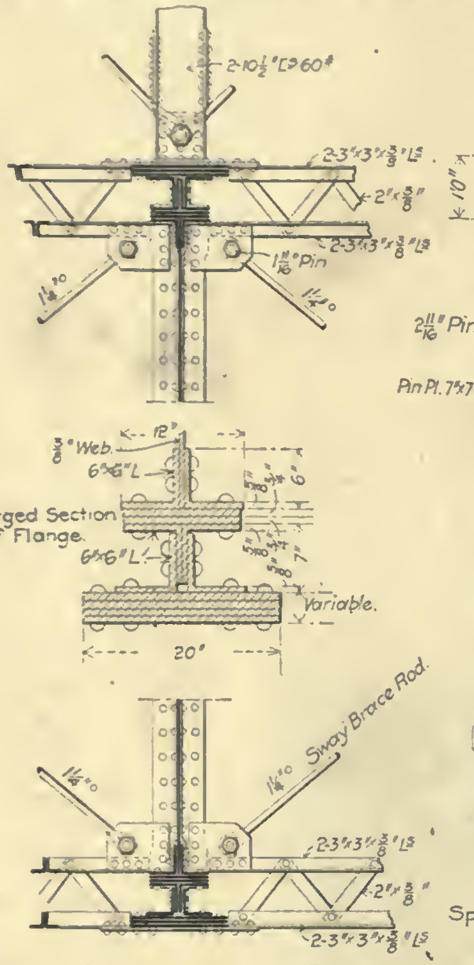
Part VII.—Construction and Equipment of Power House, Boiler House, Template Shop, and Auxiliary Buildings.

Power House.—The 210x84-foot power house is centrally located between the eye-bar shop and the bending and forge shop with its longitudinal axis perpendicular to the main lines of surface tracks which run through the yard from end to end. It has a full length center aisle 60 feet wide in the clear and 40 feet high to the lower chords of the roof trusses which is commanded by a 25-ton traveling crane. On each side of the center aisle there are narrow side aisles with pipe galleries in the upper parts, and there are floor trenches in the axis of the building and in transverse directions where the exhaust pipes are carried clear of the machinery. About half of the floor space is occupied by machinery already installed; and additional machines have been ordered or designed. The principal machines are set in two rows on opposite sides of the center line of the main aisle, the generators and their engines being located in one group and the air compressors in an opposite group, with part of the pumps at one end of the main building and the remainder in a well in an annex at the opposite end. The present installation was described in the issue of November 21 and includes three large generators and their engines, six pumps, two feed-water heaters, two air compressors, and two condensers. Provision has been made for three more generators and engines, two surface condensers and four more air compressors, all of which, it is thought, will be required when the plant is in full operation and consuming the estimated 2,000 horse-power for which the steam plant has been designed.

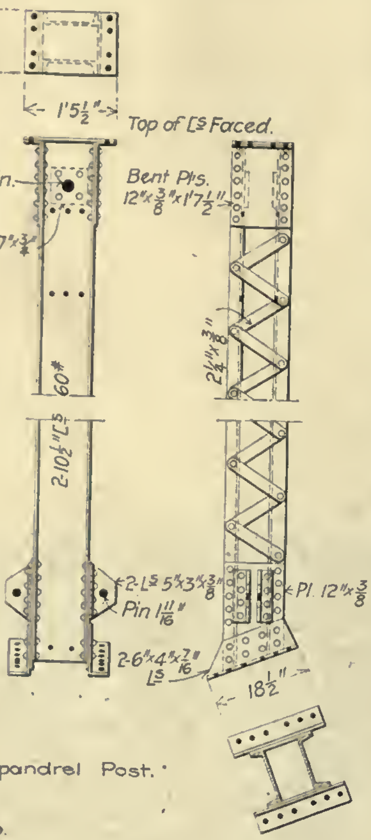
The walls of the building are of the standard Ambridge construction with 8 inches of solid concrete carried up to the sills of the side windows at a height of about 6 feet above grade and around and above their frames up to the eaves line. The 10x20-foot windows have balanced sash in the lower halves and fixed sash in the upper halves which light the pipe galleries. In the end walls there is a lower tier of windows corresponding with the side windows, and an upper tier 10 feet wide and 11 feet high occupying the space between the transverse girder and the roof truss. The window framing is made in the standard way with 8-inch vertical and horizontal channels and I-beams embedded in the concrete. The roof is sheathed with 2-inch planks, and is slated on the steep part and covered with slag on the flatter central portion. It differs from the working shops in having no skylights or monitors, but has seven 5-foot tubular ventilators.

The steel work is proportioned for a roof load of 50 pounds per square foot, a 25-ton traveling crane with 11-foot wheel base and 45,000 pounds maximum load on each wheel of the loaded end, a weight of 100 pounds per square foot of surface of wall concrete and for loads of 8,000 pounds at the centers of the pipe gallery beams. Unit stresses are taken at 16,000 pounds per square inch in tension, and in compression at 16,000 pounds per square inch reduced by the formula: $P = 16{,}000 \div [1 + (12{,}500 l^2 \div r^2)]$. To the stresses from crane loads 25 per cent. is added to allow for impact.

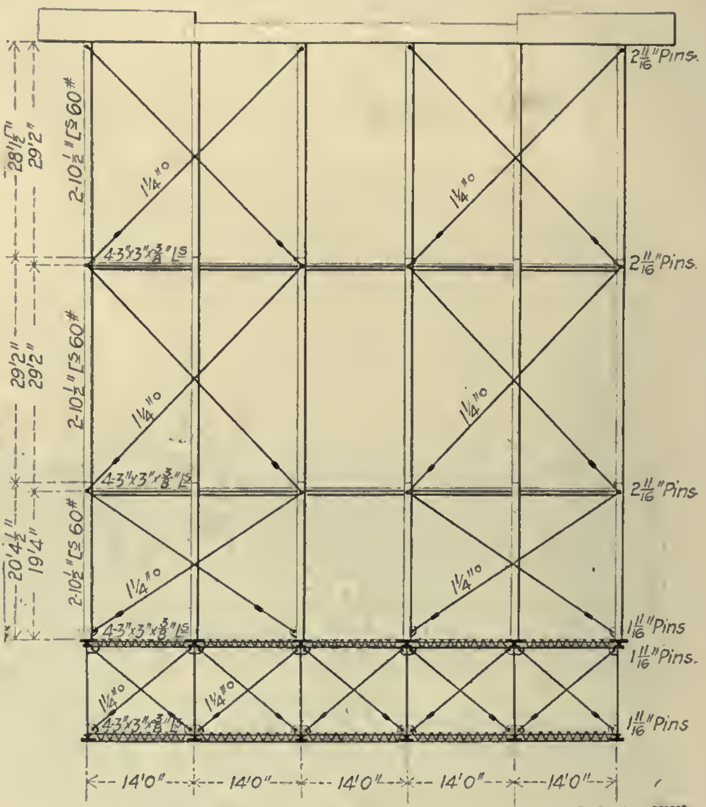
There are four longitudinal rows of columns, those in the wall being spaced only 14 feet apart, while those in the interior rows, corresponding to every third wall column and 11 feet 1 inch from them, are 42 feet apart. The tops of the interior columns are connected by longitudinal riveted trusses 8 feet deep, which carry the transverse roof trusses in the planes of the wall columns. The latter have their tops similarly connected by light lattice-girders, each of which carries at the center a rafter for the mansard roof. The longitudinal trusses also have at alternate panel points vertical suspenders carrying the ends of transverse floor-beams in the pipe gallery. This allows the space below to be unobstructed for the location and operation of large machines. The main roof trusses span the center aisle only, but the side rafters are in the same plane and give them an appearance of continuity to the wall columns. They are braced together in the planes of the top chords by eight lines of purlins and by X-braces of single 3x2½-inch angles in the end panels and in every third intermediate panel. The bottom chords are braced at alternate panel points by T-shaped longi-



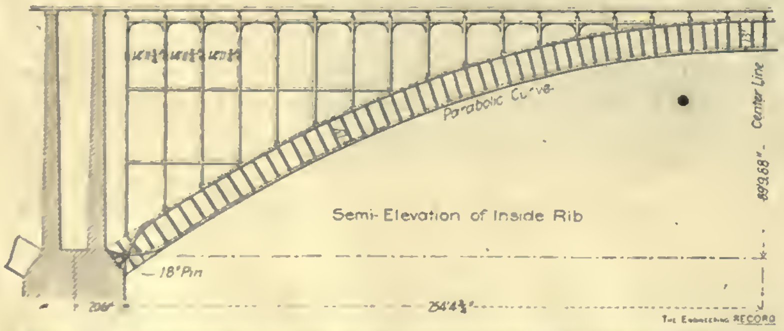
Connection of Braces and Spandrel Post to Arch Rib.



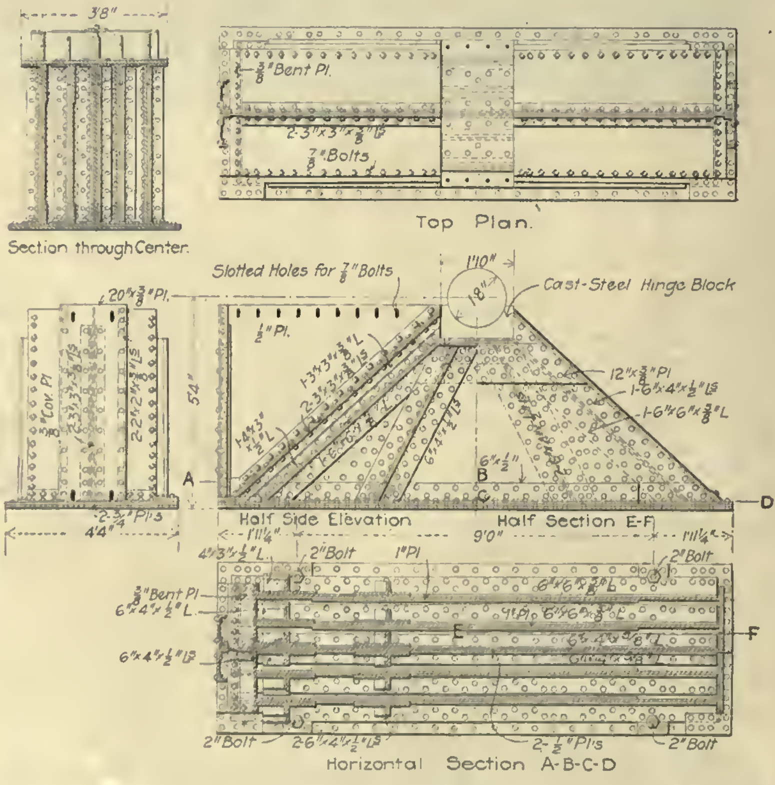
Spandrel Post.



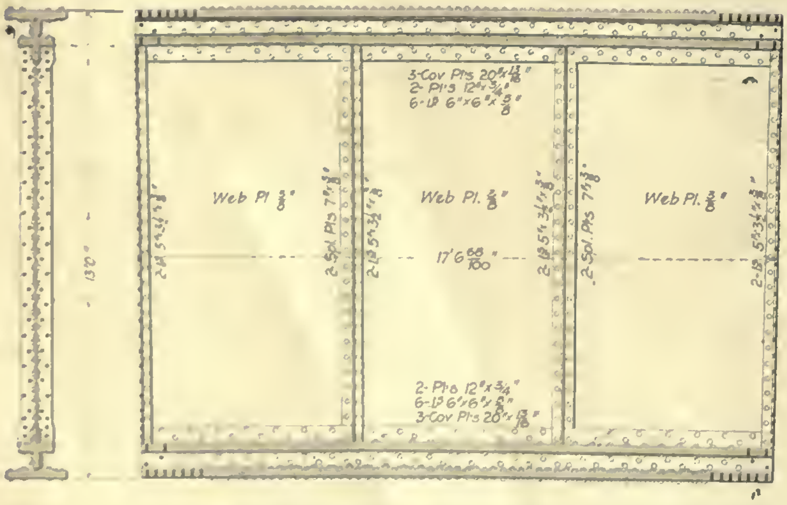
Cross-Section near Skewbacks.



Semi-Elevation of Inside Rib



Skewback Pedestal



Intermediate Section of Arch Rib.

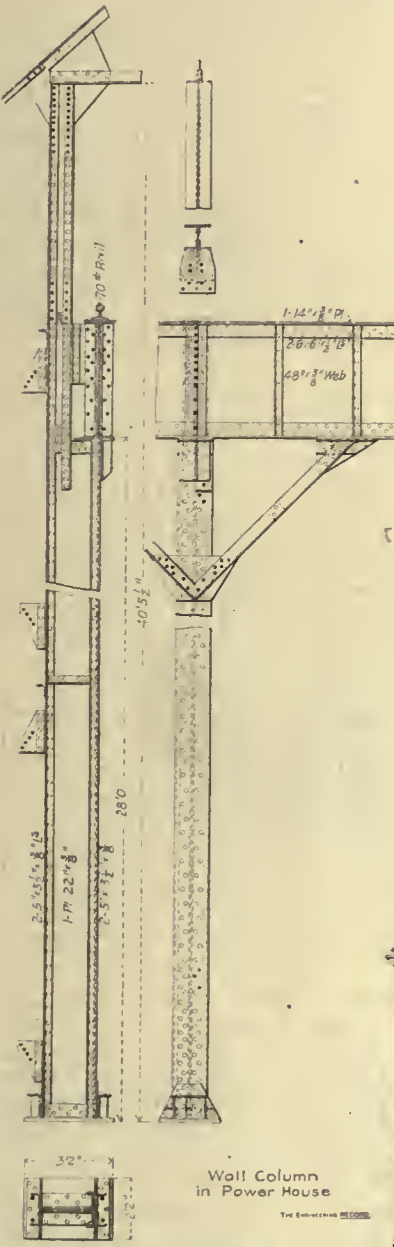
SOME DETAILS OF THE STEEL ARCHES OF THE WASHINGTON BRIDGE ACROSS THE HARLEM RIVER, NEW YORK.

tudinal struts made with a pair of 4x3-inch angles.

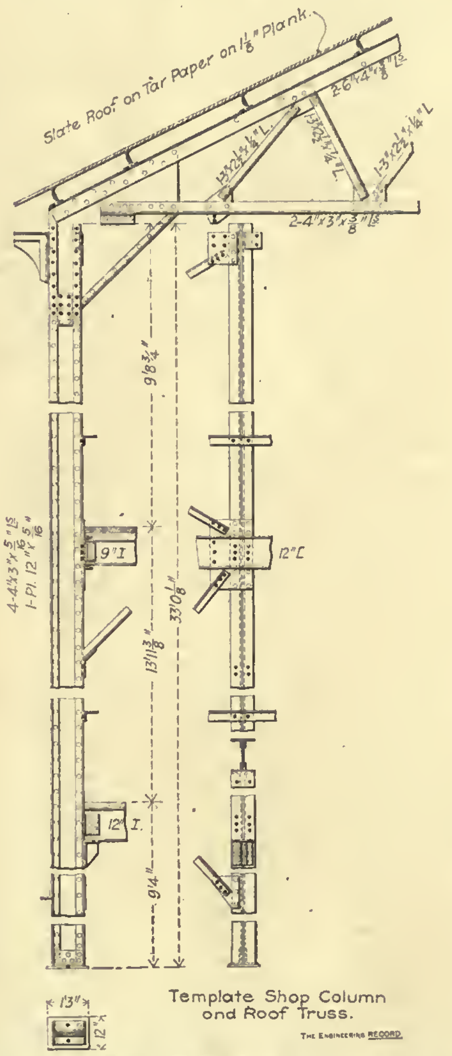
The trusses are of very simple construction, as indicated in the outline of the cross-section, and have T-shaped members all made with pairs of angles riveted together back to back and connected at panel points with gusset-plates between the angles. At the ends of the main trusses these plates are extended beyond the lower side of the truss and are field-riveted between the flange angles of the main columns, which have a section of the web omitted to receive them. The upper ends of the side aisle rafters are riveted to the same connection plates, and the lower ends engage the webs of the wall columns. The main trusses were erected in two sections each and field-riveted together with one splice in the top chord and two in the bottom chords.

The longitudinal girders have pairs of 5x3½-inch chord angles with web-connection plates riveted between them to receive on opposite sides the diagonal members, which have their flanges turned in opposite directions so as to clear at intersections where they are riveted together. These girders are connected to the column webs by field-rivets through the flanges of end vertical angles. They are just above the tops of the traveling crane runways, but are not connected to them as might be inferred from the longitudinal elevation. The runway girders have 4-foot webs and 6x6-inch flange angles with 14-inch cover plates, and are spliced together by field-rivets through their vertical end-stiffener angles. They are seated on offsets of the main columns with their webs in the planes of the inside flanges of the columns, and are braced to the upper parts of the columns by transverse diaphragms.

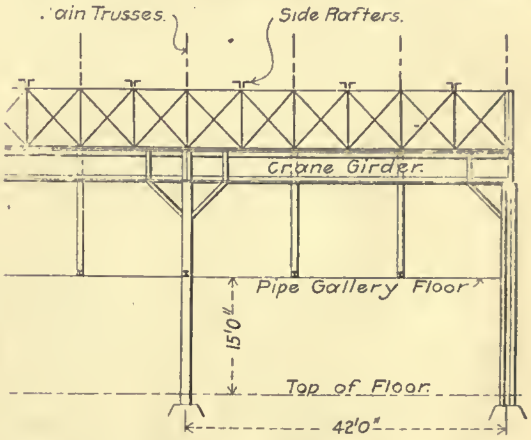
The pipe galleries are 11 feet wide and extend from end to end of the building. They have plank floors supported on pairs of 8-inch transverse channels with web-connections to the wall columns and to the suspenders from the longitudinal girders. Each



Wall Column in Power House.

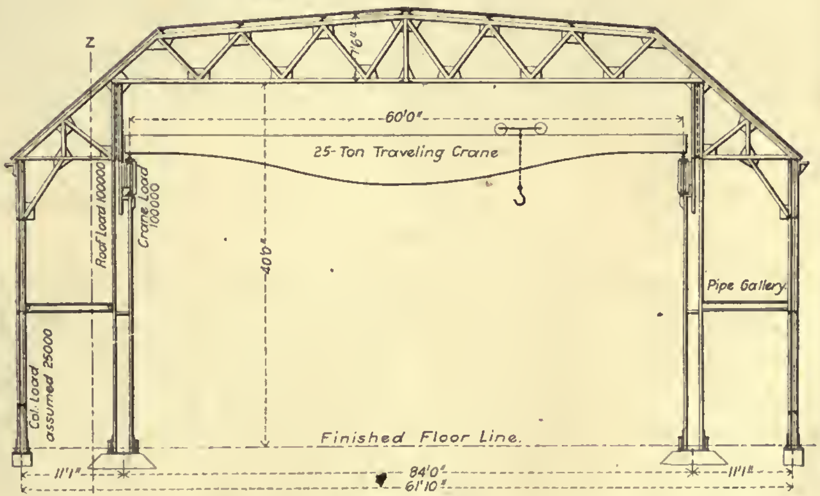


Template Shop Column and Roof Truss.

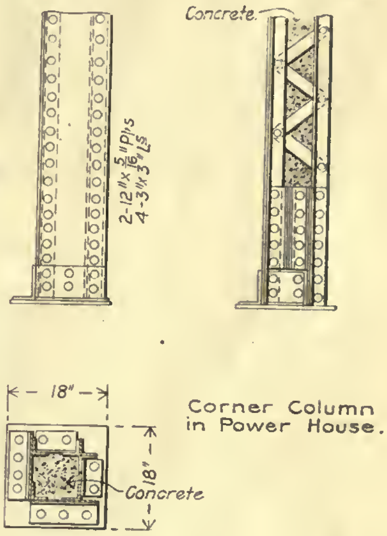


Elevation Z-Z

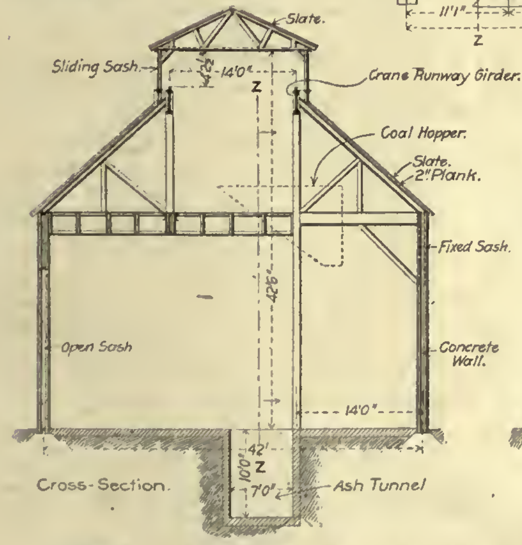
Part of Side of Power House.



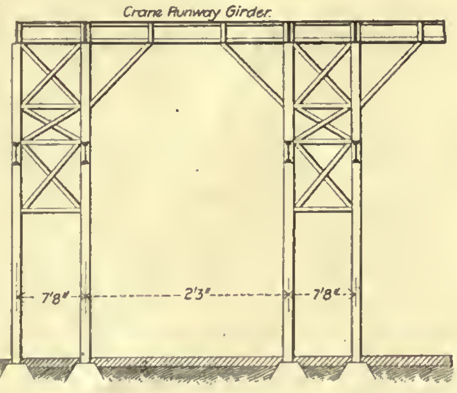
Cross-Section through Power House.



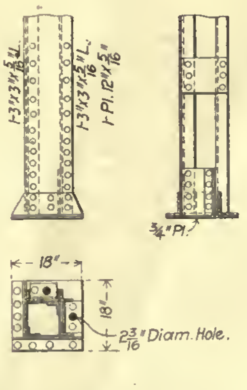
Corner Column in Power House.



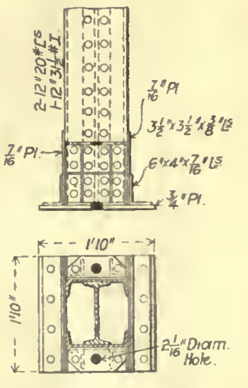
Cross-Section.



Elevation Z-Z



Corner Column.



Main Column.

SOME STEEL DETAILS OF BOILER HOUSE AND POWER HOUSE, AMBRIDGE PLANT OF THE AMERICAN BRIDGE COMPANY.

panel is X-braced by single 3x2½-inch angles. The main columns have I-shaped cross-sections with the inner flanges reinforced by a channel in the plane of the web of the runway girders. The upper portion of the column has a diminished cross-section and is solidly riveted, as already described, to the roof trusses. The columns are stiffened longitudinally by pairs of kneebrace angles to the lower flanges of the runway girders. Their 26x38-inch bases are stiffened by transverse diaphragms and have vertical stiffener angles supporting the bearings for the upper ends of the anchor rods. The corner columns have rectangular cross-sections closed on the two outer sides and latticed on the inner sides. They are made with four 3x3-inch angles and two 12-inch plates, and are filled solid with concrete. The total weight of steel in this building is about 650,000 pounds.

Boiler House.—The 42x145½-foot boiler house is parallel and adjacent to the power house with a clear space of 30 feet between them. It is a one-story structure with sharply pitched roof having a monitor which extends the full length and is illuminated by clere-story windows. One side and one end of the building are closed with the Ambridge standard concrete wall construction having a double tier of 6x8-foot windows about 5 feet above grade. The other side has a corresponding wall and two tiers of windows in the 23-foot end panel. The remainder of this side of the building and the other end is temporarily closed with corrugated iron for a height of 16 feet above grade in the panels between columns, and from that level to the eaves the space is filled with a continuous row of fixed-sash windows 5 feet high. The building contains four 250-horse-power boilers; place is reserved for four more, and one end of the building is designed for a future extension, if necessary, to increase the capacity from 2,000 to 3,000 horse-power. The framework does not carry any part of the weight of the boilers, being designed to support the roof and walls and to carry the steam pipes and the coal-conveying and storage plants above the boilers.

There are three rows of main longitudinal columns spaced alternately 23 feet and 7 feet 8 inches apart so as to correspond with the boiler settings, except at the permanent end of the building where the last two panels are each 23 feet long. The columns in the interior row are extended to the foot of the monitor clerestory to carry one line of runway girders for the traveling crane. The other line of runway girders is carried on a fourth longitudinal row of columns which corresponds to the upper part of the interior row and is supported over, and clear of, the boilers on transverse plate-girders at the eaves level, as shown in the cross-section diagram. The columns are braced together in pairs to correspond with the boiler settings, and are kneebraced to the transverse girders. They are of rectangular cross-section varied to correspond with the different requirements. The main interior columns are each built with one 12-inch I-beam and two 12-inch channels about 33 feet long. The channels are riveted to the I-beam flanges and have their flanges turned inwards. The beam and girder-connections are made on the horizontal bracket angles and web-connection angles. The corner columns are made with four vertical angles and two cover-plates so as to have solid faces on the outer sides and open faces on the inner sides, which have batten-plates but not lattice angles.

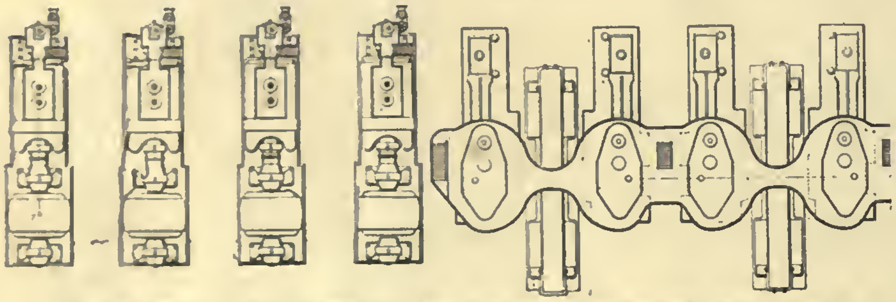
The 2-inch tongued and grooved longitudinal roof planks are slated, and are supported, without purlins, in the monitor roof by small riveted trusses and in the side roofs by 8-inch I-beam rafters 7 feet 8 inches apart. These are carried at the upper ends on the runway girders, and at the lower ends on the top flanges of light lattice girders connecting the tops of the wall columns. Both rafters and monitor trusses have angle-iron X-bracing in alternate panels. On the two closed sides of the house the columns are longitudinally braced by the concrete and the wall framing; on the other sides they are braced by diagonal angles in the wide panels.

A 10-ton 14-foot traveling crane of Pencoyd standard make is operated by two Westinghouse motors, one of 5 and one of 25 horse-power, and traverses the full length of the building to handle the boilers and steam pipes, and to deliver coal in buckets to the 60-ton steel storage hoppers over each battery of boilers. The details of the steel framing are simple and of standard type. The column and rafter connections are made with field-riveted web-plates, and the gutters are made with a channel and two small angles riveted together and seated on solid-web knee-brackets shop-riveted to the faces of the wall columns just below the eaves. The structural steel in the boiler house weighs about 350,000 pounds.

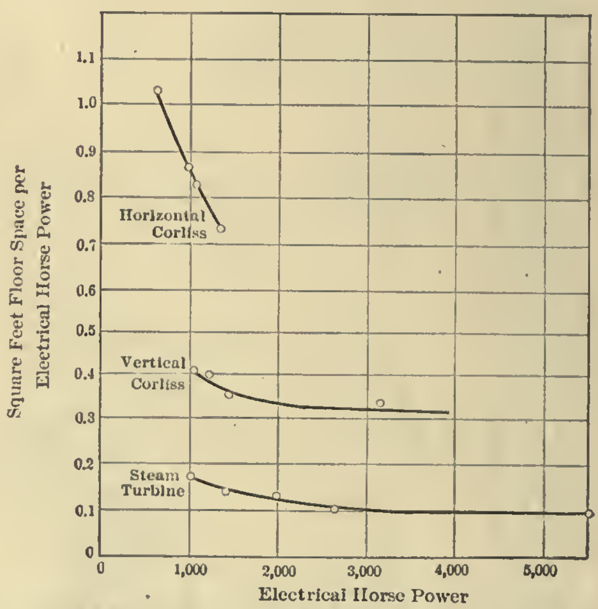
Template Shop.—The 60x512-foot template shop, between the main and auxiliary bridge shops, is a two-story building about 30 feet high above grade. It has a double-pitched roof with ten 48-inch tubular ventilators. Except about 70 feet at one end, where the steam heating apparatus is installed, the lower story is entirely devoted to the toilet and locker rooms for 2,000 of the bridge-shop workmen. The second story is intended wholly for template making, and has, suspended from the roof, two galleries where the light machines and some of the work benches are located. The construction is simple and consists of steel roof trusses and wall columns, slate roof on wooden sheathing and steel purlins, reinforced concrete walls and wooden floor boards on wooden beams and girders, supported by three longitudinal rows of one-story cast-iron columns 8 feet apart. The intermediate wall columns have I-shaped cross-sections with their webs transverse to the axis of the building. The corner wall columns have rectangular cross-sections like those in the boiler room and are made with four angles, two cover-plates and two latticed sides, and are filled solid with concrete. The upper ends of the column webs are removed to allow the flanges to engage the projecting gusset-plates at the ends of the roof trusses, which are field-riveted to them and serve as rigid kneebraces.

The roof trusses are 16 feet apart on centers and are braced together in the planes of the top chords by X-brace angles in the second and every fourth successive panel from the ends. They carry fourteen lines of 6-inch channel purlins with nailing strips bolted to their webs to receive the 1⅜-inch transverse sheathing boards covered with tar paper and slate. The four upper lines of purlins are 10-inch channels, which support a full length strip of skylight about 7 feet wide on each side of the ridge.

A gallery 18½ feet wide extends from one end of the building to within 96 feet of the opposite end. Its floor is about 14 feet above the second floor and is carried by 9-inch I-beams 8 feet apart supported at the outer ends on wall beams riveted to the inner faces of the columns and at the inner ends on fascia girders suspended by pairs of vertical angles from the second panel points in the lower chords of the roof trusses. From the end of this platform the gallery is continued to the end of the building by a similar construction 4 feet wide which serves chiefly as a passageway to the transverse bridge connecting the two sides on the gable wall. A similar bridge connects the opposite ends of the main galleries. The gallery floor is stiffened by two end and three intermediate sets of horizontal X-bracing.



Comparison of Turbo-Generators and Reciprocating Engines with Generators.



Comparative Floor Space Required for Three Types of Prime Movers.

The entrances to the template floor are by outer stairways on the sides of the building. The end of the building opposite the steam heating apparatus is peculiar from the fact that it is provided with two doors 8 feet wide and 23 feet high made in several leaves to facilitate the handling of very wide templates for girder spans. These doors are 12 feet apart on centers, and over the center of each there is a trolley track extending 20 feet into the building and equipped with two trolleys and chain hoists for carrying the large templates and bundles of template timber. The windows, of which there are double tiers in side and end walls, have sliding sash and are glazed in the lower portions with clear glass and in the upper portions with ribbed glass intended to diffuse the light in the interior.

The building is heated by a hot-blast system with ducts carried through the roof trusses and discharging through vertical branches and dampers about 50 feet apart in the center line of the building, 10 feet above the template floor. The larger machines are driven by independent motors and are located on the main floor. Some boring and planing machines are located in the galleries and are driven in groups by jackshafts operated by small motors. A system of gravity chutes is provided on the walls to deliver the shavings to hoppers in the basement, whence they are collected and removed to be burned in the boiler room. The total weight of structural steel in the template shop is about 700,000 pounds.

Sanitary Conveniences.—There are three pairs of opposite entrances to the first story, spaced equi-distantly in the length of the template shop. Between each pair is a transverse aisle for the toilet fixtures, and between these aisles there are in all six single rows and forty-three double rows of lockers and lavatory sinks alternating on opposite sides of transverse aisles reaching across the building, and intersected by passageways in the center and on both the sides of the building. Each row is divided into two sections and each section contains twenty lockers or ten sinks on each side. The sinks are provided with hot and cold water, the former supplied from a 1,500-gallon tank containing a coil of 1-inch steam pipe.

The untrapped waste pipes discharge at the outer ends of each row of sinks into concrete floor trenches covered with sectional gratings. These trenches pitch to catch-basins with bell traps and cast-iron drain pipes connected with valves to the sewer. The soil pipes from the toilet fixtures are connected under the concrete floor to Y-branches in six 6-inch cast-iron pipes which cross the building and are each connected with gate-valve, deep-seal trap and outside fresh air inlet to double Y-branches which receive the outside pipes from the roof leaders and area drains and discharge into 18-inch sewer lines, which empty into a 36-inch terra-cotta main sewer. The gate-valves are provided on the drain pipes so that on very infrequent occasions, when unusual floods threaten to rise to floor level, they may be closed and prevent back flow through the fixtures. This emergency is likely to occur only at very rare intervals, when, for short periods, it would be necessary to put this drainage system out of service. The toilet room is ventilated by openings in the ceiling to transverse horizontal ducts that connect with vertical branches in the walls and inclined ones under the roof discharging through the ten 48-inch ventilators on the center line of the roof.

A 26x55-foot lavatory 10 feet high to the eaves is located between the boiler house and bending and forge shop, and will be equipped like that in the basement of the template shop to provide for about 150 men. Hot water will be supplied from a 15-foot length of 18-inch pipe having a 2-inch connection to the high-pressure steam main and a perforated 1-inch pipe in the center, through which live steam will be injected.

Pattern Shop, Tempering Shop, Testing Laboratory and Auxiliary Bridge Shop.—The 60x128-foot pattern shop between the machine shop and iron foundry will resemble the template shop and, like it, will contain a basement lavatory with lockers and toilet rooms for 300 men employed in that part of the works.

Adjacent to the pattern shop is the 60x80-foot tempering shop for steel tools. This building has a slate roof and concrete-filled walls supported by steel framework weighing about 70,000 pounds. There is sufficient floor area for tool dressing and tempering, a Babbitting shop, and similar miscellaneous requirements.

A testing laboratory is planned, to be built near the eye-bar plant, which, in addition to the usual appliances for ordinary testing, will contain a large hydraulic machine for testing eye-bars. This machine is designed for a capacity of 4,000,000 pounds, and will be arranged for tests in either tension or compression.

The 180x584-foot auxiliary bridge shop will be constructed and equipped to correspond with the main bridge shop, to which it is adjacent, but it will have no transept. It will be served by transverse traveling cranes and assembling hoists, and will have longitudinal surface tracks. The tools will be duplicates or modifications of those described in the main bridge shop, but will be adapted chiefly for columns, trusses and similar lighter work. They will include principally punches, shears, reaming and drilling machines, pneumatic hammers and air riveters, and the usual equipment for light structural work. The structural steel weight will be about 4,200,000 pounds for this building.

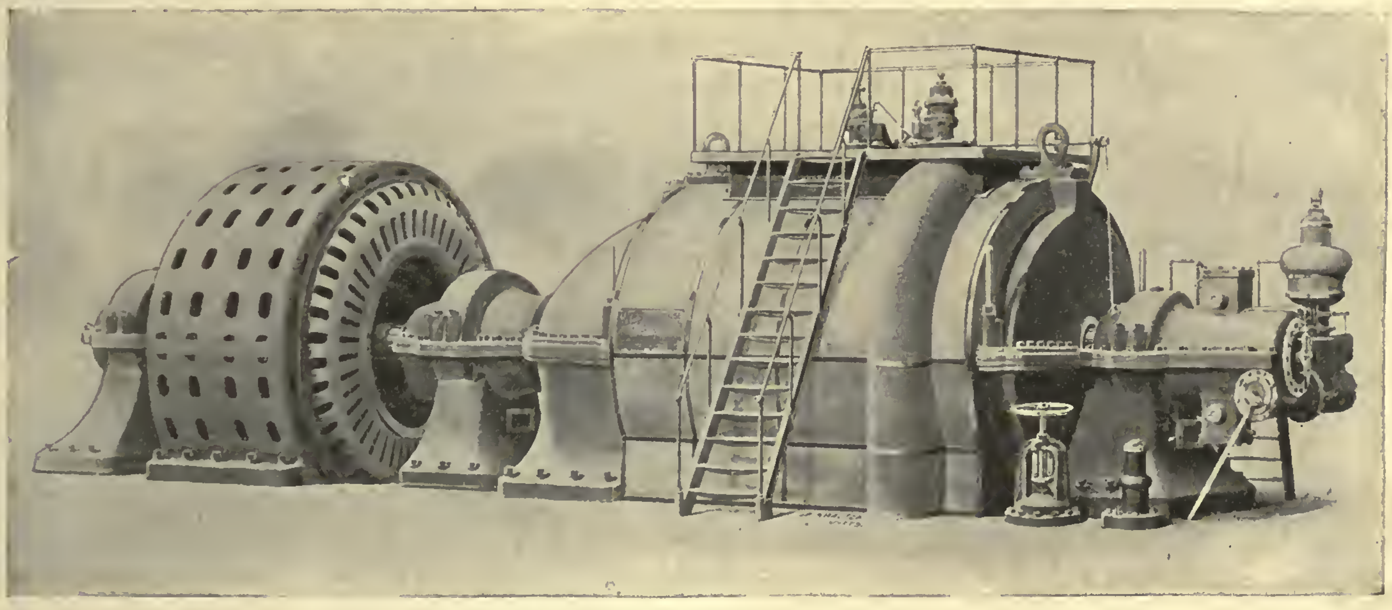
(To be continued.)

THE SIMPLON TUNNEL has been so delayed by the unusual difficulties encountered that the first single-track tunnel will probably not be completed before the spring of 1905. Consequently the agreement between the contractors, Messrs. Brandt, Brandon & Company, and the Jura-Simplon Railway Company has been modified. According to this supplemental contract the date for the completion of single-track tunnel No. 1 and the bottom drift of tunnel No. 2 is set for April 30, 1905, with a bonus of $400 per day for each day saved in the full-sized tunnel and a corresponding penalty for each day of delay beyond that date. Within two years from the date named the contractors must decide whether they will complete the second tunnel.

High Power Westinghouse-Parsons Steam Turbines.

When the Westinghouse-Parsons steam turbine was commercially introduced at the close of the last century, the sizes then built were of 600-horse-power nominal capacity, direct connected to 400-kilowatt polyphase generators. Subsequent development has been so rapid that within a period of four years turbines of 5,500-kilowatts or 7,500-horse-power nominal capacity, have been designed and are under construction. These machines will have a continuous overload capacity of 11,000 horse-power in one self-contained unit, and thus rank among the largest prime movers. Recently, marine work has been contemplated by the builders, as already stated in this journal, and the near future may be productive of turbines of still greater power, although of slightly different arrangement, necessary to adapt the present type to marine usage.

The 5,000-kilowatt turbo-generating unit illustrated herewith is representative of the general type which will be constructed for large powers. The most distinguishing features of the new type are the extreme compactness and low speed secured. These features have been practically prescribed by the necessity of minimizing the cost of power building construction for larger station capacities. The space occupied by the 7,500 horse-power turbine is approximately 27 feet 8 inches by 13 feet 3 inches, and the height to the top of the hand-railing is 12 feet. This is equivalent to 0.049 square foot per electric horse-power capacity, or 20.2 horse-power per square foot of floor area required.



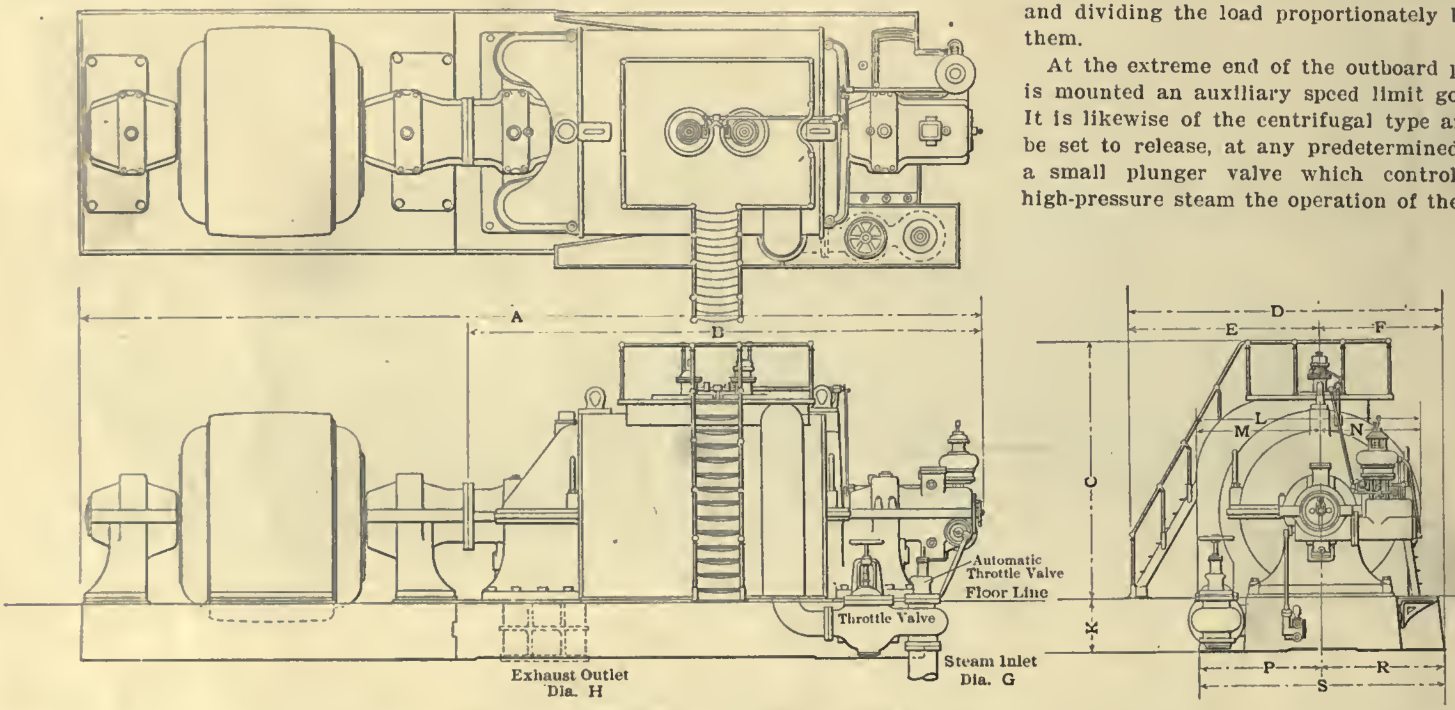
A Five-Thousand-Kilowatt Westinghouse-Parsons Turbo-Generator Set.

For the complete unit a rectangular area of 47 feet 4 inches in length and 13 feet in width is required, which is equivalent to 0.084 square foot per electrical horse-power capacity, or 12 electrical horse-power per square foot of floor space. A graphical comparison of floor space required for different types of prime movers is shown in the accompanying curves. In all cases a complete unit is taken as the basis of comparison.

In point of speed, the new type fulfils the demand for a unit operating at moderate speed. The 5,000-kilowatt unit operates at 750 revolutions per minute, the 2,000-kilowatt unit at 1,200 to 1,560 revolutions, and the 1,000-kilowatt unit at 1,500 to 1,800 revolutions, depending upon the frequency desired. These speeds, although not comparable to engine speeds, do not impose much greater stresses upon the rotating parts, and in addition secure the great advantage of reduction in the bulk, weight and cost.

The accompanying plan and elevation of the 5,000-kilowatt unit shows the general arrangement of the main cylinder body, bearings and auxiliary parts. The unit rests upon a single bedplate cast in two sections which are secured by shrunk links. To the bedplate, which is heavily ribbed to secure rigidity, are bolted the pedestals, generator casing and turbine body, but the bedplate itself is not secured to the foundation by other means than the weight of the unit. Steam and exhaust connections are made beneath the floor level.

In the smaller machines of this type, the cylinder barrel and both journals are cast in a single casting, thus largely minimizing machine work. In the large machine, however, the barrel is cast in two sections united by links, the outboard section carrying the journal and worm casing, and the inboard section, the journal and exhaust opening which extends through the bedplate. As in former types linear expansion and contraction of the turbine are provided for by a sliding foot. The inboard journal pedestal is bolted securely to the bedplate, but the outboard pedestal is free to slide between parallel machined ways. The main body of the casing is heavily lagged with non-conducting material, secured in place by sheet steel casings.



Plan and Elevations of Condensing Steam Turbine.

Leakage of air from the atmosphere into the exhaust spaces of the casing at the entrances of the shaft is prevented by frictionless packing glands. No oil is employed and in consequence the condensation from the turbine is pure distilled water.

In shaft construction great rigidity has been secured with minimum use of metal. A central steel quill carries the entire rotating parts, both blades and balance pistons. Hollow forged steel ends are forced into the two ends of this quill under hydraulic pressure, and are in addition secured by arrow-head links. High pressure steam is conveyed to all parts of this quill structure in such a manner as to eliminate stresses and consequent distortion due to highly superheated steam.

Power is transmitted to the generator shaft through a flexible coupling which is housed partly by the turbine and partly by the generator inboard journal. The coupling is split at the junction of the two shafts, so that by removing one bearing cap and the coupling bolts either section of the unit may be lifted out without disturbing the adjustment of the remaining section. In the smaller sizes the engagement surfaces of the coupling consist of the squared or hexagonal ends of the shafts, but in the larger machines a crow-foot sleeve is keyed to each shaft and the power is transmitted by an outside quill engaging the crows-feet. Thus great flexibility is secured, together with maximum facility in dismantling.

The journals in the larger machines are of the solid, self-aligning type, similar to that employed in generators and cross-compound engines. The departure from the familiar oil-cushioned journal employed in the small machines is occasioned by the speed reduction secured. The journal shells are babbitt lined and are split horizontally, the two halves being united by bolts with shim adjustment. Oil from a central system is introduced at the center under slight pressure, thoroughly flushing all parts. Axial adjustment is provided by metal shims arranged in quarter-box fashion. The diameter of the shaft at the journal of a 5,000-kilowatt machine is 15 inches, strikingly small in comparison to the 34-inch shafts required for a cross-compound reciprocating engine of corresponding capacity.

Longitudinal adjustment to preserve proper side clearance is secured by a thrust bearing located next to the outboard bearing. The bearing is not subjected to longitudinal thrusts from the action of the steam and is consequently of small size. The two half shells are advanced in opposite directions by graduated set screws, so that the actual running clearances are measured in thousands of an inch. Once set, these adjustments are permanent and do not require frequent taking up.

Steam enters the turbine successively through an automatic quick closing throttle, hand throttle, strainer and the main admission valve. A circular port surrounding the entrance to the initial stage conveys this steam to all points so as to avoid stresses incident to more localized admission of highly superheated steam.

An important feature of the steam distribution system is the provision of a by-pass valve. This valve admits high pressure steam to the second stage of the turbine on overloads in order to increase its capacity up to 50 per cent. in excess of full-rated load. By proportioning the by-pass steam to the overload on the turbine, maximum economy may at all times be secured together with reserve overload capacity. This results in a slight rise in the economy curve on heavy overloads, resembling in some respects the engine economy curve on loads exceeding that of maximum economy.

The main admission valve consists of a double-heat poppet valve operated by a small piston, this in turn being controlled by a small pilot valve directly actuated by the governor mechanism. The valve admits steam to the turbine in puffs, the duration of which are proportioned by the governor to the load upon the turbine. This intermittent method obviates the throttling of steam to accommodate loading and secures the highest economy by using at all loads steam at boiler pressure.

At the extreme outer end of the turbine shaft is mounted a worm driving a short horizontal cross-shaft. This shaft drives at one end the oil pump and at the other the governor through bevel gearing. An eccentric provides the reciprocating motion necessary for the valve mechanism.

The governor is of the fly-ball type, with 90-degree bell crank ball levers mounted on knife edges and fitted with roller contacts. The governor sleeve and spring is mounted on ball bearings and adjustment of the spring tension may be made while the turbine is running, thus affording a most simple and convenient means for paralleling alternating current generators and dividing the load proportionately between them.

At the extreme end of the outboard pedestal is mounted an auxiliary speed limit governor. It is likewise of the centrifugal type and may be set to release, at any predetermined speed, a small plunger valve which controls with high-pressure steam the operation of the quick-closing throttle before mentioned. This is normally held open by means of an overbalanced differential piston. At the moment the speed limit operates, the excess pressure is removed and the throttle closes. This device is employed purely for insuring absolute immunity from accident from excess speeds, due to the possible disablement of the governor mechanism.

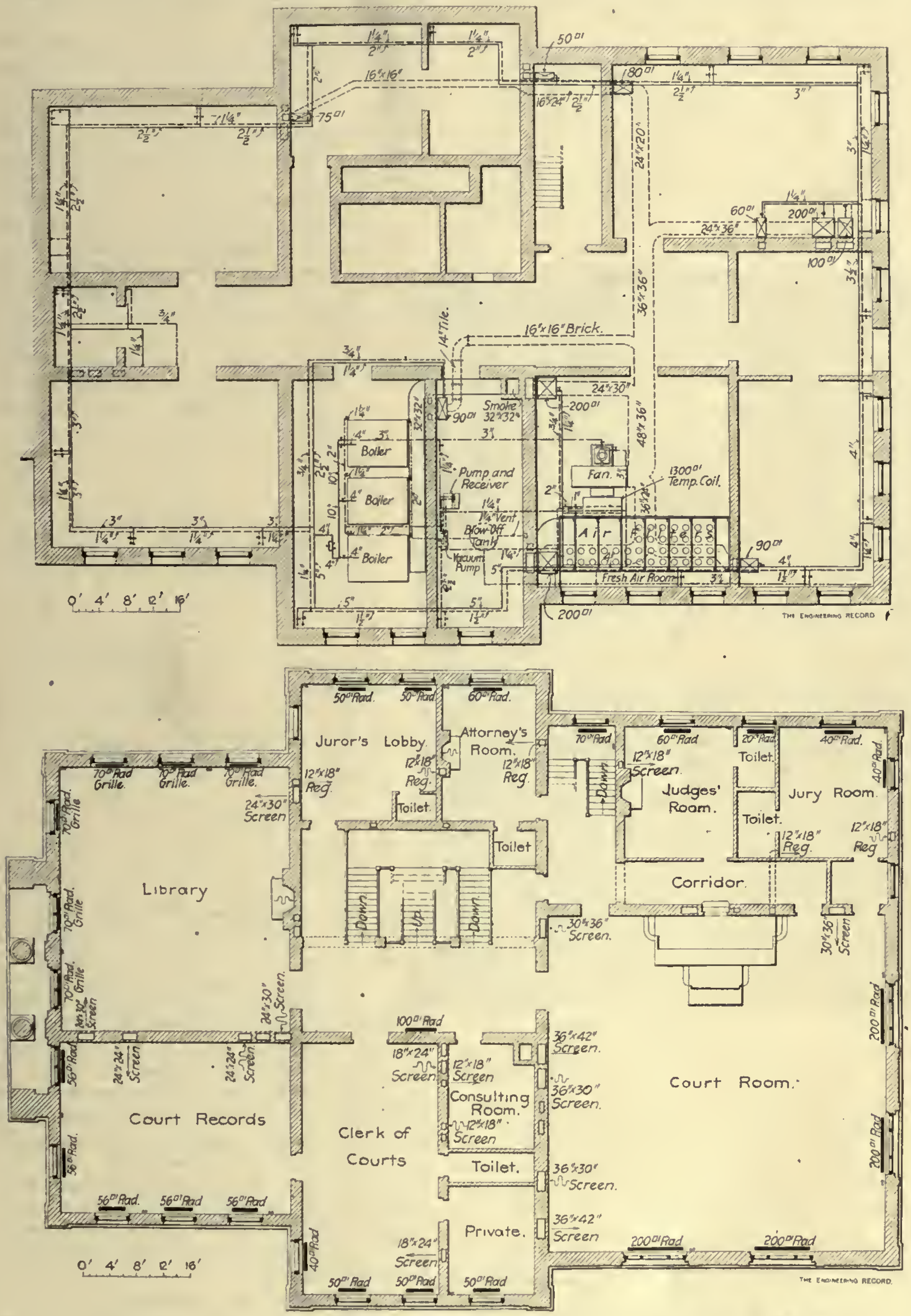
Copious lubrication is supplied to all journals by means of a plunger pump driven from the worm shaft. The warm oil returning from the bearings passes through a copper coil cooler in the bedplate and thence to a reservoir from which the pump draws its supply. The cooled lubricant is circulated at slight pressure, sufficient to insure positive flow. At no point is oil under high pressure employed for preventing erosion of rubbing parts, bearing areas being sufficient for supporting the weight of the rotating parts.

In general construction the 5,000-kilowatt turbo-generators conform to those now building for smaller machines. The field or revolving element is built from a solid cylinder of steel slotted for the reception of the bar windings, and provided with ventilating openings corresponding with openings in the laminations of the stationary element. The generators may be wound for high voltage if desired, in order to avoid the use of step-up transformers in a system of power transmission at voltages ranging up to 15,000.

The 5,000-kilowatt turbo-units illustrated will be employed in heavy electric railway service, which is the most exacting encountered in central station operation. These machines will form the initial equipment of the Pennsylvania Railroad terminal property in New York City, operating with electric locomotives the heaviest Pullman trains through the tunnel approaches to Manhattan. Three units will similarly inaugurate the power service on the Philadelphia Rapid Transit subway system now under construction. Eight 5,000-kilowatt units will furnish power to the London underground system and three 3,500-kilowatt units to the surface system of the same city. These units will operate under 175 pounds steam pressure, high vacuum, and 100 to 175 degrees of superheat.

Ventilation and Heating in the Penobscot County Court House, Bangor, Maine.

The problem of designing a mechanical plant for the Penobscot County Court House, at Bangor, Me., was considerably simplified by the fact that power was required only for the heating and ventilating, the lighting being obtained from the current mains of the local electric company. It was therefore decided to employ as low a steam pressure as would suffice to drive a ventilating fan engine, a vacuum pump for the returns of the heating system and a feed pump for the boilers; then to reduce it a consistent amount to operate the direct and indirect radiation on the Webster vacuum system.



Plans of Basement and Second Floor, Penobscot County Court House, Bangor, Maine.

To understand the reasons for adopting this scheme it will be well to know the requirements. The building is a three story structure of fireproof construction with brick walls and partitions and concrete floors, covering an area of about 10,500 square feet and exposed on all sides. On the first floor are the probate court room, rooms for witnesses, the county attorney and the grand jury, and various other rooms. These quarters are provided with direct radiation and with registers for discharging and withdrawing air for ventilation. The first story has 1,899 square feet of radiation divided among 34 radiators, the largest containing 100 square feet, the smallest 30 and the average 56, the location and distribution depending on the size and exposure of the rooms served. The combined air inlet area is 4,676 square inches and air outlet area 4,044, showing a slight balance in favor of the inlets to compensate for leakage through doors and other openings. In all the design called for twelve registers for inlets and an equal number for outlets, the lower edges of the former being placed 9 feet above the floor and those of the latter 6 inches above. With the velocity of the air through the registers fixed at about 300 feet per minute their sizes were made dependent upon the cubical contents of the rooms and the probable number of persons occupying them at one time, allowing 30 cubic feet of air per minute for each occupant provided this caused the air in each room to be changed at least once every 20 minutes. For better distribution the larger rooms are supplied through two registers at different locations. It will be noticed from the plan of the second floor, and the same applies to the first, that radiators are placed under windows along outside walls except in the corridors, while the registers are in all instances in inside walls so that the direction of supply is towards and discharge away from the outside walls.

The second floor contains two rooms which extend up through the third story—a large court room and a library, their height being 29 feet. The other rooms are 13 feet high and include a jurors' lobby, rooms for the judge, jury, attorney, clerk of courts, and four toilets. In these there is a total of 2,180 square feet of radiation, a somewhat greater amount than that allowed to the first floor, as all the rooms are higher and the exposure greater. The largest radiators are four of 200 square feet each, in the court room, while the average per radiator is about 77.5 square feet. The radiators are all of the H. B. Smith Company's make, known as the Imperial Union pattern, except those in the library, which are Crown pattern and are placed in recesses under the windows with lattice grille work on the front. The total air inlet area, as planned, is 7,632 square inches, and outlet area 5,516, both of which are in excess of those on the first floor, by reason of the greater height of the rooms. That the inlet area is so much greater than the outlet is principally due to the use as ventilating flues of the chimneys over the fireplaces in the library, attorney's room and the judge's room, as these three added to the nine regular outlets make their number equal to the inlets, twelve. Any further excess of inlet over outlet area may be attributed to the desire to ensure ventilation in the smaller, but less frequented adjoining rooms not specially provided with registers. It should be noted that such rooms are invariably outside ones having windows, and that particular attention has been given to provide plenty of air to all inside rooms.

The third floor, with the exception of the sections forming the upper parts of the library, court room and hallway, is unfinished and serves at present practically as an attic, incidentally affording space for the connecting ducts that combine the ventilating flues into a common discharge. No exhaust fan is used; therefore to ensure a positive draught a circular bank of aspirating coils containing 200 square feet is provided around the base of the short uptake that forms the final outlet through the roof.

The basement contains a number of rooms used for fuel storage and a workroom and bindery for records, and the heating and ventilating plant. The boiler room contains three No. 1,201 Gurney "Bright Idea" steam boilers each with a rated capacity for supplying 4,250 square feet of radiation. The smoke outlets from the boilers give into a 32x32-inch flue of ¼-inch wrought iron, which contains a damper controlled by a Spencer damper regulator and connects to the base of a stack of the same size 80 feet high. Steam is generated at a pressure of 25 pounds and conducted from each boiler through a 4-inch connection into a 10-inch wrought iron header from one end of which the heating system is supplied, ordinarily at a pressure of 4 ounces above the atmosphere through a Waters pressure reducing valve, provided with the usual valved by-pass, while at the other end connection is made at full boiler pressure to the lines leading to the fan engine and the two steam pumps.

The heating main is in the form of a large loop extending around the basement along the outside walls, and from it are taken the various risers, eighteen in all, for the supply of the direct radiation, and the branches to the indirects at the bases of the warm air flues. The risers in general supply two radiators on each floor and are 1, 1¼ or 1½ inches in size according to the amount of surface they supply. Those which serve the library and court room end at the second floor. The rest are continued to the third floor and are plugged so that when these rooms, at present unfinished, are converted to some useful purpose there will be an available source of steam for the radiators that will then be installed.

The supply risers are connected on the two-pipe system and the return risers are all ¾ inch and connect in the basement into a 1¼-inch loop return main that is connected to the vacuum pump. The latter is of the 8x8x7-inch Knowles type and delivers to a receiver near the feed pump. The receiver connects to the suction of a 6x3x6-inch Knowles duplex pump so that the returns from the heating become boiled feed. Both pumps are equipped with vacuum governors on their throttles, hence are normally automatic in their action. To provide against their becoming disabled both are equipped with bypasses so that the continued operation of the heating system is not indefinitely interrupted by their failing to work.

The ventilating fan is driven by a New York Safety Steam Power Company's vertical engine having a cylinder 10 inches in diameter by 7 inches stroke. This engine and the two pumps exhaust through a Webster 3-inch oil extractor back to the heating system. There is therefore no regular loss of steam as all is condensed and returned to the boilers. Such as is wasted from time to time when it becomes necessary to blow off the boilers or drain the receiver to the blow-off tank on account of the accumulation of rust or other sediment. is replaced through a connection with the city water supply. The blow-off tank has a capacity of 250 gallons and is emptied to the sewer and vented to the roof in the usual manner.

A 110-inch three-quarter-housed blowing fan, made by the Massachusetts Fan Company of Boston, having a horizontal bottom discharge and a blast wheel 66 inches in diameter by 37 inches wide, establishes the air circulation. It is directly attached to the shaft of the engine which drives it at 200 revolutions per minute, and is depended on to pass 10,000 cubic feet of air per minute. In the intake is placed a two-section bank of tempering coils containing 1,300 linear feet of 1-inch pipe, or a total surface of 450 square feet approximately. The suction chamber for the fan is a room 25 feet long by 8 feet wide with its long side against the outer basement wall covering the opening of three windows. At a distance of 8 feet from the floor this room is divided by a horizontal diaphragm of No. 20 iron, which is perforated by forty 12-inch holes each provided with a collar extending 6 inches below the diaphragm. About the collars on the lower side are tied cheesecloth bags 7 feet 6 inches long. The fresh air is admitted from the windows to the compartment above the filters and is drawn through them by the suction of the fan.

From the fan discharge a system of horizontal tree-form trunk brick ducts below the basement floor branches from both sides to the bases of the warm air flues. At each point of branching a volume damper is located to adjust the quantity of air passed and effect a uniform distribution. At the base of each riser the air passes through supplementary heaters consisting of indirect radiators of the "school pin" pattern, 15 square feet per section, manufactured by the H. B. Smith Company. These are hung from the ceiling of the basement and encased in jackets of No. 22 galvanized iron with doors at the bottom to give access to the coils. The flue is stopped off by a diaphragm level with the heater and openings above and below it into the heater casing so that the air is caused to pass through the heater in order to get back to the flue. Volume dampers are placed also in the flues at the entrances to the heaters, and as but one register is supplied from a single flue they may be individually regulated in the amount of air discharged. On all heating surfaces throughout, the Johnson system of temperature control by thermostats is used.

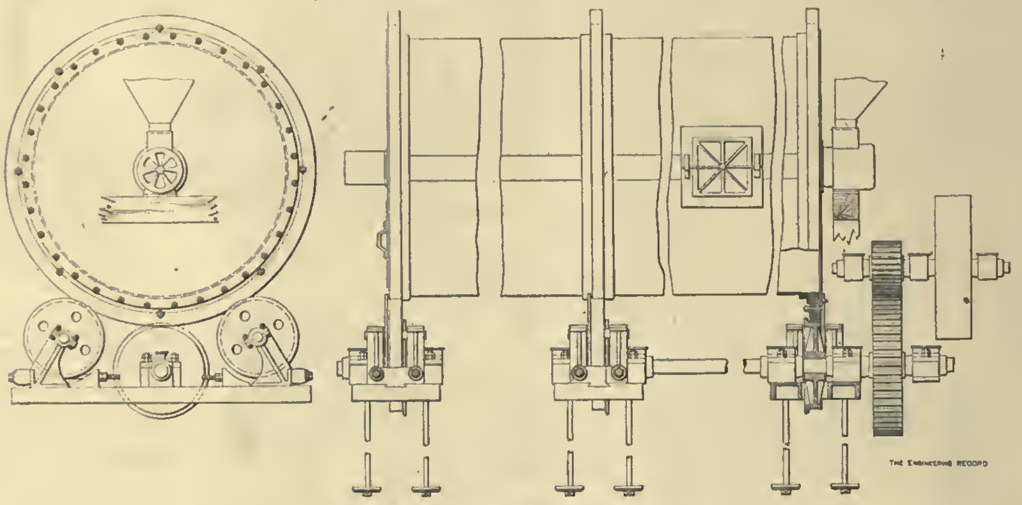
The architect for the building was Mr. Wilfred E. Mansur, of Bangor, Me., and the contractor for the heating and ventilating work, the American Steam Heating Specialty Company, Inc., of Boston, Mass.

Two Pelton Wheels, each 20 feet in diameter, are in operation at Cwm Avon, in South Wales, for driving a large tin mill of the Copper Miners' Tinplate Company, Ltd. The water is led to them under a head of 98 feet through a riveted steel 39-inch main, in which the bends have cast-iron joints packed with lead. Each of the wheels weighs 11 tons, of which about 5 tons are in the rim and buckets, and the shaft in each case carries a 50-ton flywheel. Each wheel has a capacity of 200 horse-power. The buckets are of cast iron, the segments to which they are bolted are of cast iron and the arms are of wrought iron. In a recent issue of "The Engineer," London, some views were given of these large impulse wheels.

A New Mounting for Tube Mills.

The Alsing tube mill is well-known among engineers who have to design or operate pulverizing apparatus of this type, for the first use in the United States of pebble or tube mills was probably made by the founder of the J. R. Alsing Company about 35 years ago. An important improvement has recently been made in the method of mounting them, however, which will appeal particularly to the managers of mills where power is expensive. The usual mounting of such cylinders is on hollow journals and the rotation is accomplished by means of gearing or some form of belt. The power required to run a cylinder mounted in this manner is very large, and to reduce it the system of mounting shown in the accompanying illustration has been designed. It has been in service long enough under different conditions to demonstrate its value as a method of reducing power requirements, although no definite tests have yet been made to show the percentage saving it effects.

In the new mounting the pulverizing cylinder rests on three main bearing wheels, one at each end and one at the center. The cylinder carries heavy rings at these points which are held longitudinally by flanges of the bearing wheels. The two ends of the cylinder are left free for the entrance and discharge of material, since there is no axle running through the apparatus, nor any journal bearing at either end. As the entire weight of the cylinder is carried by the three bearing wheels at the bottom, it is easily rotated by them, for the friction between the hoops and the wheels they rest on is more than ample for this kind of driving. Accordingly two of the bearing wheels are connected by a shaft which can be driven in the manner shown in the cut. The idler wheel on each side of the bearing wheel is employed only to keep the cylinder in place. These idlers are held against the rings on the cylinder by means of rubber buffers pressing against their standards, the amount of the pressure being capable of direct regulation by the nuts shown in the illustration.



New Mounting for Alsing Tube Mill.

The Turntables of Industrial Railways, used for out-door work, are often set on too shallow a foundation, the result being that they are thrown out of line by the frost. In the new plant of the B. F. Sturtevant Company, at Hyde Park, Mass., where special turntables of their own manufacture have been introduced, each rests at the top on a circular brick well with 8-inch walls extending to a depth of 4 feet, or below the frost line. These walls are set on hardpan and the center filled with loose stones, providing perfect drainage. The first winter's experience has shown them uninjured by frost.

General William Sooy Smith.

The United States Military Academy has graduated many men distinguished as civil engineers as well as in military affairs, for the school is one of the best engineering colleges in the United States. This is particularly true of the period prior to the Civil War, when the instruction in engineering at West Point was probably the best in the country in scope and thoroughness. Among the men who have applied in civil undertakings the technical knowledge gained there, none has achieved greater distinction than General William Sooy Smith. Like his classmate, General Craighill, his family was one of the earliest to settle in the colonies, one of his ancestors having taken part with William Penn in the founding of Philadelphia. Another settled near Fredericktown, Md., over two centuries ago, and the estate has ever since remained in the family. Although the family was identified with the Society of Friends, its representatives took part in the Revolution and the War of 1812, and it was after the latter that General Smith's father moved to Ohio, where he was a man of much influence, and there, in Pickaway County, the subject of this sketch was born.

He was appointed a cadet at the Military Academy in 1849, and after graduation four years later received a commission in the artillery. After serving about a year he resigned to undertake civil engineering work. In June, 1861, he was mustered into service again as colonel of the Thirteenth Ohio Infantry, and shortly afterward was engaged in the Western Virginia campaign of 1861. From this time on, his military record is one of successful operations and large responsibilities. From the command of a regiment he was placed in charge of a brigade and finally of a division. He served on the staffs of Grant and Sherman as chief of cavalry of the military division of the Mississippi, and his arduous duties in this capacity finally brought him close to death through a serious attack of inflammatory rheumatism. While recovering from this, the chief surgeon of the division reported that General Sooy Smith would never be able to return to active duty. He accordingly resigned, against General Sherman's advice, for he held that an officer permanently disqualified for the discharge of all the duties of his rank, should step aside and allow the man who does the work to enjoy the rank and pay. At the time of his resignation he had been recommended for appointment as major general of volunteers by Generals Grant, Halleck and Buell. Frequently during his military service he was assigned to engineering duty to build bridges, repair railroads and construct fortifications, always with the promise that he should be ordered to duty with his command in case it was likely to be engaged in battle. At one time he had about 15,000 men at work repairing and guarding the railways of Middle Tennessee.

General William Sooy Smith.

General Sooy Smith's early civil work of most interest at the present time was in the line of difficult foundations. In Buffalo harbor he removed three rocks by surface blasting with gunpowder, before the invention of nitro-glycerine and dynamite. His most important early service, however, was connected with pneumatic foundations, soon after they were introduced into this country by Charles Pontez about 1857. By various improvements in the process and appliances, he reduced the time required for a given amount of excavation to but one-tenth of that previously needed. A particularly important improvement was the use of an air current to blow sand and other soft material through a pipe out of a caisson. His first pneumatic caisson, probably the first ever used, was for the construction of a heavy sea wall surrounding the Waugoshance lighthouse in the Straits of Mackinac, but he had previously designed pneumatic foundations for lighthouses which the outbreak of the Civil War kept from being executed. While he was a member of the Board of Engineers to discuss plans for the St. Louis bridge, about a year before Captain Eads took hold of the work, he suggested the system of foundations which was used so successfully. One of the earliest volumes of "Transactions" of the American Society of Civil Engineers contains a valuable paper by General Sooy Smith on pneumatic foundations, and the list of the bridges for which he executed such works includes over a dozen of the leading long-span structures in various parts of the country.

Iron screw piles were also employed by him on some important foundations for piers and docks, and he invented an excellent machine for putting them down quickly and cheaply by manual labor.

It is also particularly interesting at this time, when the Morton Street tunnel under the North River at New York is nearly completed, to recall the fact that he was chief engineer of the work while about 800 feet of it was constructed. A paper on the tunnel was contributed by him to the "Transactions" of the American Society of Civil Engineers.

His most important professional work was brought about in a rather peculiar manner. At the Chicago convention of the American Society of Civil Engineers held in 1872, he secured the appointment of a committee to urge Congress to appropriate enough money for thorough tests of iron and steel. This committee, of which he was made chairman, obtained the necessary legislation, and the President appointed as a board to carry out the tests, two army officers, two navy officers, and three civil engineers, of whom he was one. During the three years of its existence, the committee had the Emery testing machine at the Watertown arsenal built. While the control of this machine was soon turned over to the ordnance department of the army, its existence and the magnificent work accomplished with it are due, in a large measure, to General Sooy Smith.

From his experience and studies while a member of this board, he became convinced that steel offered marked advantages over iron for structural purposes. In this opinion he was not in accord with most engineers and architects at that time. But his tests of the steel made by A. T. Hay, of Burlington, Iowa, were were so satisfactory that he succeeded in persuading President Blackstone, of the Chicago, Alton & St. Louis Railroad, to let him build the Glasgow bridge over the Missouri wholly of steel. This was the pioneer structure of its type, built and erected so quietly that the knowledge of it spread but slowly. This is shown by an incident worth repeating. In 1876, General Sooy Smith explained his plans to Peter Barlow, the famous English engineer, who was advocating the use of steel for bridges in England. The latter wrote to the former in 1879, asking news of the proposed structure, and the reply was made: "Trains are crossing it."

In co-operation with his son, Mr. Charles Sooysmith, he formed a copartnership with Herr Poetsch, the inventor of the well-known freezing process of excavating in water-bearing material. This process has been employed successfully in this country in sinking a number of difficult shafts, notably one put down by Sooy Smith & Son through 90 feet of quicksand and boulders for the Chapin Mining Company at Iron Mountain, Mich.

For a good many years General Sooy Smith has enjoyed a unique reputation as the designer of foundations for large buildings, and of heavy masonry generally. Among works of the latter class, may be mentioned the Cathedral of St. John the Divine, with which he has been associated as consulting engineer to Messrs. Heins & LaFarge. Many of his leading building foundation undertakings have been executed in Chicago.

The material underlying the surface of the city is clay of a variable consistency and depth. Its sustaining power is from 2,500 to 4,000 pounds per square foot. Under a load of 3,000 pounds, the commonly adopted figure of Chicago architects, a small initial settlement takes place within a few hours, after which a very slow and uneven subsidence occurs. This may seriously threaten the security of a building, as was the case with the old post-office. While the floating grillage foundation may answer in some cases, General Sooy Smith has been a strong advocate of long piles or of wells filled with concrete, both carried to rock or to the hardpan overlying it. These systems of construction have been fully described in The Engineering Record, and it is only necessary to state here that their introduction and extensive use in Chicago has been due to this engineer.

General Sooy Smith joined the American Society of Civil Engineers in 1872, and is also a member of the American Institute of Mining Engineers and the Western Society of Engineers. He is a member of the Loyal Legion, and the Union League Club of Chicago. He has given many addresses on professional subjects before technical schools, containing information of much practical and historical value. Few civil engineers have traveled so widely in connection with professional work, not only in North America, but also in Europe, Japan, Corea, Manchuria and China.

A New Metal Melting Furnace.

In the foundry of the Lunkenheimer Company, at Cincinnati, ten metal melting furnaces have recently been installed, from the company's own designs, which are giving good satisfaction. The details of the furnace were worked out with the primary object of increasing the life of the linings and thereby adding to the capacity of the apparatus. The drum is made of sheet steel with cast-iron heads, and is lined with fireproof tile having two openings on opposite sides of the cylinder. Only one of them is in use at a time, the other being closed by a fire clay filling. A furnace of this general type wears out more quickly around the filling hole than elsewhere, probably because the opening serves also as an outlet for the flame. In the furnace illustrated, when one hole is worn out this can be closed by a fireclay filling and plate, the furnace reversed, and the second hole cut out and put in service. In this way the length of life of a lining is doubled.

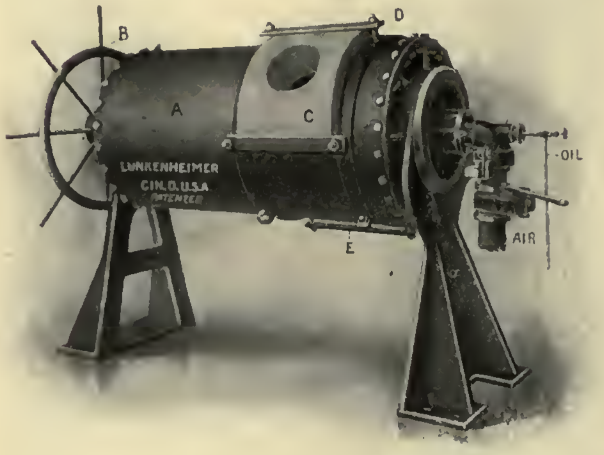
A special type of oil burner has also been employed to give the greatest amount of heat from a given quantity of oil. In the furnace employed at the Lunkenheimer foundry each heat averages about 550 pounds and the consumption of fuel varies from 2 to 2½ gallons of crude oil per 100 pounds of metal melted. Six and seven heats per working day of ten hours are secured from each furnace. The life of the linings is from 300 to 400 heats, depending considerably on the kind of metal melted. A simple form of tile is used for the lining so that it can be easily inserted and the delay incident to such work in some other furnaces in thus overcome. The success which has attended the use of these furnaces has led the Lunkenheimer Company to place them on the market, and it is now ready to supply two sizes, one of 550 pounds and the other of 1,200 pounds per heat.

Book Notes.

Most insurance adjusters are familiar with "Brown's Estimates," a small pamphlet for finding quickly the approximate cost of buildings of various types and for estimating the value of labor and materials required for their construction. The most important part of the booklet is based on the cubic-foot rule. The recent decided advance in the cost of construction has led to a revision of the figures, which are given in a form for ready application in the new edition of the pamphlet. The suggestions for building blocks of houses, for the construction and maintenance of chimneys and flues, and for conducting fire insurance negotiations alone make the work worth the quarter of a dollar charged for it by the author, Mr. James N. Brown, 415 Locust St., St. Louis.

Engineers who have tried in vain to obtain a copy of Mr. Herbert M. Wilson's "Irrigation in India" will be glad to know that this valuable monograph has been reprinted in the series of water supply and irrigation papers of the U. S. Geological Survey. While it is fourteen years since the author collected the data during a visit to India, he has revised the stastics to the year 1901 in the new edition of the book and has supplied useful information concerning works completed since his visit. Wells, inundation and deltaic canals, perennial canals, storage works, river training and land reclamation form the topics in the monograph of most interest to engineers, while those who are studying the administration of irrigation works will be glad to read the sections on finance, extent and character of the Indian irrigation enterprises, their history and administration, the effect of alkali and the duty of water. (Washington, Geological Survey, 6x9 ins., well illustrated, 238 pages.)

The report for 1902 of tests of metals and other materials at the Watertown Arsenal has appeared, and contains a large amount of data useful to the engineer. The results of the tests of the steel employed for ordnance, of steel containing 3¼ per cent. of nickel and similar steel without the nickel, of suspender rods from the Brooklyn bridge, the compressive resistance of cements under different conditions of setting, of dry-pressed and mud brick from different parts of the kiln and of the adhesion of lag screws and bolts in Douglas fir and oak, are particularly valuable. Some of the illustrations are excellent examples of engravings of test pieces. There is no discussion whatever of the results of the tests, merely the test figures, and on this account the value of the results is somewhat curtailed. While the government is doubtless warranted in withholding any comments on the tests, the technical staff that directs the work is so widely known for its spirit of scientific accuracy and impartiality that the absence of some brief explanatory notes in these reports is certainly to be regretted. (Washington, Ordnance Department, U. S. A.; cloth, 6x9 ins., 600 pages.)



The Lunkenheimer Furnace.

The American Railway Engineering & Maintenance of Way Association is an organization that accomplishes a great deal of good by thorough discussion of the details of railway civil engineering. Its committee work is remarkable for thoroughness, and the committee reports are debated fully before their adoption. For this reason the "Proceedings" of the Association form each year a volume indispensable to any one wishing to keep in touch with railway construction and maintenance. The volume for 1903 is an illustrated 550-page book, which is mainly devoted to committee reports and discussions on roadway, on iron and steel structures, on signaling and interlocking, on yards and terminals and on masonry. The volume is sold by the Association, which has its offices at 1562 Monadnock Building, Chicago.

A valuable report on irrigation in Utah has recently been prepared under the direction of Mr. Elwood Mead, M. Am. Soc. C. E., by the Office of Experiment Stations, Agricultural Department. There is an opening chapter on the general features of irrigation in the State, chapters on five typical irrigation districts, and an important section on the laws of the State concerning the use of water. The fundamental result of the investigation is the same as that brought out by Mr. Mead's earlier work in California, namely, that some public control of the water supply is necessary to the best use of the resources of an arid country. The report gives an interesting view of the organization and operation of co-operative canal companies, showing the cost of water rights, the annual cost of water and the returns obtained from its use. These co-operative companies furnish water to the companies at a lower price than other corporations, since there are no profits to pay and the assessments are just large enough to keep the works in order. To irrigators in other States the most interesting feature of the Utah system is the distribution from ditches. Instead of dividing the water supplied by a canal in proportion to the interest of each stockholder, each is given a stream of good size, but the time it may be employed is proportioned to his interest in the canal. In the preparation of the report, Mr. Mead was assisted by State Engineer A. F. Doremus, Prof. G. L. Swendsen, of the State Agricultural College, and Messrs. R. P. Teele, A. P. Stover, Jay D. Stannard and Frank Adams. (Washington, Department of Agriculture; cloth 9x12 ins., 330 pages, maps and illustrations.)

FREE-HAND LETTERING. By Victor T. Wilson, New York, John Wiley & Sons; cloth, 9x6 ins., 105 pages, 23 plates, $1.

Some time ago Mr. Wilson's excellent book on free-hand perspective for engineers was noticed at length in The Engineering Record. The same mastery of the subject, clearness of style and enthusiasm for the art which characterized that work, is also found in his new book on lettering. It is unquestionably the best manual of instructions on this art that has yet appeared. The fundamental idea of the author is that lettering is really free-hand drafting of a high order, requiring a good eye, a trained hand and a delicate sense of proportion for successful execution. The beginner is advised that all lettering is design, and that any mechanical attempt at treatment is fatal. The construction of Roman and Gothic letters is fully described, the subject of spacing is discussed, and the use of the pen is explained. The design of different styles of lettering is the subject of an interesting chapter and every young draftsman will be able to use to advantage the explanation of the best methods of laying out titles.

A CALENDAR OF INVENTION AND DISCOVERY. Compiled by John Cassan Wait, New York, McGraw Publishing Co.; cloth, 750 pages, $1.00; wall or desk calendar form, 60 cents.

Everybody needs a memorandum calendar in these days, and the form compiled by Mr. Wait is not only a handy one for use, but also a particularly instructive one to people interested in applied science. Each day's slip gives brief biographies of eminent inventors and engineers, quotations from poets, and brief notes in many cases of events happening on that date in earlier years. The labor spent in compiling this calendar must have been very great, but the results is both useful and interesting.

Not the least valuable feature of the use of this calendar will be the publicity it will give the careers of engineers whose work is almost forgotten.

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The Iroquois Theatre Catastrophe.

"Evidence submitted under oath proves conclusively that had the skylights and ventilators over the stage of the Iroquois Theatre been open, and the openings over the auditorium been closed, there would have been no fire in the audience room of the playhouse and no lives need have been lost by panic." This is the statement of the attorney of the Chicago Fire Department, concerning the frightful loss of life in one of the theatres in that city on December 30, when about six hundred people were killed and injured. As such an affair apparently implies faulty design or construction, or both, a brief statement of the arrangement of the theatre and its condition after the fire, is printed elsewhere in this issue. It will be seen from that account that the building is structurally intact, a few ladders and steam coils are twisted, and a pair of light girders in the scenery loft are somewhat bent. The remaining damage is confined to the plastering and furnishings. In other words the building passed through the fire practically uninjured from a structural point of view, and the terrible loss of life was not due to any lack of fire-resisting properties in the materials of construction.

The statement of Attorney Fulkerson above quoted, is of the same tenor as the information received from The Engineering Record's Chicago staff and from its friends in that city, who have been so kind as to furnish reports of the results of their visits to the theatre. The disaster occurred from a cause repeatedly pointed out as a source of danger by Mr. Wm. Paul Gerhard and others who have made a careful study of theatre design. The auditorium and the stage must be capable of absolute separation by fireproof material in case of fire. If this is not done, the ventilation of the auditorium will cause the flames from the stage, where the fire generally originates, to be sucked toward the roof of the auditorium by the draft. This is what happened in Chicago. The fireproof curtain could not be lowered so as to separate the two parts of the house, and the loss of life resulted. The auditorium ventilation requires an opening in the ceiling which must remain open during the performance. In the roof over the stage of the best theatres there are large skylights; these are kept closed normally, but can be opened in case of fire so that the draft will be upward from the stage and not outward toward the audience. To insure the opening of the skylights in case of fire, the New York laws require them to "be so constructed as to open instantly on the cutting or burning of a hempen cord, which shall be arranged to hold said skylight closed, or some other equally simple approved device for opening them may be provided." The failure of the proscenium curtain to drop as it should and the closed position of the stage skylights, which together form the leading cause of the loss of life, have nothing to do with the fire-resisting features of the building as an architectural structure. They come under the province of theatrical management and under the inspection of the fire department.

Alternating Current Motors and the New York Central Contract.

The leading topic of engineering interest in electric railway affairs to-day is probably the position to be taken within a few years by the alternating current motor. The system of distribution of current for the direct-current motor is not a desirable one when lines of considerable length are concerned. The direct-current railway motor is an admirable example of skilful designing, but the motor is only one part of the electrical equipment of a road. The line and the rotary converters have to be taken into consideration when the present system is being compared with a proposed substitute, and when the whole installation is examined carefully the reason is apparent for the almost simultaneous announcements from Italy, Germany and the United States of the advent of promising alternating-current motors. The details of these new motors and their accessories, a subject foreign to this paper, have been explained in the "Street Railway Journal" and the "Electrical World and Engineer," and it is probably safe to say that the articles on railway electrical engineering which these publications have lately contained are as important as anything in this field which has appeared since the experiments on the Richmond street railway years ago.

In this recent development Mr. Lamme, Dr. Finzi and Messrs. Eichberg and Winter have been working with commutator type single-phase motors. These have a certain kinship with the direct-current railway motor which Mr. Lamme brought out clearly in his articles in the journals mentioned. The results of tests with the Finzi motor show that the old bugaboo of a low power-factor in such apparatus during starting amounts to very little. These experimenters state that the sparking of the commutator of a single-phase motor is also greatly overestimated, and as their practical knowledge of the subject exceeds that of other engineers it only remains for a public demonstration of their motors under service conditions to settle this matter beyond reasonable dispute. Mr. Arnold's system is of a different character. He employs a synchronous motor, in which the speed of the armature relatively to the field remains constant. In order to provide for the speed variations necessary in running a car, both members of the motor are so mounted as to be capable of rotation. When the car is running at slow speed the surplus energy is employed in compressing air and when the car is running under conditions calling for a large amount of power the compressed air helps out the motor. This system presents all the advantages of the other in the way of power distribution from the central station, while it has special merits in its uniform loading of the power-house through the continuous operation of the motors and in permitting a certain amount of operation by compressed air alone in places where electric conductors are undesirable. The ingenious manner in which the details of the apparatus have been worked out is characteristic of Mr. Arnold's bold designing, and the destruction of his perfected experimental car before the tests with it were made is an accident all engineers deplore.

In view of these facts, it will doubtless appear strange to many who are in touch with electrical developments that the authorities of the New York Central Railroad have adopted direct-current motors for the operation of the passenger trains running into the Grand Central Station in New York. It has been said that these motors would be obsolete by the time they were in use. Admitting this to be true for the sake of argument, the fact remains that Mr. Wilgus and his technical staff have followed the only course that their obligations to the public permit. They are not in charge of a new transportation system which must develop a business, but are responsible for the operation of a system with an enormous, long-established train service where no experiments should be permitted. Half an hour's interference with the movement of trains at the Grand Central terminal means an inconvenience to thousands of people, and only a few such accidents would be needed to bring down on the officials endless denunciation and, probably, trouble with various public authorities. The same reason that led to the rejection of electricity for the suburban service of the Illinois Central Railroad a little more than ten years ago has doubtless led to the rejection of the alternating-current motor at New York now, namely, the obligation of a great railway company to keep up its schedule and to avoid any experimenting which will jeopardize that schedule. What is legitimate, even praiseworthy, for a new road may be too hazardous for one already handling a large traffic.

An examination of the situation which faced the New York Central officials in connection with this choice of operating systems reveals some interesting facts. In the first place the elevated and rapid transit roads have adopted direct-current motors, and if any interchange of cars is ever desired between these lines and the New York Central road the equipment of the latter must be direct-current also. It has often been said that there is no possibility of such interchange of cars because the rolling stock of the present steam-operated system is too large for the tunnels and elevated structures of the Interborough company. This criticism loses weight when it becomes known that the New York Central suburban equipment will be designed so as to be capable of passing over any of the transit facilities in New York City and vicinity.

From the technical side of the subject a number of objections to the alternating-current system arise in the case of this particular installation. The operation of overhead trolleys, such as the alternating-current system presupposes for its greatest efficiency, involves a trolley wire for which there is no room in the tunnel leading into the Grand Central Station. The clearance of the large locomotives and Pullman cars at many points is less than one inch. A trolley pole cannot be properly operated under such conditions, and; moreover, a trolley wire will be corroded by the gases from locomotives of freight trains and be a source of danger to freight-train crews. Lowering the four tracks in the Park Avenue tunnel, so as to permit safe trolley operation, would be a very hazardous and costly undertaking, and the erection of trolley poles on the viaduct portions of the line might be prevented by the city authorities, who have refused all applications for the use of trolley systems in Manhattan.

It is understood that a considerable difference exists in the estimated first cost of the alternating current systems proposed by the two leading bidders for this contract, both being higher than for direct-current installations. It is probable, however, that the first cost of the system did not receive any very great weight in the consideration of the projects submitted. Very likely the railway authorities expect that the direct-current apparatus will soon be supplanted by alternating-current motors. When that time comes the motors of the direct-current system can be sold for a considerable sum, and the costly power station equipment need not be changed. If alternating-current motors of the size needed for this service were adopted now, they would doubtless be obsolete very soon, and the market for them would be a limited one, as was the case with the double-reduction motors some years ago. Hence it is not difficult to see that the railway authorities have showed a conservatism of judgment in this important matter that should strengthen public confidence in the success of the difficult undertaking they have in hand.

The New York Department of Bridges During the Low Administration.

It is always both profitable and instructive to review in a fair and reasonable manner the conduct of any department of a great municipal government like that of the City of New York, especially when the problem of city corporate organization is yet unsolved in its main features. At the close, therefore, of an administration in the City of New York, moved by an honest and earnest desire to conduct all public affairs in a just and business-like manner, the main motive being a desire for the highest efficiency and a service for the best interests of the people, an analysis of the course of affairs in such a department as that of bridges cannot fail to disclose results of value. These observations apply with particular force to the Department of Bridges during the administration of Mayor Low, for the reason that the commissioner, Mr. Gustav Lindenthal, M. Am. Soc. C. E., is an engineer of ability and extended experience, not only in bridge construction, but in other fields of engineering.

The position has been taken, even by many engineers, and was so taken when the retiring commissioner was first named for the head of the Department of Bridges, that such an office should not be filled by a civil engineer, but by a man of executive capacity and experience in some other calling. The argument was made that a civil engineer commissioner would be probably tempted by his professional interests beyond his power of refusal, to concentrate his attention and efforts too much upon the technical matters of his department, thus neglecting more or less the executive functions of his office and trenching upon the field of the engineering staff. This, it was figured, would weaken or destroy the efficiency of the department and perhaps render it impracticable to secure or retain the services of a competent chief engineer.

It may be admitted at the outset that if the appointment of some particular civil engineer would lead to these results, he certainly should not be selected as commissioner; but precisely the same objections may be urged against a candidate from any calling whatever, whose predilections, training and experience prevent him from appreciating the broader responsibilities of such a position. Unless civil engineers as a body are prepared to admit that the character of their calling is such as to dwarf or prevent the development and exercise of administrative capacity, no valid objection can be brought against the appointment of civil engineers to positions of administrative or executive functions. This journal has always believed and maintained that the broadest fields of responsibility are open legitimately to civil engineers, and that both their training and experience are peculiarly adapted to develop in them precisely those qualities requisite for the highest and most efficient discharge of administrative duties. It is simply necessary to select civil engineers, as in selecting other men, for executive positions who possess the administrative faculty. The development of railroads and great corporate industries in which the principal executive officers, even to the highest, are engineers, shows that there are many members of the profession qualified to conduct the greatest business organizations of the present time with the highest degree of success.

A review of the administration of the Department of Bridges during the past two years will show that faith in the executive capacity of civil engineer commissioners is greatly strengthened and not impaired by it. There have been defects in that administration which at one time imperiled its success, but they were defects of personal temperament and not of administrative ability. There were features of the environment of the Department which rendered the commissioner's discharge of his duties particularly difficult in some respects and in which a needed degree of tact was not always displayed. It goes without saying that tactfulness is required as much by civil engineers as by other people, and when that is absent difficulties are sure to result to a corresponding degree. On the other hand it can probably be stated without the slightest exaggeration that the work of the Department of Bridges has never been characterized by greater force, more decision or more promptness in dealing with its larger problems, or on the whole with a higher degree of efficiency, than during Mayor Low's administration. Great questions of far-reaching importance, both as to expenditure and as to the handling of the greatest number of people ever requiring daily transportation, have come before the commissioner, and in no case has he failed to give those problems treatment commensurate with their importance or adequate to the public interests involved. His judgment may not always have been perfect, and the ends attained have not invariably been such as desired, but he has corrected defects in plans of great bridges, inherited from previous administrations. While perhaps the present administration may find it desirable to modify features of some plans inherited by it, on the whole what may be called the great bridge affairs of the City of New York have never been in a more satisfactory condition than at the present time.

Probably the feature of the retiring commissioner's administration which, on broad grounds, is subject to the keenest honest criticism has been his failure to separate the functions of the commissioner and chief engineer. Indeed he committed the error of practically failing to have a chief engineer by combining in himself the functions of chief engineer and commissioner. This was precisely the danger he was warned against at the beginning of this work, but strong personal characteristics overbalanced good judgment. It is not a functional defect, however, of the profession, but an idiosyncrasy of the individual. If this trait of the retiring commissioner had been held in check in a wise and tactful manner, the work of the Department would have been admirable in every respect. As a matter of fact, the conditions characterizing the administration of the Department of Bridges just closed, have been such as to develop to a maximum the defects peculiar to a professional commissioner, and the result is too pronounced to be passed without comment.

One of the admirable features of Mr. Lindenthal's administration, for which he cannot receive too much credit, has arisen from his correct appreciation of the value of the aesthetic treatment of bridge structures, especially when built for the great City of New York. Hitherto bridges have been designed, as a rule, with such an absence of aesthetic character as to be positively abhorrent to the cultivated eye. It is not a mere sentiment, it is a legitimate necessity, that great municipal bridge structures should be in the best sense of the word monumental in character and so designed as to exhibit in the highest possible degree features of grace and beauty. The commissioner's commendable appreciation of beauty in bridge design prompted him to associate with the Department the services of a competent architect to work in co-operation with the engineering staff. This was a wise departure from past practice. It conduces to the legitimate and necessary ornamentation of the city on the greatest possible scale without trenching in the least upon the engineering efficiency of the bridge structure. It may be unqualifiedly stated that engineering efficiency and artistic design go together readily under an intelligent and appreciative co-operation of masters of the two arts. Whatever the present commissioner of bridges may do, it is most earnestly to be desired that the ornate development of the city's bridges may be continued along the lines laid down by Mr. Lindenthal. On the whole, the city and the profession may be congratulated upon the strong administration of the Bridge Department just closed. The broad and forceful policy of the department, in the main, has placed the great structural affairs of the city far higher than they have hitherto been. The administration of the department by a man who was technically trained, cared nothing for politics and laughed at the newspapers, has been a good thing.

The Report of the United States Steel Corporation.

Few reports in the financial world are of such interest to engineers as the statements of the United States Steel Corporation. Iron is no longer king in the sense it was when the growth of railways and the reconstruction of wooden bridges made the increase in the demand for wrought iron and steel a marvelous one. Even those who took part in its production were astonished at the development, which can only be appreciated by a study of such statistics as Mr. Bridges gives in his "History of the Carnegie Steel Company." But while the industry does not occupy its once conspicuous position of exceptional exaltation, it rejoices in the possession of the greatest company of the country, the magnum opus of the corporation lawyer and the promoter. In the ranks of its employes, high and low, there are probably several thousand educated engineers, while of all the engineers in the country a large percentage looks to the corporation for material of one sort or another. During the recent flush times the powerful influence of the company kept prices at a much lower level than would have been maintained under former conditions, and great interest is manifested in its probable policy during the period of lower prices which has now begun. What the details of that policy will be only the future will reveal, but it is safe to assume that the men who have refused during the last three years to bleed the consumer by charging the maximum price the business would pay will not use their great powers in any other way than to produce sound conditions.

The downward course of the stock of the United States Steel Corporation in Wall Street must not be regarded in the same way that would have been proper twenty years ago. Wall Street no longer rules the country. Within a year we have seen the men who pass their existence in the shadow of a stock exchange, prophesy the ruin of the country and work themselves into a half-panic because the conservative investors of the country refused to see as much value in the flood of new "securities" as the makers of them desired. There were many old plants started up a few years to enjoy a temporary period of prosperity during the brief period it could last. Nobody expected them to stay in operation very long and their gradual closing down means simply a return to sound conditions, not so extremely good that we will all of us purchase castles in Scotland, but not so bad that we need to look at the New Year with apprehension as to what it may bring forth.

All this is a fairly long preamble to a consideration of the report for 1903 of the United States Steel Corporation. On the face of it, it is the least satisfactory of any that has yet appeared, but considered carefully, with regard to what is taking place in the various subsidiary companies, it indicates the working out of the problem of management, financial and technical, which must gratify those who have the welfare of the steel industry at heart. Many readers of The Engineering Record will recall Kipling's story of the ship that "found" itself; that had to pass through the strain of a prolonged storm before it ran successfully in all parts of hull and engines. The United States Steel Corporation at the present time is finding itself in the same sense. The weak parts are being detected and strengthened, the men who really do things are being discovered and lifted above those who rattle about in their places or admire their own work too highly. The organization of an industrial army takes time, particularly when the demands of business are so great that every thought must be directed toward filling orders. A slackening of trade has been really desirable for this corporation, for it will permit for the first time since its career began the careful organization of the framework of the personnel, which can be added to hereafter as the conditions of business demand.

According to the report, the net earnings of the subsidiary companies during the year were $83,708,825, from which must be deducted $19,086,945 for interest on the bonds of the corporation and $3,797,500 for a sinking fund for these same bonds. In addition $5,750,000 has been written off for "depreciation in inventory valuations" and for the adjustment of sundry accounts. This leaves a total of $55,074,380, of which $43,111,735 has been paid out in dividends, leaving a surplus of $11,962,645 to the good for this year's uses. This surplus is only about half that of last year, but it has been saved while the corporation was running under the extravagant conditions of 1902. The present year begins with a great reduction in expenses. It has been a matter of common report for some time that there were exceptional opportunities for saving money in the corporation's payroll and still pay full price for work done. Recent events indicate that this will be done, and while some injustice may result from the first readjustment of expenses, these things right themselves in the end. The larger the corporation the greater are the opportunities for the men in its employ who will recognize their responsibilities to the full and work as hard as the heads of the great departments. The corporation is now in a position to hunt out these men and to weld them to its interests firmly.

The corporation's possessions in the way of ore and coke properties, furnaces and mills, are the finest in existence, but better than all it has on its board of direction the leading financial men in the country. John D. Rockefeller's ability in the management of great undertakings, Marshall Field's exceptional judgment in foreseeing the changes in business conditions, and Mr. Frick's proved power to manage the steel industry in an unequaled manner, are all being exerted toward establishing this corporation on a position of permanent security. They not only intend that it shall be a profitable company to its shareholders, but also, by serving as a masterful governor on the industry, that it shall be a powerful influence for sound business conditions. These men and their eminent associates do not regard it as an orange to be sucked dry and then thrown to the dogs. For this reason, there seems to be no cause for regarding the course of the corporation's shares on the stock market with any apprehension. The control of the corporation rests with men to whom it matters nothing what price may be paid for the shares they do not need for their purpose. They are independent of Wall Street. For these reasons The Engineering Record expects that when the present year has passed, the United States Steel Corporation will be in a far stronger position than at any previous stage in its career.

Notes and Comments.

ROAD BUILDING in Oneida County, N. Y., has been passing through an experience which is not unlike previous occurrences in Massachusetts. Five and a half miles of State highway between Utica and Paris was undertaken by a county committee which employed convict labor. None of the committee had any knowledge of such work, but all of them probably considered themselves competent to oversee the dumping of stone on a graded surface and the consolidation of the stone by rolling. It never entered their heads that good road building requires much experience on the part of the contractors, and that the innumerable little details of the work must be mastered before success is possible. They did not even appreciate the importance of using suitable stone, and any rock was good enough for them, which made trouble with the State Engineer. Consequently the work took two years instead of five years and has been extremely expensive.

THE INTRODUCTION OF AIR BRAKES in Russia on a large scale took place in an interesting manner. In 1895 a hand-braked freight train telescoped another killing several people and doing much damage. At that time only the passenger trains had air brakes. The Czar became interested in this accident and learned that it would not have occurred had the freight train been equipped with air. As a result of this, a commission was appointed to investigate automatic air brakes. As a result of tests with five types of apparatus the Westinghouse was chosen. A $7,000,000 contract was accordingly made for these brakes. A factory was established in St. Petersburg which has since supplied all such apparatus for the Russian government.

THE EAST RIVER TUNNEL of the New York Rapid Transit line to Brooklyn was recently the scene of a little difficulty under a wharf supporting a ferry house. This was magnified in the daily papers into a serious accident, so that the official report on the affair is of interest. A hole over the tunnel was found under this wharf. A sheet of canvas was sunk over the opening and covered with bags of clay and sand. After the hole was filled the tunnel was pumped out sufficiently to allow the air lock to be opened and a boat floated through it. An examination showed that a piece of the canvas and several cartloads of bags had been forced through the hole into the heading. These were removed, the material above being supported by poling boards. The material above the tunnel is to be made tight by grouting and concrete. Practically no damage was done to the wharf.

ANALYSES OF PORTLAND CEMENT made under the direction of the New York Section of the Society of Chemical Industry were submitted to Mr. W. F. Hillebrand for his criticism. The summary of his views is as follows: "Too many chemists assume without positive knowledge that those materials used by them are satisfactory. No chemist can be said to do justice to his employers or patrons who does not know what order of errors his results may include. Too often is a known contamination thoughtlessly excluded as negligible when a quantitative test might have shown the falsity of the belief. Probably the most fruitful plan for arriving at a method of procedure in analyses that would best suit the conditions prevailing in the majority of cement works would be through a committee of not more than three well-selected members, who should not only be analytical chemists but men familiar with cement works. Now that the conditions governing accurate work are understood, such a committee should be able, by accurate experiment on a standard sample, to work out a detailed scheme of analysis that would be a satisfactory compromise between the imperative demands of the factory for immediate results, on the one hand, and a proper regard for reasonable accuracy on the other. Such a method might be known as the 'factory control method,' while for more precise work one of greater refinement might be given in detail."

The Almendares Portland Cement Works, Cuba.

The works of El Almendares Fabrica de Cemento Portland, near Havana, afford an interesting example of the rapid changes during the past few years in the methods of manufacturing Portland cement, and show how rapidly the American system of cement manufacture by the rotary process is growing in favor. This installation has demonstrated its superiority for cement manufacture even under conditions least favorable to its commercial success, that is, where fuel is high and labor cheap.

The works are located in Marianao, one of the suburbs of Havana, about 40 minutes trolley ride from the center of the city. The plant is situated on the banks of the Rio Almendares which has sufficient depth to allow small barges and schooners to come up to the wharf to discharge or receive cargoes. The military road from Havana to Marianao passes directly by the works, and it is expected that a branch from the trolley line will shortly be built to the works.

General View of the Almendares Portland Cement and Tile Works near Havana.

The plant was originally constructed in 1898 and 1899 by and according to plans furnished by Fried. Krupp, of Magdeburg, Germany, and illustrated the best German practice of that date. The raw materials used are a soft coral limestone and clay; the average analyses of the limestone and the clay immediately in connection with the limestone are as follows:

	Per cent.	
	Stone.	Clay.
Silica, SiO_2	2.22	41.49
Alumina, Al_2O_3	.92	26.05
Iron oxide, Fe_2O_3	.18	10.73
Lime, CaO	54.08	4.29
Magnesia, MgO	.10	1.38
Sulphuric anhydride, SO_3	None	.16
Loss on ignition	42.50	16.69

As originally designed and built by Krupp, on delivery to the plant the limestone was first partially dried in open air under storage sheds, the drying being finished by passing the stone through a vertical dryer built of brick in the form of a common limekiln. The clay was brought from the deposit and stored in open sheds, the drying being finished in a rotary dryer similar in construction to those generally used in the United States. The dried clay and limestone were then passed separately through four No. 5 Krupp ballmills which ground them to such fineness that they would pass a No. 20 mesh sieve. The clay and limestone were then mixed by weight and fed to two 16-foot Krupp tubemills, in which the raw materials were finely ground and thoroughly mixed. From these mills the finished raw material in a dry state was taken to the brick works. Here water was added and the raw material passed through pug mills; from these it was fed to the brick presses, from which the bricks were taken in cars to open sheds where they were partially air dried, the drying being finished in a Rappol tunnel dryer with artificial heat generated in a furnace. From this tunnel the bricks which had remained on cars throughout the process of drying, were taken to the kilns. These were four in number, being continuous fixed vertical kilns, similar to those commonly used in German practice. The clinker was drawn at the bottom in the usual manner and sorted by hand, then wheeled to storage sheds from which after long exposure to air for seasoning, it was taken to the cement grinding room in which was installed one No. 8 Krupp ballmill and one 16-foot tubemill. After grinding the cement was conveyed to storage bins, from which it was packed by hand.

The buildings were of wood covered in some cases by corrugated iron, and very open in their construction on account of the climate.

Power to operate the plant was furnished by two Corliss engines of European manufacture, one of 140 horse-power and the other 390 horse-power, three boilers being installed.

The installation as above described proved unsatisfactory, the principal difficulty being the inability to dry the bricks successfully, the two dryings being very expensive. Owing to the humid atmosphere, little or no benefit was derived from the air drying, the drying having to be done almost entirely by artificial heat. Another objection was the small production of the kilns and the uncertain burning of the clinker; in some instances, fully 50 per cent. had to be returned to the kilns for reburning.

In the summer of 1902, the management took under consideration the modification of the plant by the installation of the rotary system, and the contract for preparing the plans and furnishing and installing the necessary machinery for this change was entrusted to Messrs. Lathbury & Spackman, of Philadelphia, Pa., in the fall of 1902. As it was desirable to keep the cost of remodeling the plant at the lowest possible figure, it was decided to utilize the grinding machinery in the raw material and cement grinding departments as originally installed; the only changes made in these departments being a slight alteration necessary to the conveying and elevating machinery and the installation of storage bins for the ground dried material. It was also decided to drive electrically the machinery installed in the new part of the plant, as this could not be conveniently erected so as to permit of taking power from the main lines of shafts in the original plant. The new installation exclusive of some slight alterations to the power plant, and grinding rooms, consisted of crushing and drying machinery for the limestone, and the necessary conveying and elevating machinery. The preliminary crushing of the limestone offered a rather difficult problem, the stone being soft and sticky in its character, and carrying from 12 to 18 per cent. moisture which resulted in the clogging of the crushing machinery originally installed, and none of the first installation could be used for this purpose. This difficulty was overcome in the new plant by the installation of rolls for the preliminary crushing. From these rolls the material passed through rotary dryers, from which it was conveyed to the storage bins in the grinding room.

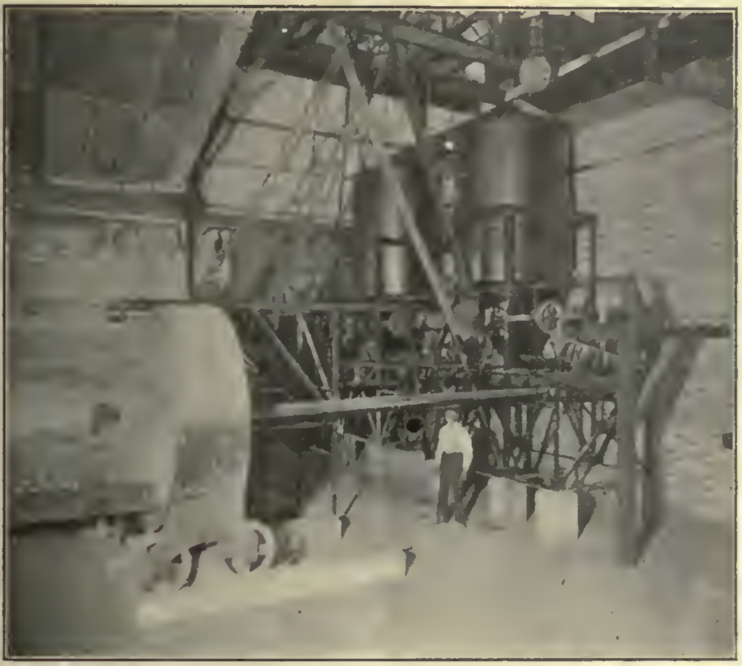
In addition to the machinery installed for handling the limestone, two 6x60-foot rotary kilns with the usual equipment were installed. From the kilns the clinker was elevated to two vertical steel towers 8 feet in diameter and 30 feet in height, equipped with baffle plates in the usual manner. Cold air was forced in by a fan at the bottom, and the hot air drawn out at the top was used for forcing the powdered coal into the kilns, thus utilizing a portion of the waste heat from the clinker.

In the coal room was installed rolls for the preliminary crushing of the coal, a large coal dryer, a 16-foot Smidth tubemill with the customary accessories of elevators, bins, conveyors, etc.

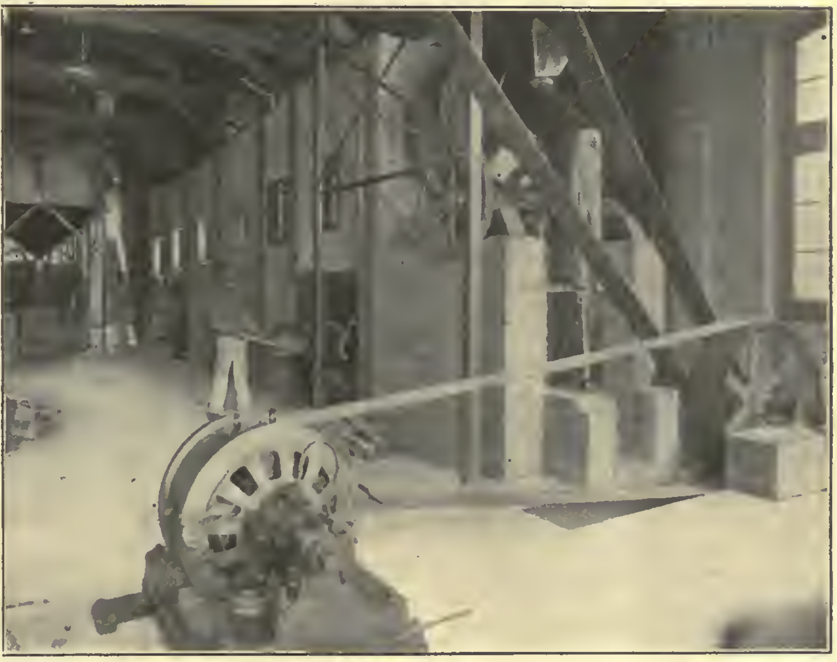
The entire mechanical outfit, machinery, bins, conveyors, elevators, belts, etc., was shipped from the United States. The motors and generators, however, were purchased in France, so they would correspond in make with those already installed for supplying power to the tile works.

The general layout of the remodeled plant, owing to the fact that it was necessary to utilize the machinery of the old installation as far as possible in its original position, and to adapt the new machinery to the buildings already built, was not absolutely satisfactory, necessitating as it did the conveying of materials in course of manufacture for considerable distances back and forth in opposite directions. But considering the fact that the machinery was fitted into buildings already erected and utilized the major portion of the previous installation made for an entirely different process of manufacture without change, the layout was more satisfactory in its results than was at first expected, considering the circumstances.

The contract which was closed in September, 1902, called for the completion of the plant and its complete erection in readiness for operation by the end of March, 1903. The work of installation was completed a little in advance of the contract time, but owing to delay in the arrival of coal, manufacture of cement was not started until the middle of April. The results were entirely satisfactory, the first week's operation of the kilns averaging 180 barrels of clinker per day per kiln, with a coal consumption of less than 100 pounds of coal per barrel of cement produced, which was considerably in excess of the guarantees, viz.: 150 barrels of cement per kiln per day, with a consumption of not over 125 pounds of coal. These results were considerably bettered in the subsequent operation of the plant during the time it was under trial. This production, however, was greater than the capacity of the clinker grinding room which had not been changed from the original installation, as the management was doubtful of the kilns producing the amount guaranteed. Changes had to be made in this department, additional grinding machinery being installed, so that the two kilns were not operated continuously until the middle of the summer. Since then they have been in constant operation, with a production of about 200 barrels of clinker per day per kiln, and a coal consumption in the kiln of less than 100 pounds of coal per barrel of cement produced.



View in Kiln Room.



View in Coal Room.

The clay found on the property in conjunction with the limestone, as would be expected from the analysis, was not very satisfactory for the manufacture of Portland cement by the rotary process, being too high in iron and alumina, and the resulting cement was too quick setting to be desirable. After about two weeks' operation on the clay formerly used in the set kilns, another deposit was secured, the clay from which showed the following analysis:

	Per cent.
Silica, SiO_2	58.04
Alumina, Al_2O_3	14.63
Iron oxide, Fe_2O_3	9.27
Lime, CaO	1.53
Magnesia, MgO	2.02
Sulphuric anhydride, SO_3	.37
Loss on ignition	12.67

This gave most excellent results, the cement produced being of the highest quality. Large quantities of this cement were used during the past year for engineering works in Havana and vicinity, and the product is shipped to all parts of the island.

El Almendares Fabrica de Cemento Portland is a French corporation, the principal offices being in Paris, and most of the capital in the plant is French. In addition to the manufacture of cement, the company has extensive works for the manufacture of cement tiles, brick, drain pipe, etc., and the products from this factory would be a surprise to the American manufacturers of cement. The market for tiles in Cuba is very large, they being used both for the roof and flooring of the houses. The tiles are made of many patterns and colors, running from the rough building tile to some elaborate designs with as many as six different colors, and it is difficult to tell them when in place from the best porcelain or clay product, and they seem to be even more durable.

These tile works can be seen on the left of the general view of the plant. The office building shown in the center of this photograph was built entirely from such tiles. In these works they also manufacture large quantities of building brick, ornamental urns, vases, railings, etc., the artificial stone work being exceptionally good, and in this particular branch of the cement industry, or rather in the manufacture of cement products, the Spanish people seem far ahead of ourselves. The operation of such works in the United States in conjunction with the cement mills might be a good business venture to insure a market for a considerable portion of the product during dull times.

The quarry from which the limestone is taken, is located about one-half mile up the Almendares River, and on the opposite side of the stream. An overhead telpher line was originally installed to transport the limestone from the quarry to the mill, but failing to work satisfactorily, its use was abandoned previous to starting the rotary plant, the limestone now being brought from the quarry to the mill by barges holding about 80 tons. The stone is dumped directly from the quarry cars into the barges, and these are then poled down the river passing under the pontoon bridge shown in the view of the plant, the clearance of the brick limiting the size of the barges. The limestone is unloaded from the barges directly into carts at the dock and hauled to the storage sheds back of the raw material department.

In the general view of the plant, the office building is at about the center of the picture, with the kiln building directly in the rear. Back of this can be seen the stacks of the old fixed kilns and the elevator for hoisting the bricks to the charging floor of these kilns. To the right of the kiln building is the coal grinding building, with the storage sheds for coal. The coal is brought by boat to a dock located just beyond the extreme right of the view. This dock is equipped with coal handling apparatus by which the barges are emptied and the coal cars loaded, it taking about two hours to discharge an 80-ton barge. A trolley line runs from this dock around the plant, so that coal is readily distributed to storage pockets at the boiler house and coal grinding room. This dock can also be used for the shipment of cement by water.

The clinker grinding department is just back of the kiln room, the power house being between it and the raw material building, the roof of which can be seen just back of the stacks of the vertical kilns.

In addition to the quarries from which the present material is taken, El Almendares Fabrica de Cemento Portland control a very valuable deposit of natural cement rock which is located at Regla, about two miles east of Havana Harbor, but owing to the difficulties of transportation, this rock is not utilized at present, although previous to the rotary installation, natural cement was manufactured from it, the stone being brought by mule teams from the quarry to the plant. This necessitated the ferrying of the carts across the harbor and the hauling of the rock through Havana to the plant. The rock from this quarry could be brought by water, but the supply obtained in this manner would be uncertain owing to the difficulties of navigation when the wind is from the north. It is, however, probable that a second mill will be built to utilize this deposit, the stone of which is one of the finest for making Portland cement, being soft and readily quarried, and of almost perfect analysis for cement making purposes.

Analysis, Regia Stone.

	Per cent.
Silica, SiO_2	15.22
Alumina, Al_2O_3	4.92
Iron Oxide, Fe_2O_3	1.18
Lime, CaO	41.60
Magnesia, MgO	1.59
Sulphuric anhydride, SO_3	.10
Loss on ignition	34.19

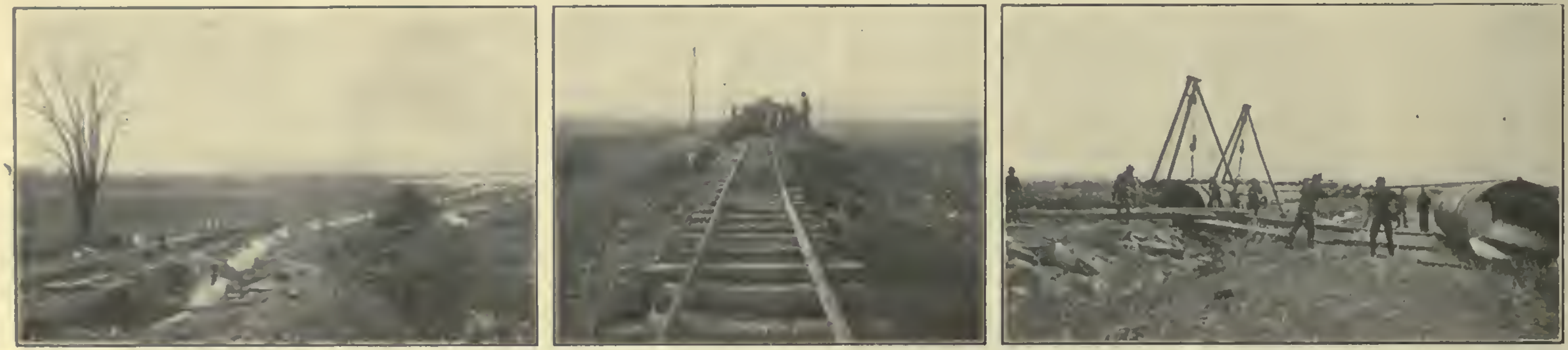
In the kiln room space has been provided for the installation of two additional kilns. The view of this room shows the discharge ends of the kilns, the coal bins, and the apparatus for blowing the powdered coal into the kilns, also the elevator taking the hot clinker to the cooling towers which are located just outside of the kiln room. In the view of the coal grinding room, the coal dryer is in the foreground, with the coal grinding tubemill at the rear.

The plant was started in operation by American burners, but is now entirely operated by Cuban labor, with the exception of the chemist, who is from the United States.

The Conduit of the Jersey City Water Supply Company.

Part I.—Steel Pipe Lines and Connections.

Extensive works for supplying water to Jersey City have been under construction for nearly four years and are now nearing completion. A general description of the system and detailed accounts of the construction of some of the parts appeared in this journal July 21, 1900; December 13, 1902, and August 8, 1903. To convey the water from the large reservoir in Boonton to the city, a conduit 22.99 miles long has been built from the lower gate house at the Boonton dam, comprising 3.59 miles of reinforced concrete conduit in cut-and-cover, 1.95 miles in two concrete and brick-lined tunnels, and 17.45 miles of 72-inch steel pipe line, including two difficult river crossings. The masonry conduit has a slope of 0.0947 per thousand feet, or 6 inches per mile, and an estimated capacity of 70,000,000 gallons per day, while the capacity of the pipe lines is about 50,000,000 gallons per day. Provision for connecting a duplicate pipe line when required by the increase of consumption, has been made in all the masonry structures. The novel method used for crossing the Hackensack and Passaic rivers and some details of pipe-making and laying have been previously described.



Jersey City Conduit: Laying Steel Pipe and Building Embankment across Hackensack Meadow.

Considerable portions of the pipe line are situated on broad and substantially level tracts of land known as the Great Piece and Hackensack meadows, which are frequently inundated in times of freshet, and the latter by high tides also. Fortunately, the seasons during which pipe-laying was in progress across these meadows were unusually dry. Across Great Piece meadow the pipe was laid with its top about 3 feet beneath the surface in order to get sufficient weight over the pipe to prevent its floating when empty without raising an embankment which could act as a dam and cause trouble during freshets.

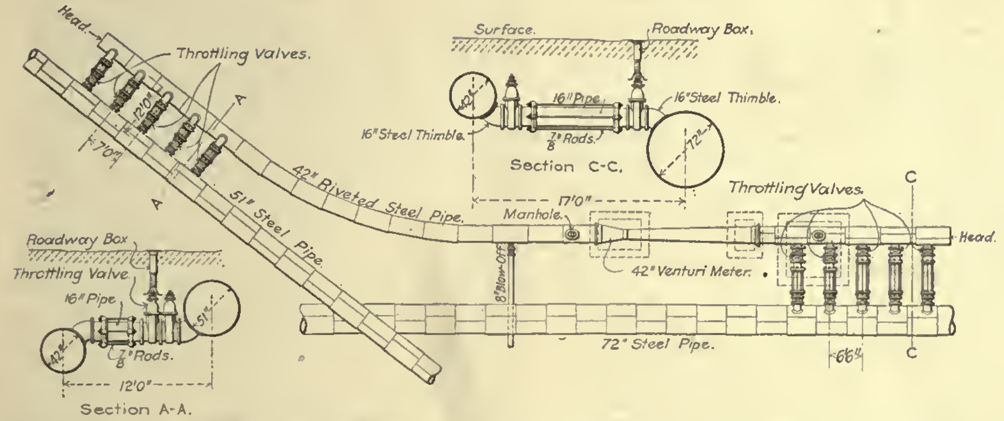
On the Hackensack meadows an embankment high enough to put the bottom of the pipe above extreme high tides, excepting for 300 feet under some side tracks entering a steel works plant, was built of materials obtained largely, on the west side of the Hackensack River, from a railroad cut through a hill west of the meadows, and on the east side of the river from a cut for a railroad yard, both of which the contractor for the pipe line was making under other contracts. This material was placed by means of temporary narrow-gauge tracks and dump cars, the tracks subsequently being removed. The bank on the west side of the river was built up to a level about 2 feet above the bottom of the pipe one and a half years in advance of pipe laying. On the east side of the river the bank was built about six months before pipe laying began, and the contractor at the same time placed a quantity of earth along the line which was estimated to be sufficient to cover the pipe to the required depth of 3 feet on top. The pipes in 30-foot lengths were hauled out over the embankment by the teams which brought them from the contractor's shop, in Paterson, and delivered alongside the embankment on the meadow, where they were exposed to the brackish tide water. Afterwards the trench was excavated and the sections of pipe rolled onto timbers bridging it and lowered to place by two A-frame derricks, as shown in one of the group of three views. After the pipe had been laid, tested and left full of water, the tracks were relaid on the west side of the river on the embankment at one side of the pipe, it having been built broad enough for this purpose, on the side opposite to that on which the material excavated from the trench was cast. A few hundred feet from the river the track was graded up to the level of the top of the pipe and the ties laid directly on the pipe with only sufficient support of earth or stones under the ends of some of the ties at short intervals to prevent tipping and sliding, and the materials were dumped from the cars to raise the bank to the required depth over the pipe, as shown in another view. As the filling progressed the track was shifted accordingly. The cars were always pushed ahead of the locomotive as a precaution, but the locomotive also sometimes went on top of the pipe. On the east side of the river the embankment settled into the marsh more than expected, and so after the pipe was laid there was not sufficient available earth to cover it to the required depth. Consequently it became necessary for the contractor to relay the tracks on top of the pipe, at considerable expense, in order to place the additional filling.

Besides the final 10.9 miles of pipe line from Watchung Mountain, the highlands west of Hackensack meadows, to the city distribution reservoir, there are three other sections of pipe line crossing two valleys and the Great Piece meadow, alternating with the sections of masonry conduit. At all crossings of streams intercepting the pipe lines, the pipe was laid beneath the stream bed. No expansion joints were used anywhere, it being considered that the curvature of the line and the friction of the surrounding earth would take care of any tendency to movement caused by temperature changes, which would be slight after the pipe was connected and covered. Eleven 48-inch horizontal geared gate valves made by the Rensselaer Manufacturing Company, of Troy, N. Y., were set at intervals in the line with reducers 12 feet long on each side. Near the gears of these valves, at one side of the pipe line, a brick shelter house 8x10 feet by 10 feet 6 inches high inside was built to provide shelter for the men operating the valves, as well as places to keep wrenches and other small tools. At all summits and on both sides of each gate valve, Coffin cluster air valves were set thirty-five in all, and covered with suitable chambers. Brick manholes were also built over the gears of the valves. The manhole in each gate or air-valve chamber is covered with an iron frame and cover. A double wooden cover made with a 2-inch air space is placed in each frame about 8 inches below the outside cover.

At the ends of sections of masonry conduit, concrete chambers have been built with connections for two pipes and grooves for stop-planks. One pipe connection in each chamber is closed by a brick bulkhead 24 inches thick. For about 60 feet from the chamber the pipe is surrounded with concrete about 1 foot thick, with collars 3 feet wide projecting 18 inches, spaced 15 feet on centers, in which there are 4x3-inch angle-iron rings riveted to the pipe. The concrete around the pipe is tied to the chamber by 3-inch No. 10 expanded metal embedded in it for about 10 feet and extending into the wall of the chamber. In crossing these chambers there is a drop from the invert of the conduit to the bottom of the pipe usually of about 4 feet, so that the end of the pipe will always be filled when there are 50,000,000 gallons or more flowing.

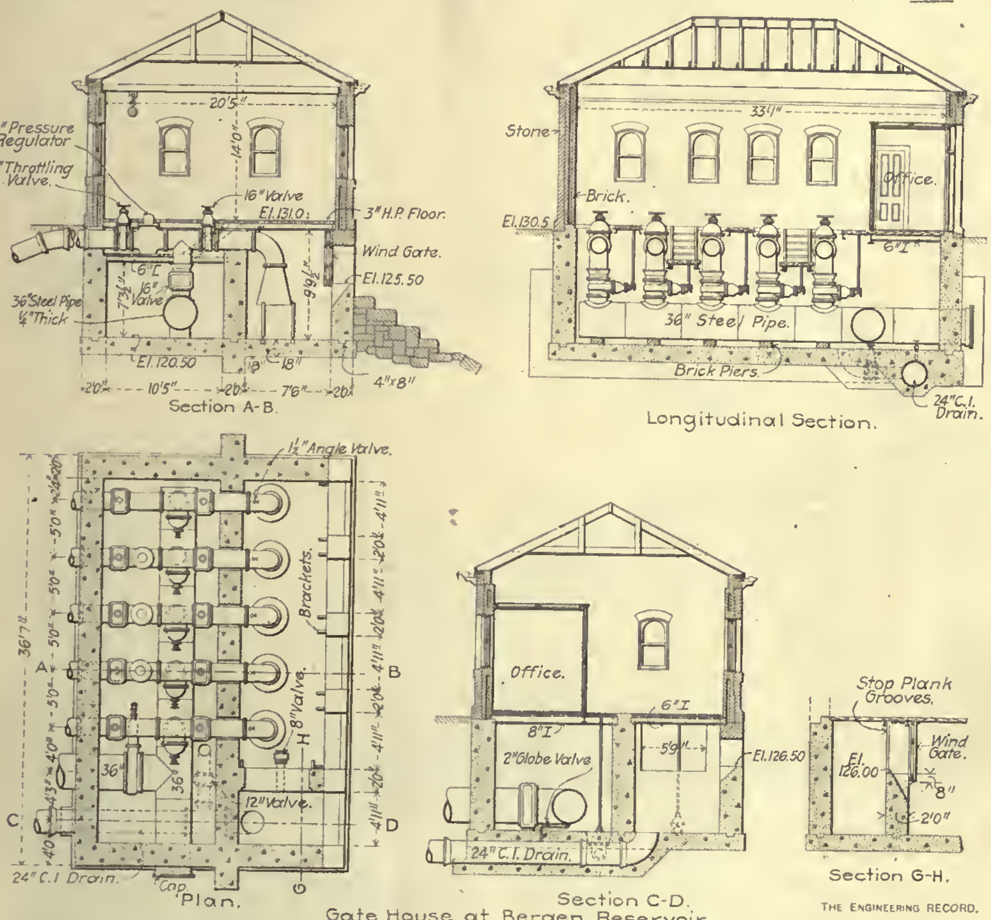
The pipe consists of slightly tapered sections, each made of one plate, with the smaller end of each section entering the larger end of the following section. These sections were shop-riveted into lengths each about 30 feet long, which were tested in a hydraulic press and coated by being partly immersed horizontally and revolved in a trough nearly filled with hot mineral rubber asphalt, furnished by the Commercial Asphalt Company, of New York. While the pipe-laying was in full progress on Hackensack meadows, one week a record of 3,725 linear feet was made in the six working days and one day 870 feet were laid. The total length laid for the month of August was 8,925 feet. All sections of the pipe line were made and laid by the T. A. Gillespie Company, of New York.

According to the general contract made by the city with Mr. P. H. Flynn, in 1899, the works were to have been completed in February, 1902, but, when this date approached, scarcely half the construction had been accomplished. Consequently it became necessary for the city to make an arrangement with the East Jersey Water Company for a continuance of the supply which was being furnished under a contract terminating in October of that year. In order to put a sufficient quantity of water in the city mains, a connection was made between the 51-inch steel conduit of the East Jersey Water Company and the new 72-inch main, the arrangement of which is clearly shown in one of the illustrations. The 72-inch main crossed beneath the 51-inch about 500 feet east of the end of Section 4 of the masonry conduit and advantage was taken of this circumstance. This connection has been in use since June 9, 1903, enabling the city to abandon the other line of supply via Belleville reservoir which included several troublesome pipes across the Hackensack River. Each 16-inch connecting pipe between the mains and the 42-inch riveted steel manifold contains two gate valves, the second valve for security in case of accident to the valve ordinarily in use and for convenience in making repairs, and two of the five 16-inch pipes between the manifold and the 72-inch main have three valves.



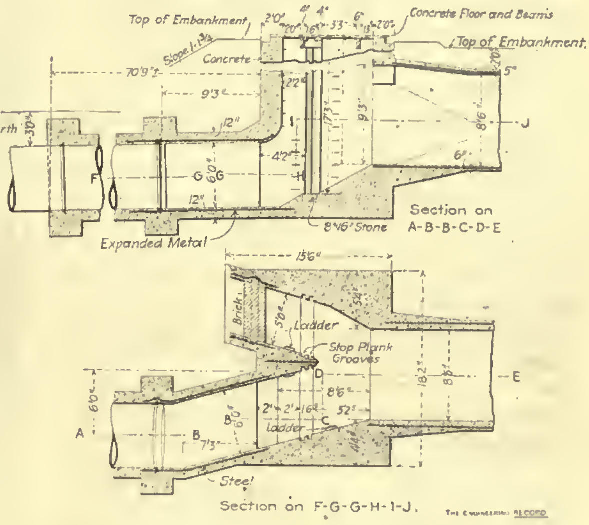
Connection between Steel Pipes of Jersey City Water Supply Company, and East Jersey Water Company.

THE ENGINEERING RECORD



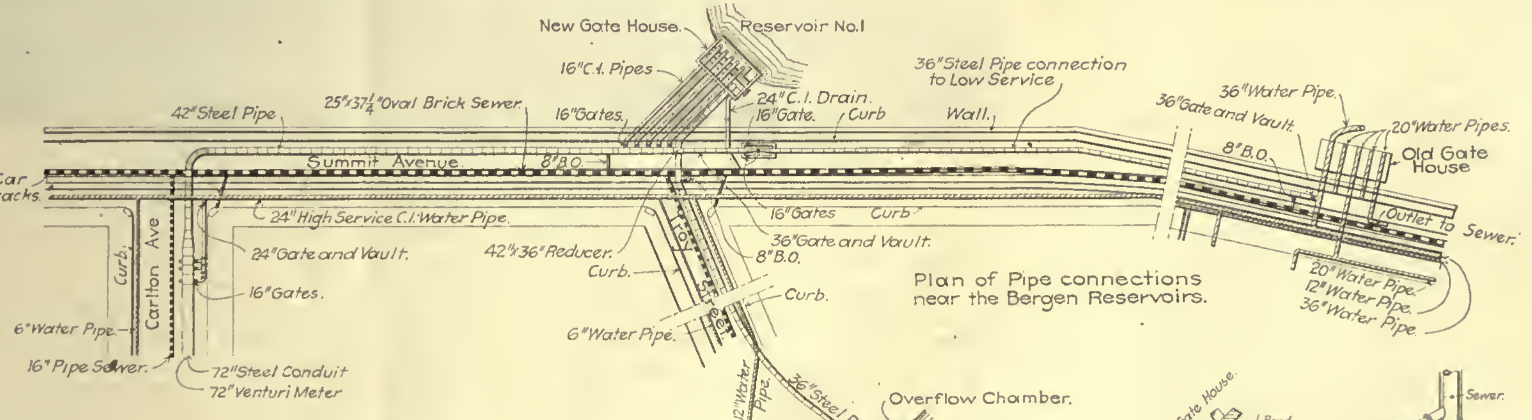
Gate House at Bergen Reservoir.

THE ENGINEERING RECORD.

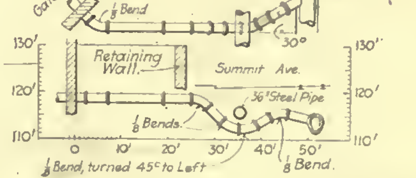


THE ENGINEERING RECORD

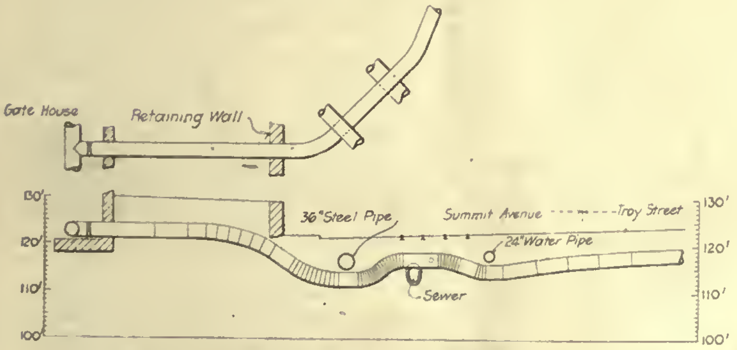
Chamber at Junction of Steel Pipes with Conduit.



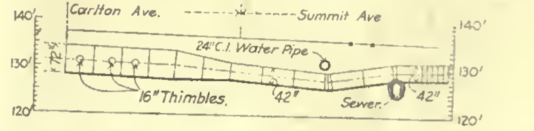
Plan of Pipe connections near the Bergen Reservoirs.



Plan and Profile of 24-Inch C I Drain from Gate House.



Plan and Profile of 36-inch Steel Pipe across Summit Avenue near Troy Street to Reservoir No. 2



Profile of 72-42-Inch Pipe at Corner of Carlton and Summit Avenues

THE ENGINEERING RECORD

JERSEY CITY CONDUIT: SOME DETAILS OF THE STEEL PIPES AND THE TERMINAL GATE HOUSE AND CONNECTIONS.

The supply furnished through the 51-inch main is drawn from the Passaic River and pumped at the Little Falls pumping station without filtration. This water is furnished to other municipalities besides Jersey City, and at the point of connection under description has a greater pressure than is required in the 72-inch main. Hence, ordinarily three or four of the 16-inch pipes from the 51-inch main to the manifold are opened and the valves in these are so throttled as to give the desired pressure. Correspondingly, one or two of the 16-inch connections to the 72-inch main are opened wide and further adjustment is secured by the manipulation of the valves in the two pipes having three valves each. In order to maintain the proper pressure in the Jersey City distribution system, an attendant is on duty at this connection at all hours of day and night, and opens or closes the valves so as to maintain the reading on a pressure gauge on the 72-inch main substantially constant.

The 72-inch steel conduit ends near the Bergen reservoirs of the Jersey City water-works, and a 72-inch Venturi meter furnished by the Builders' Iron Foundry, of Providence, was set in the line about 180 feet westerly from Summit Avenue for measuring the total quantity of water delivered to the city. This meter is claimed by the makers to be the largest now in use, and its recording apparatus, located in the gatehouse described below, is fitted with a chart recorder as well as with the usual dials. Just beyond the meter the conduit is reduced to 42 inches, and from this part of the main five 16-inch cast iron branches are led into a gatehouse, recently completed, on the bank of reservoir No. 1. Besides these there is a 24-inch connection from the 72-inch conduit to the 24-inch high-service main to the city, made by means of three 16-inch side outlets from the conduit. The arrangement of all these connections, which are manipulated by one attendant, together with the design of the gate chamber, is clearly shown in accompanying drawings. A number of combinations for directing the flow of the water in different ways are possible. It being necessary to feed the city low-service distribution under a nearly constant pressure through all the variations of draft, and the pressure in the 72-inch conduit being several pounds in excess of the allowable pressure on this system, Ross pressure regulators have been set in three of the 16-inch pipes, in the gatehouse. Ordinarily only one regulator is in use and a part of the supply goes through one of the 16-inch pipes which has no regulator, the gate being throttled if necessary. Surplus water overflows from the gatehouse into reservoir No. 1, or through a 36-inch steel pipe about 500 feet long into reservoir No. 2, and deficiencies are made up from the reservoirs. Each 16-inch pipe is controlled by means of two Rensselaer hand-wheel indicating valves in the gatehouse and may be shut off by means of another 16-inch valve in the street.

The gatehouse is in telephonic communication with the attendant at the connection with the 51-inch East Jersey conduit and with the pumping station at Little Falls, and changes in the quantity admitted to the conduit to meet considerable changes in the demands are made at these points on the request of the attendant at Bergen reservoir. This attendant lives near the gatehouse and a warning bell in his house is electrically connected with a float in the gatehouse, which carries two pointers set to complete the electric circuit whenever there is a material change in the rate of flow, or the reservoir reaches the established maximum level. A diagram of the pipes has been mounted on a framed board and is hung in the gatehouse. The gates are marked by brass cup hooks, and on each hook is hung a ¼x¾-inch eyelet tag marked with an initial or number indicating whether the gate is wide open or shut or showing the number of turns that it has been partially opened. A row of hooks at the bottom of the board holds the spare tags.

In Summit avenue, opposite the new gatehouse, there is an interesting combination of pipes and valves for controlling the flow through the 36-inch steel pipe direct connection from the conduit to the low-service system at the old gatehouse. A 36-inch valve in the main provides for shutting it off, and just beyond there is a 16-inch gate with a long reducer on each side, around which there are two 16-inch by-passes with 16-inch gates, as shown. The advantage of this layout is the regulation of the supply by means of three small valves instead of throttling a large valve.

Mr. J. Waldo Smith is consulting engineer, Mr. E. W. Harrison, chief engineer, and Mr. William B. Fuller, resident engineer.

(To be continued.)

The Main Span of the Williamsburg Bridge, across the East River, New York City.

Part IV.—Classified Schedule of Erection, Riveting, Special Apparatus, Measurements, Adjustments, and Final Connections.

Commencing Erection of Stiffening Trusses after Completion of Floor System.

Progress of Work.—The progress of the work was carefully arranged in the office by the engineer of erection, and a schedule of operations was furnished in advance to the erectors and was substantially followed by the superintendent. This provided that, at each end of the bridge in the first forty days the traveler should be assembled by the tower derrick in panels 31, 32, 33 and 34 of the main bridge span, and should move from the towers to the center of the bridge, erecting all of the floor system of a total weight of 1,365 tons. The second movement of each traveler from the center of the main span to the towers was given fifteen days for the erection of 606 tons of floor-beam brackets and outside stringers. Twelve days were allowed for the third movement from the tower to the center of the span, and the storage of material on the floorbeam brackets; twenty days for the fourth movement of the traveler from the center of the span to tower, storing 1,127 tons of material between the trusses. In the forty-seven days allowed for the second, third and fourth movements, 15,000 rivets were to be driven in the floor-beam connections. In the fifth movement of the traveler from the towers to the center of the span, 1,679 tons of material, completing the span, were to be erected in thirty-three days and 30,000 rivets driven. Fifteen days more were allowed for the removal of the traveler and in this time and fifty-five additional days it was estimated that the remaining 105,000 rivets could be driven by ten pneumatic hammers. Ten days longer were allowed for the completion of the painting, which it was calculated might be finished by 23 men in seventy days, assuming that one man could paint 2½ tons of iron two coats in one day. This schedule assumed simultaneous operations of both travelers, which were kept at all times within one or two panel points of the same position relative to the center of the span. All the above data apply to one-half of the bridge only. The schedule was slightly modified in execution and no rivets at all were driven until the erection of the trusses was practically completed.

Handling and Riveting Members.—It was planned that the field rivets in the joints of the floor-beam and lower chord connections should be driven as indicated by the accompanying diagrams. Suspender rods A and C were to be removed and the adjacent rivets e, f, g, and h, driven through the lower chord webs. Rods A and C were then to be replaced, B and D removed, the remaining rivets i, j, k, and l driven through the chord webs, the rivets were to be driven through the diaphragm and the rods B and D replaced, but their nuts not screwed down until the final adjustment. This plan was changed and all four suspender bolts were removed, all the rivets driven at once, and the bolts replaced. Special wrenches were required for the nuts on the suspender bolts and special pneumatic hammers for driving the rivets e, f, i and j. Special dolly-bars were also made for this work and for riveting the hangers from the overhead trusses, provided with beveled bearing blocks, to which they were chained. None of the lower chord splices were bolted until after all of the material erected by the first traveler movement was suspended from the cables, just prior to the meeting of the bottom chords at mid-span.

The 20-ton chord sections were hoisted by special riveted plate clamps which had bearing angles engaging the under sides of top and bottom flanges and were locked to the chord, as shown in the detail drawing. Owing to the different dimensions, different clamps were required for the top and bottom chords, but they were substantially alike. A few special sections of the bottom chord were lifted by clamps which consisted of a shackle, like that shown in the top chord clamp, with the side pieces replaced by flat vertical plates 18 inches wide, ¾ inch thick and 5½ feet long, each of which had twenty-two open holes through which it was bolted to the chord web.

The floor-beams were handled by flat plate hook clamps with holes in the horizontal lips through which they were bolted to the top flanges of the floor-beams. After the fourth movement of the travelers, when all of the material for the suspended span had been distributed, and previous to the erection of the stiffening trusses, the cables were subjected to their final dead load, less the roadway floor, and had assumed their approximate ultimate position. To secure this position it had been necessary to make an adjustment of the suspension bolts so as to secure uniform loading of the cables and regularity of the floor camber. This was accomplished by screwing the nuts until the measured vertical distances between the centers of the upper chords and the centers of the main cables at the different panel points corresponded to the tabulated computed distances. As these distances vary from 12 to about 190 feet, and the cables were inclined and were not in the vertical planes of the trusses, there was considerable difficulty in making the measurements. The work was finally accomplished by computing a table of constants and measuring to fixed points, from which accurate distances could be determined and required dimensions obtained by the application of corrections.

Williamsburg Bridge, New York: Assembling Top Chord of Stiffening Truss.

Measurements and Adjustments.—A light wooden lattice girder about 22 feet long and 2½ feet deep was seated across the pairs of cables with bearings on the suspender saddles. The ends of the lower flange of the girder were graduated so that the men on each cable could set them to corresponding figures and so center the truss with the cables. At the center point of the truss a vertical hook-bolt passed through the flanges and was adjusted by nut bearing on top. From the hook was suspended a piano wire 100 feet long, and from the bottom of it measurements were taken to the lower point, on an ordinary steel tape in the panels near the towers. When the height of the cables was less than 100 feet above the chord, the wire was replaced by an ordinary 100-foot steel tape which was attached to the hook. Differences in elevation of the cables were corrected by wedging under one end of the girder. The distance from the hook to the top of the frame seated on the chord was recorded, and the level of the top of the frame was marked with paint on both the suspended cables. The frame was about 4 feet high and enabled the measurement to be taken to the upper edge more accurately than it could be made on the chord. Constant corrections were determined for the vertical distance between the centers of the cables and the zero point of the tape line or the upper end of the wire. Other corrections were determined to allow for the vertical distance between the top of the measuring frame and the chord, as well as for the slope in the longitudinal offset made by setting the frame a short distance beyond the panel point. These corrections were all applied to the recorded measurements and the difference was taken between the result and the required height at this point.

The suspender nuts were then screwed on or off until the distance from the top of the chord to the painted marks on the suspender cables was brought to the required amount. After the truss was completely assembled, these measurements and the camber of the bridge were made as exact as possible before the chord splices were riveted. The last splices to be riveted were those just outside the towers between panel points 31 and 32, at the end panels where the truss is supported on rocker bents in the towers. The last connections to be riveted were those of the end lateral struts to the tower members.

The suspended span is not connected to the tower in any way except by means of a rocker, which allows of expansion, but it cantilevers through the tower and picks up the end of a span suspended from it and from a cantilever arm on the shore. The pin connecting the main span and suspended span was driven as soon as the former was erected at that point, because it was feared it might afterwards be impossible to make the holes come fair, on account of the movement of the cable. The first splice from the tower in the bottom and top chords was left open, and was connected on a hot day, when the temperature made the chords butt.

The erection of the suspended span conformed to the requirements of the Department of Bridges of Greater New York, Mr. Gustav Lindenthal, commissioner; Mr. L. L. Buck, consulting engineer, and Mr. O. F. Nichols, engineer in charge of the Williamsburg bridge. Mr. K. L. Martin was the assistant engineer in charge of the shop work, and erection of the suspended span. The Pennsylvania Steel Company was the contractor for the manufacture and erection of the center span; Mr. J. V. W. Reynders, superintendent; Mr. F. W. Cohen, engineer of erection; Mr. Walter T. Brown, resident engineer. The erection was under the immediate supervision of Superintendent A. N. Gross, who had previously erected the famous Gokteik viaduct built in Burmah by the Pennsylvania Steel Company and described in The Engineering Record of January 12 and 26, 1901.

The Filter Galleries for the Water-Works of Laredo, Texas.

By A. L. McLane, Superintendent.

In a concave bend of the Rio Grande, at Laredo, Texas, is an island of sand and gravel formation resting upon the rock bed of the river. This island is 300 feet distant from the east bank and 500 feet from the west bank of the river, and extends up and down the river 1,800 feet, varying in width from 200 to 500 feet, with a gradual rise in its surface from the water's edge to a maximum height of only 7 feet, so that the entire island is frequently submerged. The rock bed of the river is from 3 to 16 feet below low-water level. The bottom of the river is a clean gravel and coarse sand resting on the rock bed; in shallow places the rock bottom is bare. The top layer of sand on the island is a fine sharp white or gray sand, when dry. At the highest points it is about 2 feet deep, decreasing in depth towards the water's edge. Next follows a coarser sand mixed with fine gravel. Both sand and gravel increase in size with depth until the gravel, or a large proportion of it, is from 3 to 6-inch cobblestones.

Under this deposit of sand and gravel 3,100 feet of horizontal galleries or conduits have been built by the Laredo Water Company to conduct the filtered water to a tunnel excavated in rock under the river and emptying into the receiving well located in the pump house on the river bank. The pump room is 20x60 feet, and its floor line is 60 feet below the general level of the city. The pumping machinery comprises one Worthington and two Blake pumping engines, having an aggregate capacity of 4,000,000 gallons daily. There is also one 6-inch centrifugal circulating pump of the double-suction type directly connected to a 5x5-inch vertical engine, all made by the Wheeler Condenser & Engineering Company, of Carteret, N. J., which discharges 1,000 gallons of river water per minute on to the island, at times of continued low water, at a cost of 8 cents per hour for steam consumption. This raw water is retained by sand banks to prevent its flowing back into the river.

The galleries, so far as built, form the sides of a parallelogram measuring 300 and 320 feet at the ends and about 1,250 feet on each margin of the island. From three corners it is proposed to extend the galleries in line with the long sides of the parallelogram, and from one of these corners the tunnel beneath the river follows a continuation of the line of one of the short sides; but it is at a level 13 feet lower than that of the galleries. At this corner there is a shaft down which the water falls to the tunnel, and in which are the valves for regulating the flow from the galleries to the tunnel. The tunnel is 375 feet long, 4 feet wide and 5 feet high; it has a second shaft 75 feet from the pump well, at the margin of the river, known as shaft B. On the west side the galleries are located about 100 feet distant from low water. They consist of 6x6-inch timber cribbing bolted to the rock bed, having an inside width of 3 feet and a height of 12 inches. The trench was back-filled with sand and gravel to the original ground level. The filtered water enters laterally between the rock and the lower timber. The outlet from these galleries into the tunnel is on a level with the top of the timber conduit, thus keeping the woodwork constantly submerged. On the east margin of the island the floor of the conduit is at a uniform depth of 9 feet below low water, except at depressions in the rock, which are built over with cribbing resting on the gravel bed. This conduit is excavated through rock, and its width is 2½ feet. The top is covered with concrete arches, the edges of which rest on brick walls laid without mortar, with the exception of a length of 250 feet, which is made watertight to prevent the entrance of sand at high water.

The flow of water into the tunnel from either line of filter galleries is controlled by suitable arrangements of valves, and likewise the flow from the tunnel into the pump well. The rock walls of the shaft at the entrance to the tunnel are pierced by holes into which are built two 12-inch cast-iron pipes, at right angles to each other, tapping the two galleries which meet at this point. These short pipes are controlled by Ludlow gate valves, and the stem of each gate rises to a working platform in the upper part of the shaft. Each of these pipes is laid at the level of the gallery floor, but ends in a short riser in the shaft extending to the level of the top of the gallery. The elbows of these risers are flange connected so that they can be removed, thus making it possible to draw the water below the tops of the galleries, if desired. At shaft B and also at the pump well, there is a brick wall closing the tunnel, and through each of these walls there is a 12-inch cast-iron pipe with a Ludlow check valve, preventing backward flow into the tunnel. The pipe extending into the pump well has a 12-inch Crane valve provided with an indicator post on the engine-room floor, and ends with an upturned elbow. There is a float indicator in the well.

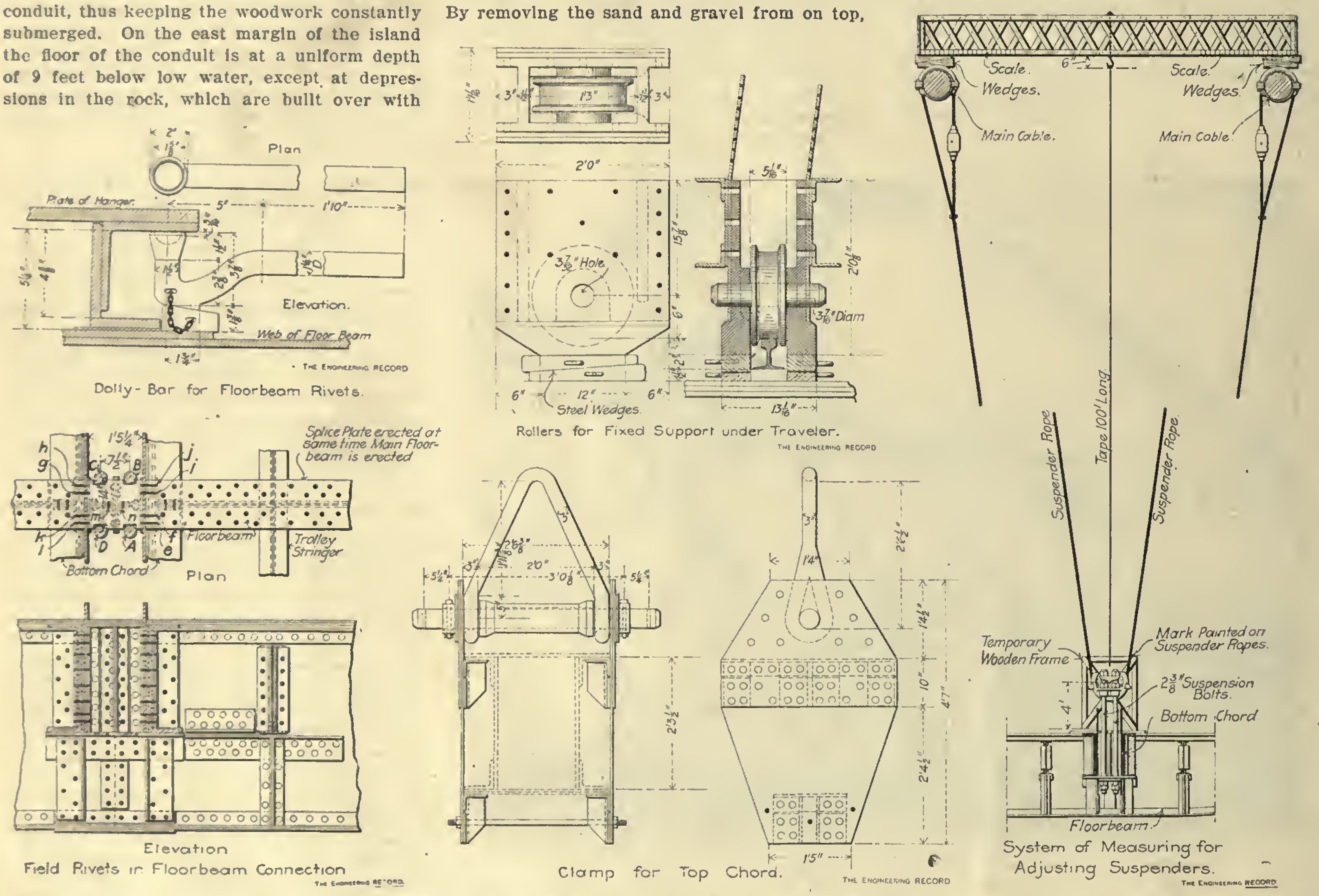
There are several places on each line of galleries provided with entrances for inspection. These entrances are made of and covered with cribbing and filled over with gravel and sand. Their covers are about 8 inches above low water in gallery, but below low water in the river. By removing the sand and gravel from on top, the cover can be unscrewed and removed in sections. This allows inspection at a given point only, but these entrances, being at the lowest depressions in the gallery, each indicate the condition of the gallery to the next entrance above and below. The last statement applies to the gallery on the west margin of the island only, which is covered by the river by a rise of only 18 inches, leaving this gallery in the bed of the stream. The gallery on the east margin can be entered, inspected and cleaned if necessary for most of its extent.

A number of springs were developed in the rock cut which furnish a considerable supply. By pumping sixteen hours daily for a period of twenty-one days, during low water, with an average draft on the filters of 960,000 gallons, the water was lowered 5 feet. A rise of 4 feet in the river increased the supply so that a draft on the filters of 1,600 gallons per minute for ten days did not perceptibly lower the water in the galleries. A section of the gallery on the west margin has been in use fourteen years, and no trouble has been experienced from sand or silt. The gallery from the tunnel entrance shaft across one end and along one side of the parallelogram has been in use two years, and no trouble has been experienced from the entrance of sand. The supply seems to increase with use. The only expedient adopted to prevent the entrance of sand is to avoid lowering the water below the top of the cribbing so that there is no draft below that level.

There has been no noticeable change in the quality of the filtered water shown by analysis. The effect on boilers is more satisfactory than that of the river water. Various analyses of the river water gave 36 grains of solids to the U. S. gallon. The results of an analysis of the filtered water made by the Kennicott Water Softener Company, of Chicago, are given below:

	Grains per gallon.
Calcium carbonate	7.17
Calcium sulphate	6.25
Calcium chloride	None
Magnesium carbonate	1.37
Magnesium sulphate	5.41
Magnesium chloride	None
Sodium sulphate	3.32
Sodium chloride	11.07
Sodium carbonate	None
Oxides of iron and alumina	Trace
Carbonic acid	4.68
Silica	1.54
Alkalinity	7.58
Suspended matter	None
Total incrusting solids	21.74
Total non-incrusting solids	14.39
Total solids	36.13

The annual rise in the Rio Grande at Laredo begins in April and continues until November, varying in height from 12 inches to 25 feet. During most of this time the river carries about 555 grains per U. S. gallon of sand, clay and silt, but the velocity of the river on both sides of the island is such as to prevent deposits of silt in that part of the river.



Dolly-Bar for Floorbeam Rivets. The Engineering Record

Elevation
Field Rivets in Floorbeam Connection. The Engineering Record

Rollers for Fixed Support under Traveler. The Engineering Record

Clamp for Top Chord. The Engineering Record

System of Measuring for Adjusting Suspenders. The Engineering Record

Williamsburg Bridge, New York: Miscellaneous Details of Erection.

The Marietta Long-Span Highway Bridge.

PART II.—APPROACHES AND SHORT-ARM CANTILEVER.

The general design, stresses, dimensions and deflections of the new highway bridge across the Ohio River between Marietta, Ohio, and Williamstown, W. Va., were treated in an article published September 26. The Ohio approach is a plate-girder viaduct, about 644 feet long on the center line, which carries an electric car track, a carriageway and a 5-foot sidewalk at 6 per cent. grade. The height above the surface of the ground varies from about 15 feet at the end of the embankment approach to nearly 53 feet at the anchor pier of the 130-foot anchor span. For the first 251 feet, the viaduct is nearly parallel with the river, and is connected by 90 degrees of a curve of about 57½ feet center radius with a 382-foot section nearly at right angles to it which reaches to the anchor pier, where it intersects the line of the truss spans at an angle of 38 degrees and 55 minutes.

The plate girder approach was designed throughout for the same live load as given in the previous article for the floor system of the trusses. The girders are all 30 feet span and 36 inches deep, except at the curve, where the length varies, and at the lower end of the approach, where, in order to provide the required head room, a girder 18 inches deep was set up in the plane of the floorbeam. They are built with a ⅜-inch web and four 5x3½x7/16-inch flange angles, and rest directly on top of the columns with a slotted connection for expansion at each tower.

The columns are composed of four 4x5/16-inch Z-bars and one 7x¼-inch web plate. The length or height of the columns varies from about 10 feet at the lower end to 44 feet near the bridge. The columns and girders are set in two lines 20 feet apart on centers, and are connected transversely by a latticed strut, 36 inches deep, between the girders and directly over the columns. All columns are braced together transversely with diagonal sway bracing forming them into bents, and longitudinally the bents are braced so as to form each two bents into a tower, except near the curve, where the towers are irregular.

Each column rests on a concrete pedestal about 5 feet square at the bottom, stepped off to 3 feet square at the top, and is connected to the pedestal by two 1-inch bolts, extending through a gas pipe thimble about 2 feet long, in the top, and engaging an anchorage plate near the bottom of the concrete. The concrete extends about 5 feet below the surface of the ground and 1 foot above. The pedestal is nicely rounded off on top with 6 inches of neat cement mortar. The base of each column is filled with concrete to the top of the bottom gusset plate, a depth of about 12 inches, to prevent water from collecting there.

The floorbeams, which are 20-inch I-beams, rest directly on top of the girders. They are spaced 15 feet apart, and at each end project about 4 feet beyond the girder. At every second floorbeam is an angle knee brace, on the down grade side, from the web of the beam to the flange of the girder, to react any tendency of the beam to tilt down grade. The roadway is brought to the proper radius around the curve by varying the lengths of the ends of the floorbeams projecting beyond the girders, which are here set on irregular arcs of the curve.

Above the floorbeams are the wooden joists supporting the roadway, the 5-foot sidewalk, and the street railway track. The approach railing 39 inches deep is the same as that on the bridge. The top flange is a Carnegie tee No. 154; the bottom flange one 2x2x¼-inch angle, and the web is made of curved 1x1x 3/16-inch angles. On the straight part of the approach the hand rails are set 28 feet apart in the clear. Around the curve in the viaduct this distance is widened to 30 feet 6 inches, to clear the street car in turning. A clearance is provided for the car rounding the curve at the end of the 130-foot span by carrying the sidewalk outside of the truss for one panel. The street railway track is laid in the roadway on the side opposite the sidewalk just far enough in to clear the hand rail. This track was laid at one side throughout the entire length of the bridge, so that another track can be laid alongside if the traffic demands it.

The end of the 130-foot span, under all ordinary conditions of loading, exerts an upward force on the anchorage pier, causing tension in the top chord, which, for this reason, is composed of eye-bars, as noted in the previous article. To provide for any possible compression that might arise from a heavy load on the 130-foot span with no load on either the 80-foot arm or 270-foot span, the top chord eye-bars in the first four panels from the anchorage pier are laced together, forming a member capable of transmitting compression.

The maximum uplift on the anchorage pier figured for dead and live load is 129,200 pounds for each truss, but during erection this increased to 210,000 pounds. The anchorage has two vertical 6x1⅛-inch eye-bars 39 feet 8 inches between pin centers, extending down through an opening in the pier. The lower ends of these bars pass between two 20-inch I-beams, and are pin-connected to them. Resting on top of the 20-inch I-beams are six 12-inch I-beams 34 feet long, three on each side of the eye-bars, extending horizontally through the masonry from the anchorage bars of one truss to those of the other. The vertical opening in the pier for the bars is 24x27 inches to the coping stone, where it is reduced to 8x18 inches. There is also a horizontal opening in the bottom of the pier sufficiently large for a man to enter and adjust the anchorage pin if necessary.

At the top of the main anchorage bars a pin 5⅞ inches in diameter connects them with a vertical 2¾x2¾-inch U-bar about 10 feet long. The loop is down and the legs pass through the bottom chord of the truss on each side of the truss pin, thence upward through a riveted bearing box and a cast-steel rocker saddle resting on the box. The upper ends have nuts bearing on top of the rocker saddle and secured, after final adjustment, by means of ¾-inch set screws.

To provide anchorage laterally and allow longitudinal motion for expansion and adjustment, a solid cast-iron block, beveled to fit the grade, is riveted to the bottom chord of the truss, and engages a cast-steel pedestal which is dapped into the pier and anchored with four 1¼-inch stone bolts. The U-bar passes through slotted holes in both the cast-iron block and the cast-steel pedestal, thus allowing free longitudinal motion. As it was possible for a heavier lateral stress to occur here during erection than at any other time, temporary wooden struts were provided to brace the pier. As it was necessary to have the cast-steel pedestals true longitudinally, they were not set until after the 270-foot span was swung. They were made in two parts, bolted together through the vertical web, so they could be set at any time after the erection was begun.

To secure proper adjustment longitudinally after connecting the cantilever portions at the center of the 270-foot span, the trusses were set on rollers at pier No. 2. Seven of them, 6 inches in diameter, under each truss, were set on a cast-iron bed plate 2 inches thick and guided by a tongue on the plate working in a groove in the rollers. They had a square hole in each end so a wrench could be inserted to turn them and move the trusses backward or forward, as the case required. After the permanent adjustment was made, these rollers were formed into a solid fixed bearing by filling the spaces between them with rust cement and tamping it in firmly. It was actually found unnecessary to move the trusses longitudinally, as they were sufficiently accurate in position without adjustment.

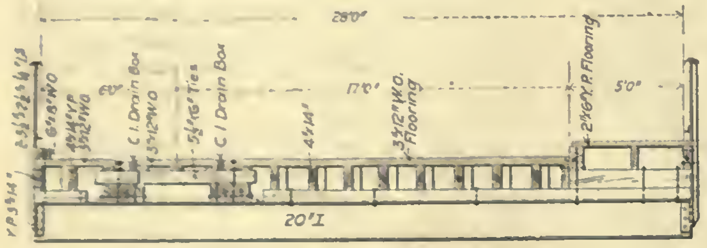
As may be seen from the general elevation published in The Engineering Record of September 26, the top chord is made continuous from the cantilever arms to the suspended span. This, however, is for appearance only. After the suspended span was swung, a panel of bars was inserted with slotted holes for the pin at U 1, so that no chord stress can pass through this point. The top lateral stress of the 270-foot suspended span is carried down through the portal and inclined end posts to the bottom chord, where it is transmitted to the cantilever arm. On the end floorbeam of the 270-foot span a ⅜-inch web plate extending the entire length of the beam is riveted to one angle of the bottom flange. This web extends out toward the cantilever arm to a width of about 30 inches at the center, but is cut down gradually to a width of about 3 inches at each end, and on its outer edge is riveted a 6x4x⅜-inch bent flange angle with the 6-inch leg turned up. At the center of the beam is another web plate of the same width, but only about 3 feet long, connected to the web of the floorbeam in a plane parallel to the long one, but about 6 inches above it. These webs are connected at the outer side, and supported from the web of the floorbeam by two brackets. They carry a 6x4-inch solid rectangular vertical pin about 1 foot long, held rigidly in all directions by passing through a hole in each web plate. This pin engages a longitudinal slot 22 inches long in a horizontal web projecting from the end floorbeam of the cantilever arm. This web is similar to the one on the other floorbeam, but has the 6-inch leg of its flange angle turned down, instead of up, and passes below the other web with only a slight clearance between them. This connection between each end of the 270-foot span and the cantilever arms resists any lateral motion, but allows free longitudinal motion. The 270-foot suspended span is hung from the cantilever arms at each of the four corners by two 8x1 5/16-inch vertical eye-bars laced together, with the end floorbeam riveted to the inside bar. Wherever eye-bars are laced to form a stiff member, one flange of a 2½x2½-inch angle is riveted to each bar, and the lacing is riveted to the other flange of the angle.

The floorbeam at each panel point of the 130-foot span, the 270-foot span, and the 80-foot cantilever arm has a maximum moment of 3,474,000 inch-pounds and an end shear of 38,000 pounds. The 36x⅜-inch web is reinforced at each end by two ⅜-inch plates which are cut out to clear the bottom chord of the truss and extend above the top flange of the beam to receive a riveted angle connection to the vertical post. These floorbeams carry three lines of 20-inch I-beam stringers connected to the lower part of the web, and support on their top flanges one 12-inch I-beam sub-floorbeam. The steel floor system of the 600-foot span and the 300-foot cantilever arm is similar to the one described here, except that the floorbeam web is 43 inches deep; the I-beam stringers are 24 inches deep and carry two sub-floorbeams, which are web-connected to the stringers.

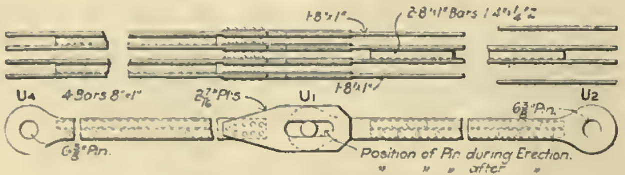
In the 300-foot cantilever arm, as well as in the 130-foot span and 80-foot cantilever arm, where the top chord is composed of eye-bars, the vertical posts extend above the pin and form a connection for the top struts and lateral plates.

At the high hip of the 600-foot truss where eye-bars are pin-connected to the built section, it was necessary to use a pin 10½ inches in diameter to resist the heavy bending moment. On account of the cantilever connection, only tension is transmitted through the top chord at this point. To obtain the necessary section to transmit this tension long pin plates were used, riveted to the webs of the chords and extending about 10 inches above the cover plate, and along the chord 8 feet back from the pin center. To clear these pin plates, the cover plate was cut off 16½ inches back of the pin. At pier No. 4 each truss of the 600-foot span rests on a nest of six 7¾-inch rollers, and the web plates of the shoe extend above the pin and support the end floorbeam.

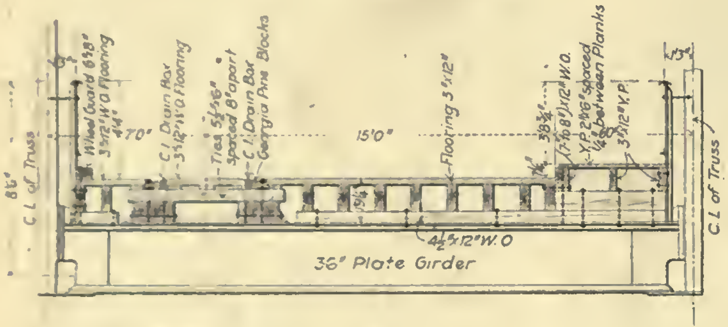
Centering over pier No. 3, where the 300-foot



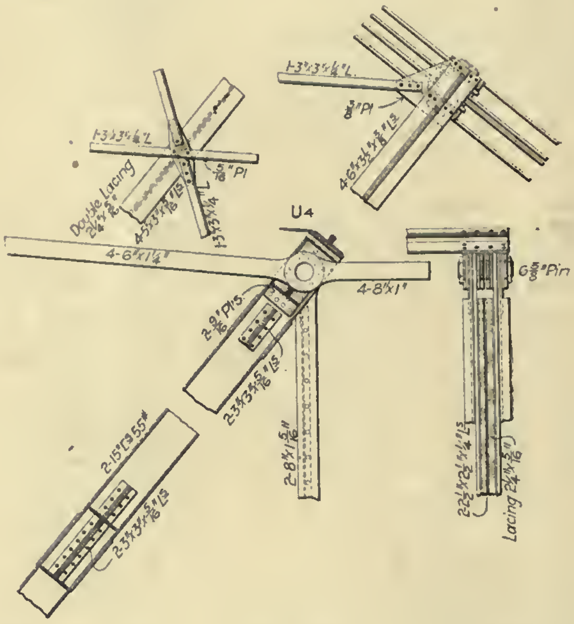
Floor System in Viaduct Approach



Top Chord Adjustment.

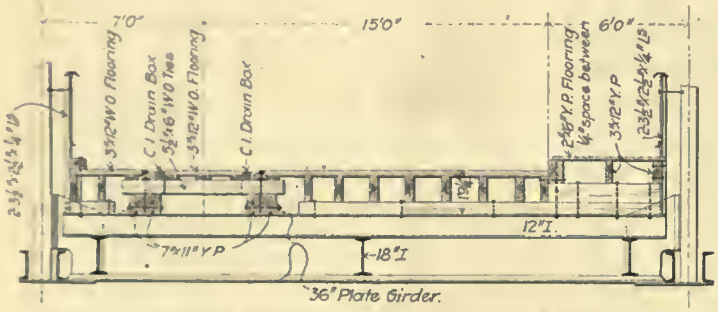


Floor System in 220' Span



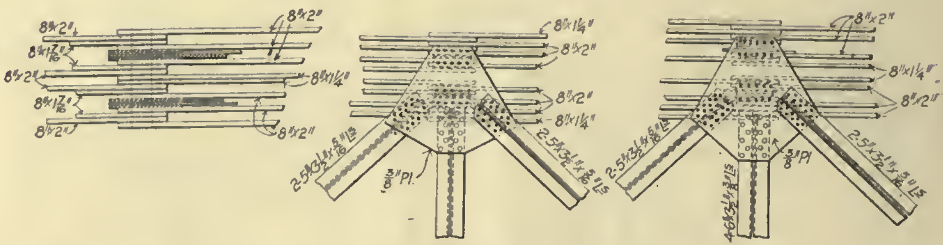
Top Chord connection of 270 Foot Span with Cantilever Arm

THE ENGINEERING RECORD

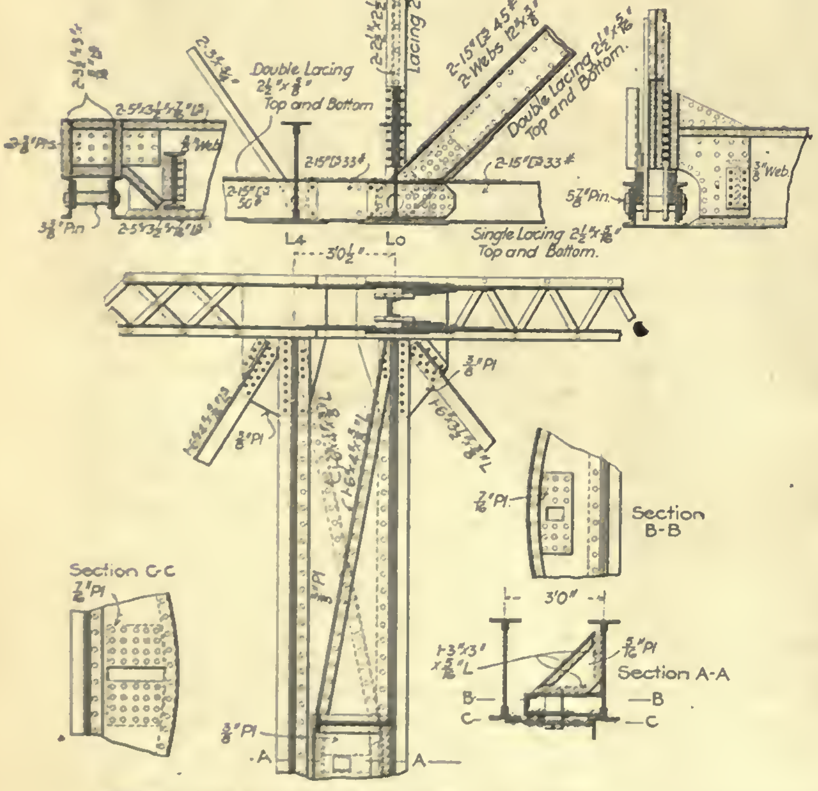


Floor System in 270, 80 and 130 Foot Spans

THE ENGINEERING RECORD

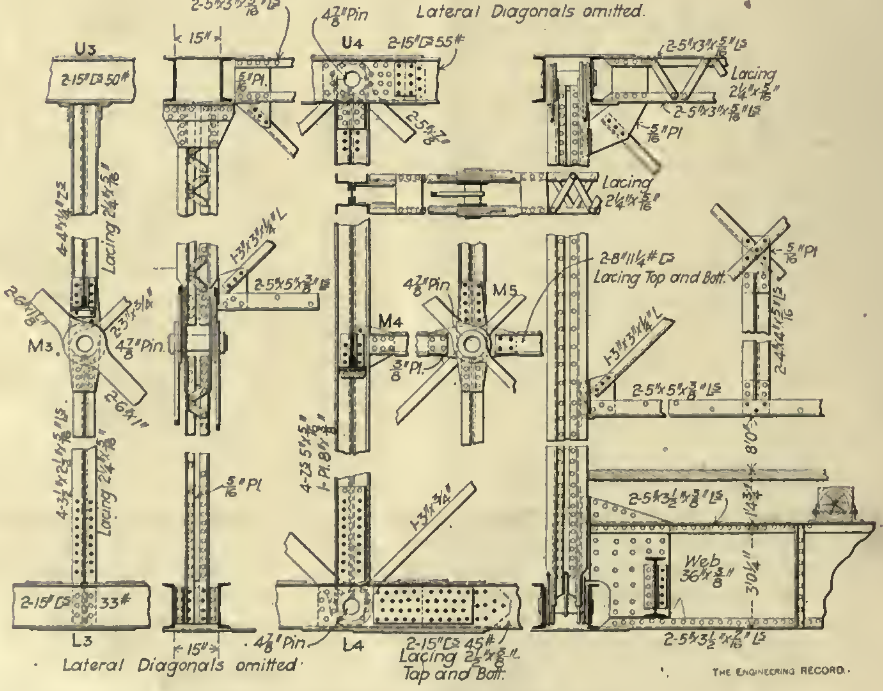


Top Lateral connections.



Bottom Chord and Lower Lateral connection of 270 Foot Span and Cantilever Arm

THE ENGINEERING RECORD

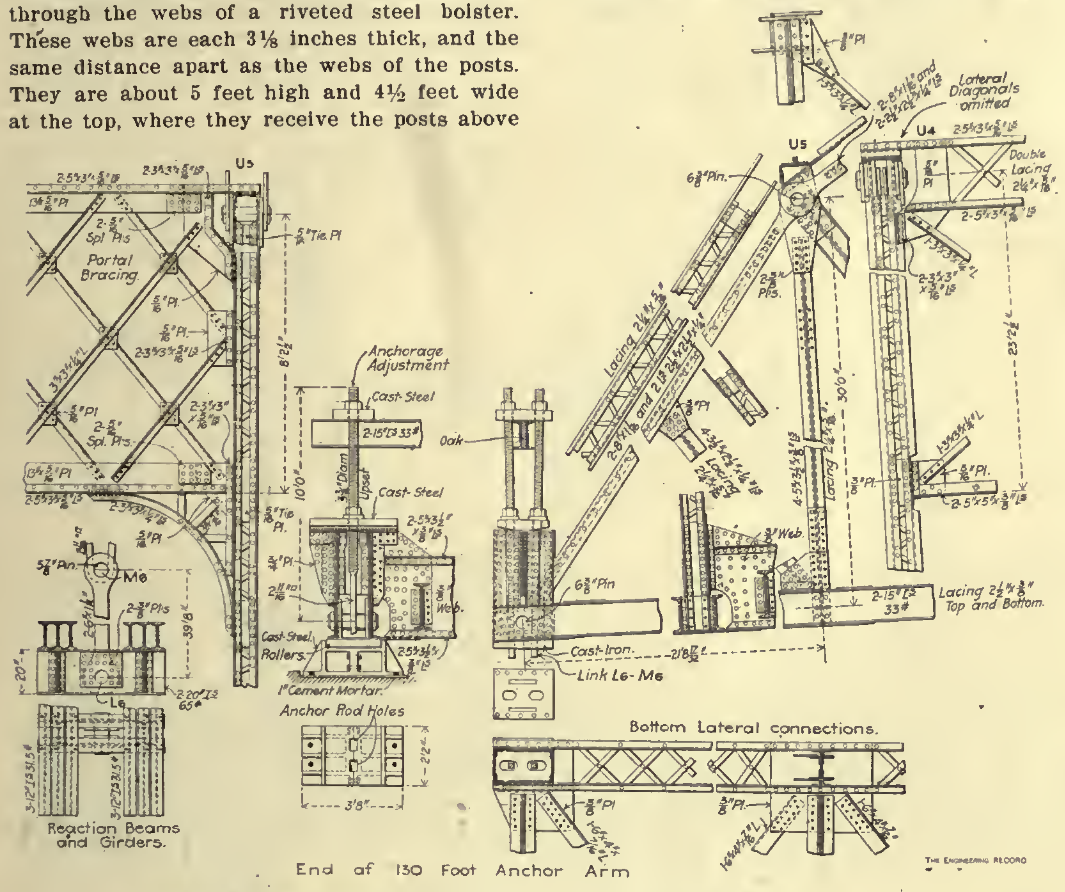


Typical Details of 270 Foot Center Span.

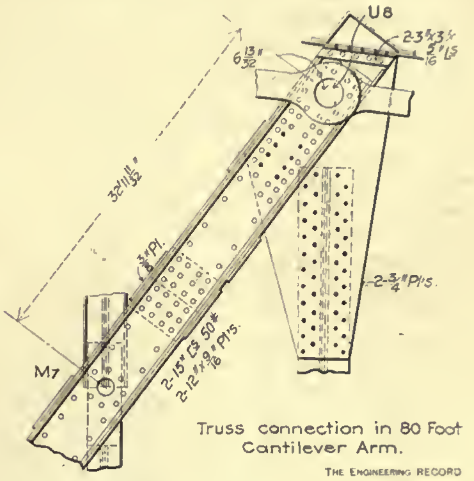
THE ENGINEERING RECORD.

THE MARIETTA BRIDGE: THE FLOOR SYSTEMS AND SOME DETAILS OF THE CENTER SPAN.

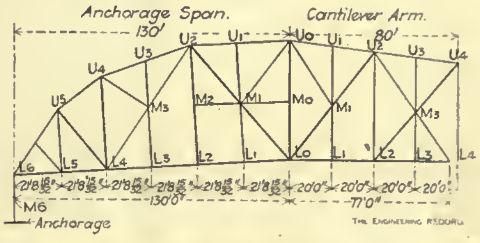
cantilever arm meets the 600-foot span, there is a load of about 2,000,000 pounds from each truss, and a lateral stress of about 400,000 pounds total has also to be transferred to the masonry at this point. The vertical loads are transmitted from the posts by direct bearing through the webs of a riveted steel bolster. These webs are each 3⅛ inches thick, and the same distance apart as the webs of the posts. They are about 5 feet high and 4½ feet wide at the top, where they receive the posts above the bottom chord. They pass down between the webs of the chord and connect to it by a 6-inch pin, and also by angles riveted to the flanges. They are connected to each other by three diaphragms, thus forming a rigid bolster which takes bearing at the bottom on a cast-steel pedestal or shoe. Here the webs are 2 feet wide, and are planed concave to a 33-inch radius. The casting being planed convex to fit the bearing surface of the bolster forms the equivalent of a joint with a pin 24 inches in diameter. Jaws 1½ inches thick extend up from the casting about 9 inches on each side of each web of the bolster. Passing through these jaws and bolster web is an eye-bolt 4⅞ inches in diameter. The eye of this bolt is connected by a 5½-inch pin to a bracket riveted to the bottom flange of the floorbeam. This bracket takes bearing on a planed surface on the inside of the cast-steel shoe, and is held firmly against it by the eye-bolt, which has double nuts on the outer end bearing against the opposite side of the casting. By these means the floorbeam is rigidly connected to the

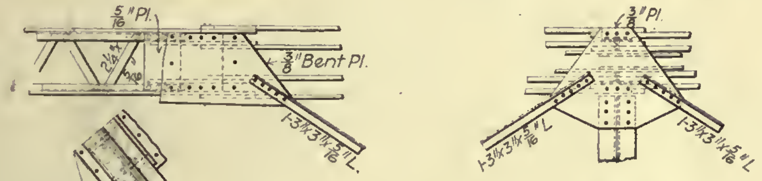


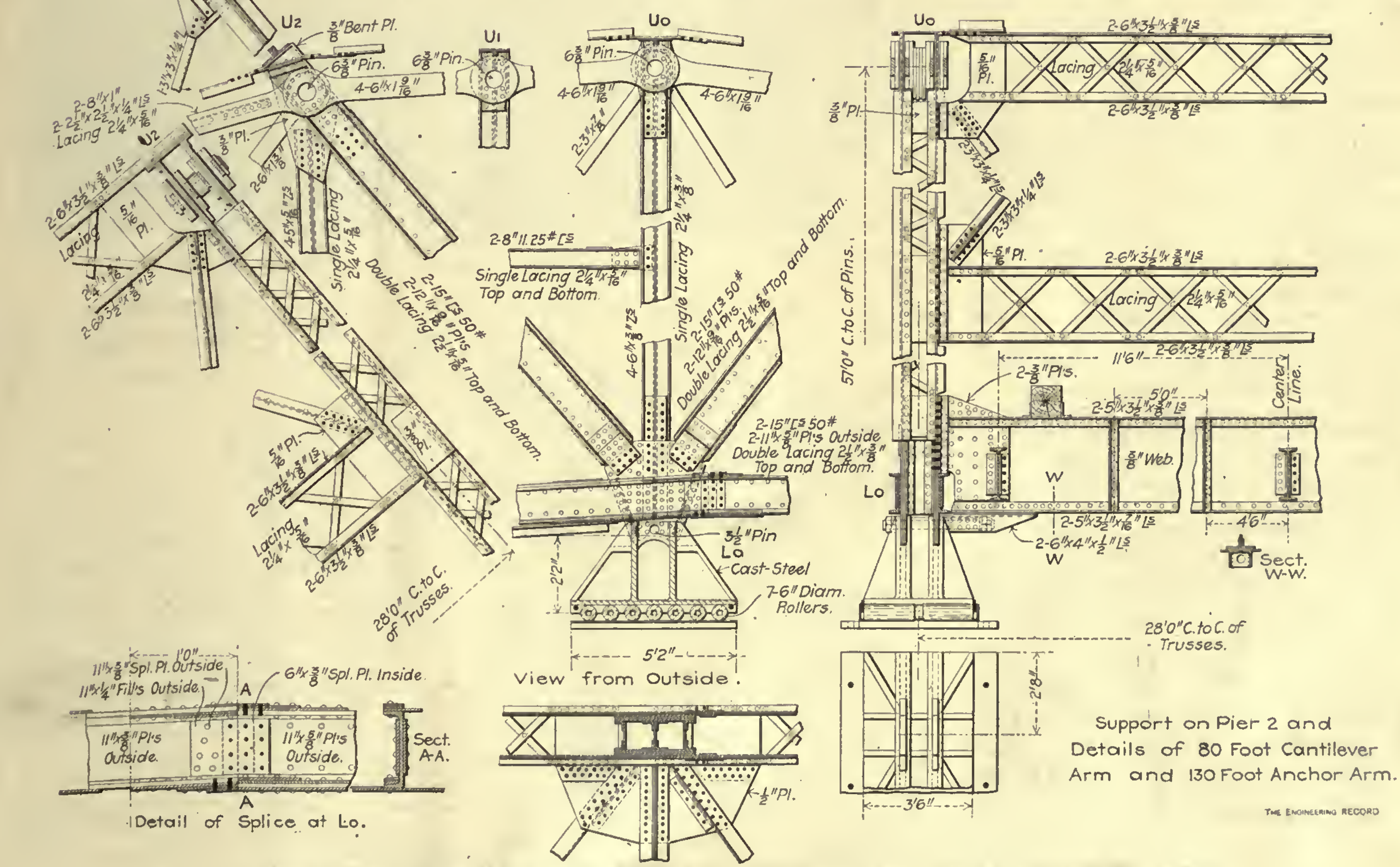
End of 130 Foot Anchor Arm



Truss connection in 80 Foot Cantilever Arm.







Support on Pier 2 and Details of 80 Foot Cantilever Arm and 130 Foot Anchor Arm.

THE MARIETTA BRIDGE: SOME DETAILS OF THE SHORT CANTILEVER AND ANCHOR ARMS.

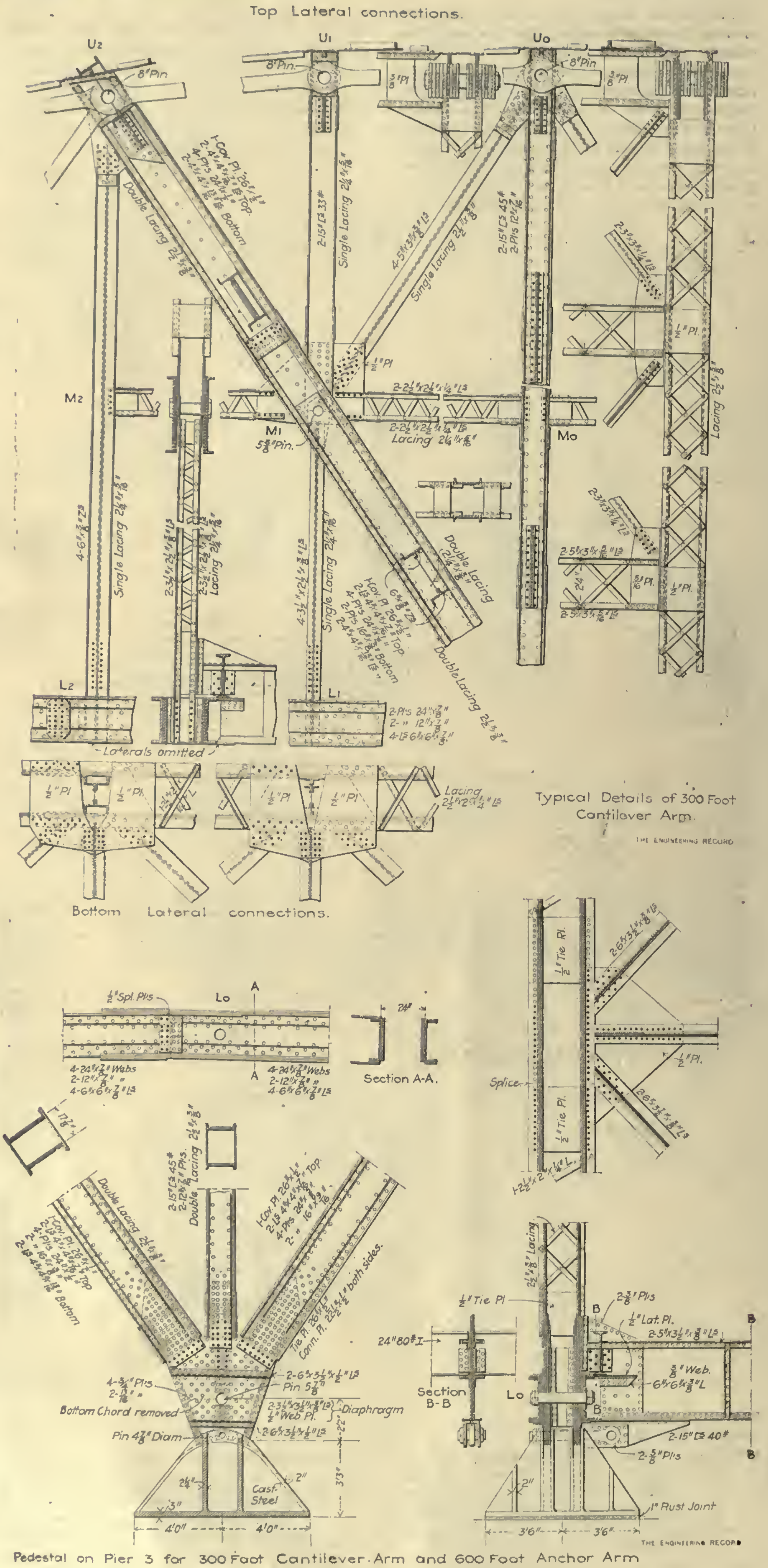
cast-steel shoe, and through it the lateral stress is transmitted to the masonry. The cast-steel shoe is 4 feet high, has a 7x8-foot base, and rests on a rust cement bed 1 inch thick on the top of the pier. The thickness of the metal is 3 inches in the base, 3⅜ inches in the main webs under the bearing bolster and from 2 to 2½ inches in the other webs. It weighs about 36,600 pounds, and is anchored to the masonry by four 1⅞-inch stone bolts. The shoes on pier No. 2 are similar to those here described, but are lighter.

Above the steel floorbeams are wooden joists supporting the roadway and sidewalk floors and wooden stringers for the street railway. The roadway joists are long leaf yellow pine all 14 inches deep, except over the I-beam stringers in the 300-foot and 600-foot spans, but vary in thickness from 3 to 5 inches according to the lengths of the panels. The longest unsupported panel for the wooden joists is 18 feet in the 220-foot spans, where no sub-floorbeams or steel stringers are used. The shortest one is 10 feet on the 300-foot and 600-foot spans, where two intermediate sub-floorbeams are used. Under the 14-inch joists on top of the floorbeams 4½-inch oak raising blocks are used to bring the roadway floor up level with the rail in the street-car track.

The street railway is built with 4½-inch American standard T rails on 5½-inch white oak ties. Except in the long panels, as noted later, the ties rest on four lines of 7x11-inch long leaf yellow pine stringers, two lines under each rail, and the stringers rest directly on the top flanges of the floorbeams. On the plate girder approach and 220-foot spans, where the panels are 15 to 18 feet long, the stringer under each rail is composed of two 8 to 10x11-inch pieces, and one 4 to 5x14-inch piece, all yellow pine. The 14-inch piece is dapped to 11 inches at the ends, and the separate pieces forming one stringer are bolted together with ½-inch cast-iron separators between them. All track stringers are connected to the floorbeams by bolts through angle lugs riveted to the top flanges of the beams.

The sidewalk is raised 7¼ inches above the roadway by means of a second raising block on the floorbeam under its joists. These joists are two lines of 3x12-inch yellow pine and the curb or wheel guard along the sidewalk is an 8x12-inch white oak timber, which also acts as one line of joists for the sidewalk. Throughout the bridge the sidewalk floor is of 2x6-inch yellow pine surfaced four sides, and laid ¼ inch apart in the clear. The roadway floor is of unplaned 3x12-inch white oak. It is intended to have the wooden floor system move with the steel as it expands and contracts, and to allow for its displacement an opening ½ inch wide is left in the floor over each main floorbeam. At this point, if one plank covers the ends of joists in two adjoining panels, it is nailed to the joists in one panel only, and the joists of one panel only are nailed to the railing block on any floorbeam. There are five expansion joints for the trusses, and the opening in the floor over each of these points is covered with a steel plate bolted to the timber on one side and free to slide on the floor on the other side of the opening. Here also a special expansion joint is made for the rails in the street railway.

Just inside each rail in the car track is a line of paving blocks extending out about 8 inches from the center of the rail. These blocks rest on the ties and on oak blocks between the ties, and are cut away on top next to the head of the rail to form a groove for the flange of the car wheels. At intervals of 60 to 120 feet cast-iron grated scuppers are inserted in each line of paving blocks to provide an opening for the discharge of storm water.



Typical Details of 300 Foot Cantilever Arm.

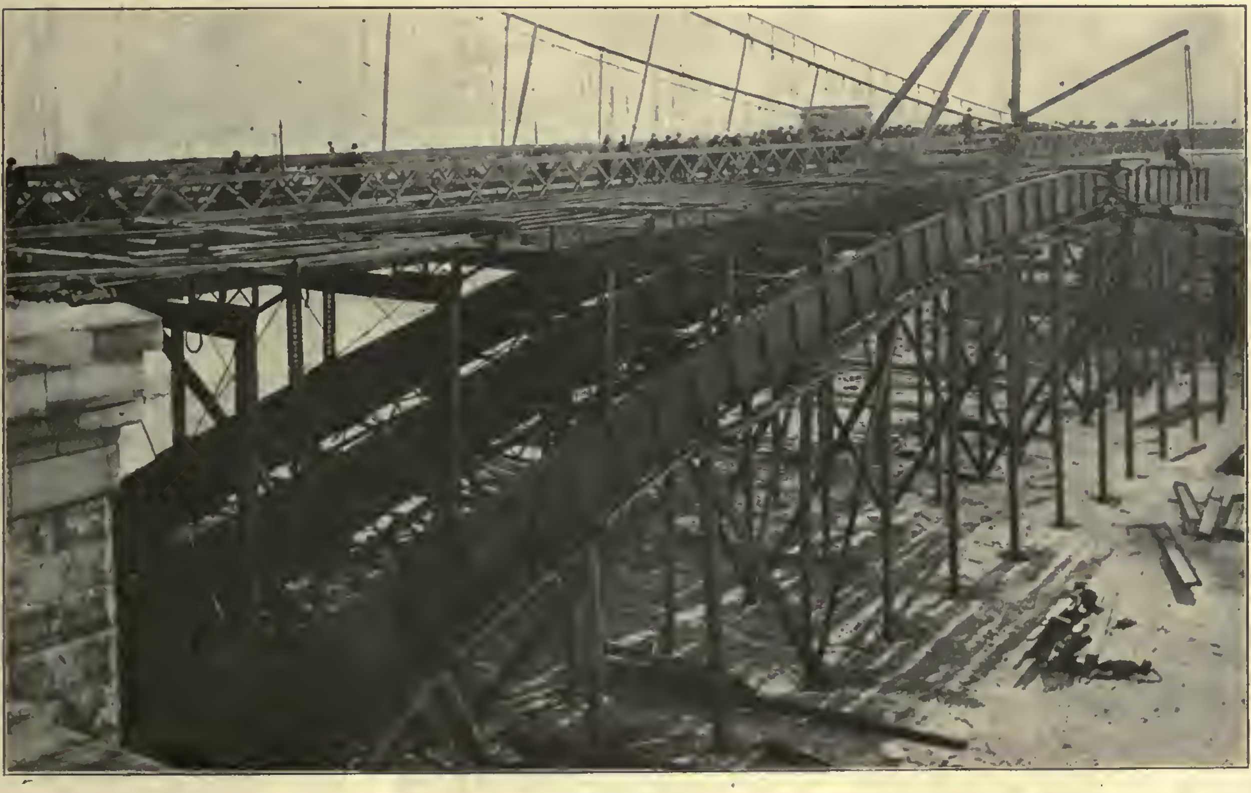
Pedestal on Pier 3 for 300 Foot Cantilever Arm and 600 Foot Anchor Arm

The Marietta Bridge: Some Details of the Long Cantilever and Anchor Arms.

The 600-foot span is placed on a grade of 3 per cent., rising towards the 650-foot span. The 650-foot span is the highest part of the bridge, and is level except for the camber. These two spans were cambered in such a manner that the bottom chord of both forms approximately a continuous curve which rises about 18 inches at the center of the 650-foot span. In order to form this curve, the theoretical length for each member was first figured, then allowance was made for the change of length for each member under dead load stress, so that under dead load the bridge conforms to this curve. The 130-foot span is placed on a grade of 6 per cent., the same as the approaches, and is cambered as an independent truss.

(To be continued).

Reforestation of Coal and Iron Pit Waste Land, in England, is being urged. The "Gardeners' Magazine" advises for this purpose the sowing broadcast of the seeds of the poplar, willow, ash and sycamore, particularly the ash and sycamore because of their suitability for timber.



Erection of Girder Ribs of the Minneapolis Steel Arch Bridge on Falsework through Ice.

The Economy of Automatic Stoking was discussed recently by the Pennsylvania State Street Railway Association. Hand firing in one case, including unloading the coal, handling ashes and tending water, was said to cost 35 cents per ton, while with stokers the cost was 17 cents. For repairs the stokers cost 3 cents per ton more than hand-fired furnaces. Information was also presented, covering, it was stated, the performance of a number of central stations. In these, the cost of firing was 25 to 32 cents per ton with hand work, and 6 to 7 cents with automatic stokers supplied from overhead coal bins. The repairs, it was reported, ranged from 25 cents to $1 per horse-power per year greater with stokers. In a plant of four 250-horse-power Babcock & Wilcox boilers equipped with stokers, the repairs and renewals amounted to 25.8 pounds of castings per horse-power per year, and they consumed in operation about 2 per cent. of the steam generated. The equipment showed a capacity to stand an overload of 100 per cent. without unsatisfactory results. The stokers cost about $3.50 per boiler horse-power installed.

Types and Details of Bridge Construction.—XVII.

By Frank W. Skinner, C. E.

Plate Girder Arches (Continued).

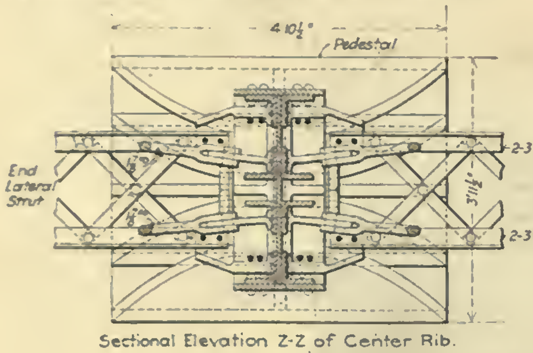
The Fern Hollow highway bridge carries Forbes Street across Nine-Mile Run, Pittsburg, and was described in The Engineering Record of February 18, 1902. It includes a 195-foot three-hinge plate girder arch span about 94 feet high, with a 36-foot roadway and two 6½-foot cantilever sidewalks, carried on vertical spandrel posts 24 feet apart which are seated with bent plate connections on the top flanges of the two plate girder ribs. It is proportioned for a uniformly distributed live load of 65 pounds per square foot, for a concentrated load of 30,000 pounds and for 50 pounds wind pressure. The arch ribs are 6½ feet deep, 36 feet apart and have a rise of 59 feet on centers. They are made in sections from 17 to 21 feet long, with planed radial joints web-spliced with triple rows of rivets through double cover plates. They are divided into approximately square panels by radial web stiffener angles and the flanges are curved to arcs of concentric circles.

At each end of each semi-arch rib the web plate is replaced by a flanged cast-steel hinge plate riveted to the girder flange cover plates which are extended like jaws to receive it, and to their end web stiffener angles. The hinge plates have 14-inch hubs 12 inches thick, bored for 8-inch pins. The pedestals have 3x9-foot bases which are bedded on sheets of lead 1 inch thick and secured to the masonry piers with four 2-inch anchor bolts through each. The pedestals are extended above the ribs to receive the feet of the skewback tower posts. At each hinge there is a radial joint between the cast-steel plates, with ½-inch clearance which is covered by a tongue and groove extension of the web.

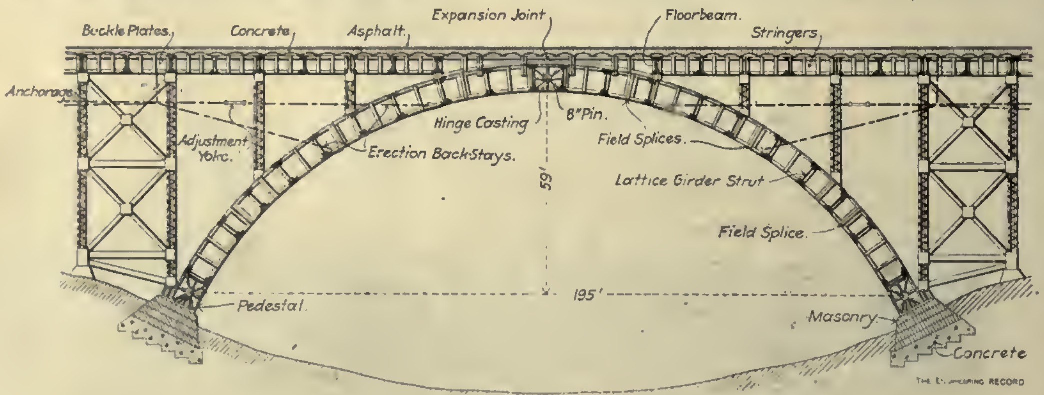
The arch ribs are connected in radial planes by eighteen horizontal lattice-girder sway frames 6½ feet deep, which are riveted to their top and bottom flanges. The two sway-brace frames at the crown are double, one pair each side of the hinge pin, and those of each pair are latticed together on the top and bottom flanges to form rectangular cross-sections. The panels between the sway-brace frames are X-braced with single angles in the planes of both top and bottom flanges. Each panel of lateral bracing is stayed by a longitudinal angle parallel to the girder flanges, in the axis of the bridge. The spandrel posts are braced transversely with I-shaped struts made with two pairs of light angles, latticed. The posts are pairs of 15-inch channels, latticed, and are web-connected to the 48-inch stringers and the floor-beams. The stringers are stiffened longitudinally with solid-web curved kneebraces and at the crown they are beveled concave to fit on the upper flanges of the arch ribs and are spliced with slotted web-holes. The floor-beams carry 12-inch I-beam joists with their top flanges flush, and their webs are pierced for four lines of large gas and water mains. The asphalt pavement has a concrete foundation leveling up the concave upper surfaces of the 5/16-inch buckle plates riveted across the top flanges of the beams and girders.

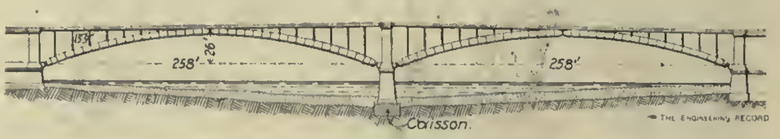
The plate girder approach trestle viaducts were erected from both abutments simultaneously by overhead stiff-leg traveling derricks, each with two 30-foot beams, which were skidded along on the finished structure. After erecting the skewback towers, these derricks erected the arch spans panel by panel cantileverwise until they met at the center of the span. The arch ribs were supported during erection by the skewback pins, by inclined shores and by temporary backstays, arranged as shown in the sectional elevation by dotted lines. The upper ends of the skewback sections of the arch ribs were supported on inclined shores until the second sections were assembled to them, their splices riveted and connections made at the upper ends of their lower flanges to the backstays. The third sections were erected like the second ones and also connected to the backstays before they were released from the derricks, and the fourth and last sections were held by the derricks until their hinge pins were set and the adjustments were operated to swing the arch. The anchorages were made at one end by steel bars built into the masonry and at the other end by reaction beams in loaded platforms. The adjustments were made with double horizontal transverse I-beam yokes crossed by the screw ends of the pairs of 2x2-inch steel rods, which were pin-connected to bent plates bolted to the girder flanges. The yokes were separated by 70-ton ball-bearing screw jacks which, when slacked off, lowered the ends of the arch ribs.

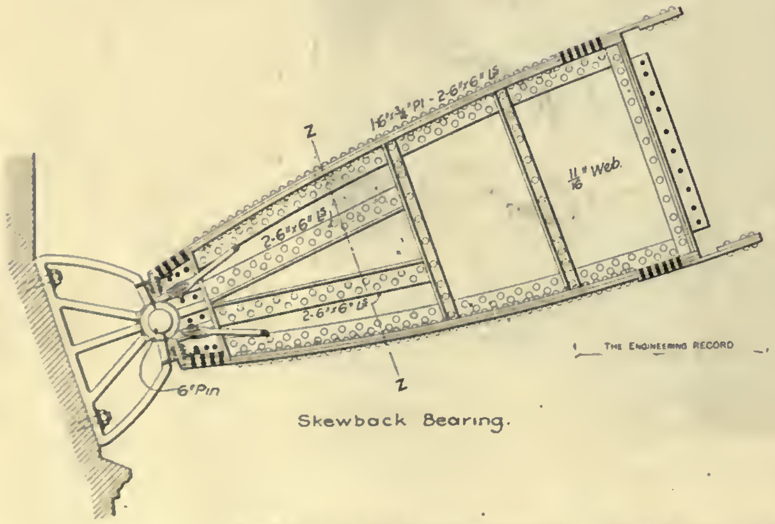
The South Market Street highway bridge across the Mahoning River, at Youngstown, O., was described in The Engineering Record of February 4, 1899. It has a main span with two segmental plate girder two-hinge arch ribs of 210.58 feet span, and 60 feet rise, 28 feet apart on centers. The ribs are curved to a radius of about 122 feet and have a uniform depth of 90 inches. Each flange is made with two 6x6x⅝-inch angles and three 16x11/16-inch cover plates. The webs are spliced with double cover plates made longer near the flange angles. The flange angles converge to the 10-inch end pins, but the web is continued full width to the ends where it is cut off square through the pin center and reinforced to a thickness of 4 inches, and has diagonal stiffener angles. The skewback pedestals have triple webs and resemble those for a pin-connected truss span. The outside webs are extended to the full width at the top and have flange angles connected to the end flanges of the arch ribs, thus continuing the outline of the latter to the abutments. They are seated on grillages made of 18-inch I-beams with top and bottom cover plates. The arch ribs are connected by 16 sway-brace frames in radial planes and by lateral X-brace angles in the top and bottom flange planes. The 40-foot roadway and two 7-foot sidewalks are carried on 30-inch plate girder floor-beams with cantilever ends. The floor-beams are seated 15 feet apart on the top flanges of longitudinal lattice girders supported by vertical spandrel posts about 30 feet apart. The end posts are connected to the skewback pins and the intermediate ones have oblique bases field-riveted to the top flanges of the girders. The bridge was proportioned for a live load of 80 pounds per square foot, for a 15-ton roller with a 10-foot base, for a 20-ton traction engine with a 12-foot base and for a dead load of 6,200 pounds per linear foot. The arch was erected from one end by an overhead traveler with two 30-foot booms of 20,000 pounds capacity. The arch ribs were received from the shops in straight 20,000-pound sections, 30 feet long, and were assembled on pairs of oak camber wedges on timber cribbing on the falsework caps. The last joint was made at the section nearest the second skewback, and the splices were field reamed with a pneumatic tool.



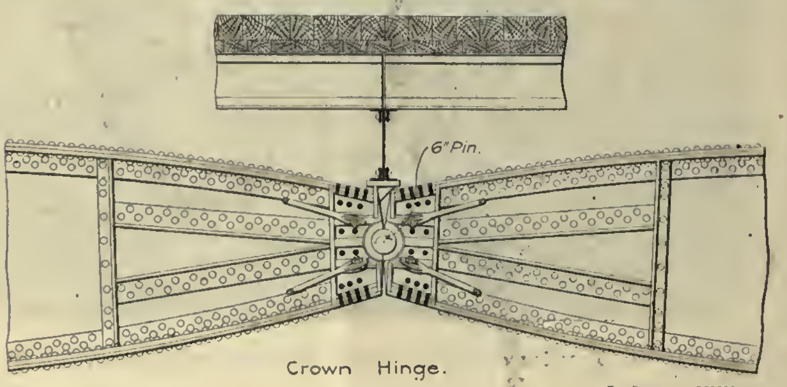
Sectional Elevation Z-Z of Center Rib.







Skewback Bearing.



Crown Hinge.

Elevation of Fern Hollow Bridge; Diagram and Crown and Skewback Details of Minneapolis Steel Arch Bridge.

The Main Street highway bridge across the Mississippi River, Minneapolis, was a two-span suspension structure which became inadequate for the traffic, and was first widened by the construction of a 40-foot roadway alongside carried on steel arches. Afterwards the suspension bridge was replaced by similar steel arches. Each span of the first structure has three three-hinged plate girder ribs 15 feet apart, with a length and rise of 258 feet and 26 feet respectively on centers. Vertical spandrel posts about 13 feet apart are seated on the top flanges of the arch ribs and carry the floor, which has a 12-foot sidewalk cantilevered about 3 feet beyond the outside rib. At the feet of the spandrel posts the arch ribs are braced together by lattice girder sway-brace frames field-riveted to the radial web-stiffener angles, and every panel between sway braces is X-braced in the planes of the top and bottom flanges with sleeve-nut rods which have jaw ends pin-connected to the splice plates of the top and bottom flanges. The spandrel posts are also sway braced by pin-connected sleeve-nut rods between the floor-beams and rib frames. Each semi-arch rib is made in ten sections about 13½ feet long, spliced together with web and flange cover plates shop-riveted to one section to make jaws which are field-riveted to the adjacent section. The ribs have straight parallel flanges and have a uniform depth of 5 feet except the sections nearest the crown and skewbacks, which are tapered so that the flanges converge towards the center of the 6-inch hinge pins. The crown and skewback sections of the girder arch rib are alike and their webs are engaged between the double webs of steel bearing castings, to which they are secured by 1-inch turned taper bolts. The castings have horizontal semi-cylindrical bearings about 15 inches long with stiffening flanges for the hinge pins. At the skewbacks the pins are seated in cast-iron pedestals with 4x5-foot bases. All the steel castings have longitudinal flanges to receive the lateral pins and are made with V-shaped clearances above and below the pins. The crown castings are made alike except that only one of each pair has a horizontal shelf to carry the plate girder floor-beam, which also serves as a lateral strut. The skewback castings have transverse webs to which the end sway-brace frames are bolted, as shown in the detail. The three ribs were proportioned for different loadings; the maximum was 1,400 pounds dead and 1,800 pounds live load per linear foot, and the corresponding cross-sections of the crown and skewback sections were 163 and 85 square inches. The weight of the span was about 1,500,000 pounds, and it cost about $77,000. It was described in The Engineering Record of May 10, 1890.

(To be continued.)

The Assuan Dam across the Nile and the reservoir formed by it have proved capable, during their first year of service, of performing the duty for which they were designed. The following interesting statement is made by "The Surveyor," of London, on the authority of an Egyptian journal. Partly completed in October, 1902, at a cost of £2,500,000, the dam was immediately closed by Mr. A. Webb, C.M.G. Director-General of Reservoirs, and by the end of January had filled its reservoir to its theoretical high-water level. The 1,000,000,000 of cubic metres of water which were impounded were utilized in May and June, and had a very appreciable effect on the low summer supply of the Nile. The Nile at its lowest this year was discharging 200 cubic metres per second at Assuan; the Assuan reservoir was adding the same quantity to the river; and between Assuan and the sea the infiltration water which leaks into the river from the sub-soil was adding another 200 cubic metres per second. Of the 600 cubic metres of water per second which Egypt received at the height of the summer the reservoir supplied one-third. This quantity of water enabled the Public Works Department to give perennial irrigation to 170,000 acres of basin land recently converted to perennial land. The rise in value of the land was fully £30 per acre. Within the next three years a further 270,000 acres will be converted from basin to perennial irrigation, and value increased £8,000,000.

An Example of Central Station Supply for Lighting, Power and Refrigeration in the Hotel Jefferson, St. Louis.

The Hotel Jefferson, which is rapidly nearing completion, at St. Louis, is a notable example of central station supply. It is located at Twelfth and St. Charles streets and is thirteen stories high, exclusive of the basement. As all the electric power for lighting and elevator service, also the refrigeration service, will be taken from central station supply companies, a power plant has not been installed. The heating plant consists of three 72-inch by 20-foot boilers, each having seventy 4-inch tubes. The boilers are equipped with the Hawley down-draft type of smokeless furnaces. The stack is of steel 66 inches in diameter and, extending about 30 feet above the top of the building, is approximately 190 feet high. This is surrounded by an outer steel shell providing a 6-inch space between the inner and outer shells for the purpose of preventing excessive heat being communicated to the parts of the building adjacent to the stack, which is carried up just outside of the wall at one corner of a court. This space between the stack and its outer envelope, is used for ventilating the boiler room and the kitchen.

Fern Hollow Bridge Skewback Hinge and Pedestal.

The heating of the first story and basement is by means of a hot blast system. The cold air is brought down from above the first story through a shaft approximately 5x6 feet in size and is passed through a tempering coil. It is then passed through an Acme Thomas air washing and purifying apparatus and then through a fan and heating coils which have been furnished by the B. F. Sturtevant Company. The air is distributed through the various rooms by a system of ducts controlled by thermostatic dampers. The ventilation of the first story and basement is effected by means of two Sturtevant steel plate exhausters, one at the north and the other at the south end of the building. These discharge the foul air into an alley. The heating of all the stories above the first, is by means of direct radiation from an over-head down-feed one-pipe system. All of the radiation in the building, including the hot blast heating and tempering coils, is equipped with the National Vacuum Steam Heating Company's system of vacuum heating.

The water supply of the building is obtained through two mains from the city's system and will be filtered. The filters are in duplicate, and a storage tank, having a capacity of approximately 10,000 gallons, has been installed.

The electric service for the building will be supplied by the Union Electric Light, Heat & Power Company, at a pressure of 235-470 volts on the three-wire system. The various cables from the underground system of the company will be brought to a switchboard located in the machinery room of the building. This switchboard will contain duplicate meters, one supplied by the central station company and the other by the hotel operating company.

The wiring for the electric light circuits will be in conduit throughout. There are two main raceways running from the basement to the top floor of the building, with two distributing cabinets on each floor. Each room is equipped with a center chandelier, two brackets and two outlets placed in the baseboard for connecting portable reading lamps. Each closet is supplied with a bracket controlled by a closet switch. The chandelier in each room is controlled by a switch, so that when a guest leaves his room he will, by locking the door, extinguish all the lights which have been left on. On this return, he will again turn them on by unlocking the door. The door locks are provided with double tumblers, so that by locking the door from the inside of the room, the lights will not be extinguished. The lighting in the café and dining room, library and bar on the first floor will be by means of 8-candle-power frosted lamps placed in ornamental plaster rosettes on the ceilings. There will also be side brackets. The lighting of the main rotunda and ladies' parlor will be by means of 16-candle-power lamps concealed within metal reflectors which reflect the light from the ceiling panels.

There are five electric elevators, three for passenger service with a capacity of 2,500 pounds at a speed of 325 feet per minute, one freight elevator having a capacity of 3,500 pounds at a speed of 200 feet per minute, and one service elevator with a capacity of 200 pounds at 300 feet per minute. These are of the latest type of Otis magnet control double-geared machines operating at 500 volts pressure.

The refrigeration for the hotel will be furnished by the St. Louis Refrigerating & Cold Storage Company by means of their underground ammonia system of distribution. This service will be brought into the building and the ammonia pipes carried through a brine cooler placed in a thoroughly insulated room. The brine will be circulated by means of duplicate electric pumps through a system of piping supplying the various ice boxes and cold storage rooms. The supply of ice, however, will be furnished direct to the building and stored in large ice boxes until ready for use, as no attempt will be made to freeze water at the building.

Messrs. Barnett, Haynes & Barnett are the architects. The mechanical plant has been put in under the supervision of Mr. H. H. Humphrey, electrical and mechanical engineer, of St. Louis, and the plumbing and sanitary features were designed and installed according to the specifications of Mr. W. S. MacHarg, of Chicago.

A Long-Span Unstiffened European Suspension Bridge.

A bridge has recently been completed in France of a type, namely: the unstiffened suspension bridge, which is usually restricted to short and very light structures. The construction is peculiar on account of the combination of vertical and inclined suspenders arranged so as to relieve the main cables from all the weight of the end spans and of the ends of the main span, and some of the details are of a class that would not be adopted in American practice. The Vernaison suspension bridge across the Rhone near Lyons, France, is a highway structure with a channel span of 763.76 feet and side spans of 172.2 and 139.1 feet each. It has a roadway of 15.73 feet wide in the clear suspended from four sets of twisted steel cables. The two sets on each side of the bridge are 12 inches apart in the same vertical plane, and those in each set are side by side with the axes in the same horizontal line at any transverse section. Each cable is made of 127 wires with a combined cross-sectional area of 2.41 square inches and a strength of 187,000 pounds per square inch. They are supported at different levels on cast roller saddles on masonry towers, and have screw rod connections to anchor castings with offset, oblique cut stone bearings in concrete piers.

The towers are 101.5 feet high above water level and have pneumatic caisson foundations. The plate-girder floor-beams 4.4 feet apart carry longitudinal oak plank and pine transverse wearing surface boards and are suspended by U bolts and double eye-rods which connect with badly designed forked eyes and clamp bars to the upper and lower cable sets, alternately. The floor-beams are connected by a center line of shallow longitudinal beams at the lower flange, and the roadway is stiffened by eight steel hand-rail trusses 4.5 feet deep over all. For a distance of 100 feet each side of each tower the vertical roadway suspenders are replaced by eight back stays from the tops of the towers, which are connected to a 12-inch longitudinal girder clamped by U bolts to the tops of the floor-beams so as to carry all the floor loads.

The main cable was drawn across the river suspended from temporary erection cables, and the floor system was erected by another cableway system. The three spans were separately and simultaneously tested by a uniformly distributed load of 37 pounds of gravel per square foot, which caused a maximum deflection of 19½ inches and 1.3 inches movement of the tower saddles. A live load of two 8-ton wagons, drawn in opposite directions by five horses tandem, produced a maximum deflection of 12½ inches. One 11-ton wagon, drawn by nine horses tandem, produced a maximum deflection of 13 inches. The total metal weight of the bridge, including cables, is 917,000 pounds; its cost was $69,000, and the cost of the masonry was $36,000. It was described in the "Genie Civil," July 4, 1903.

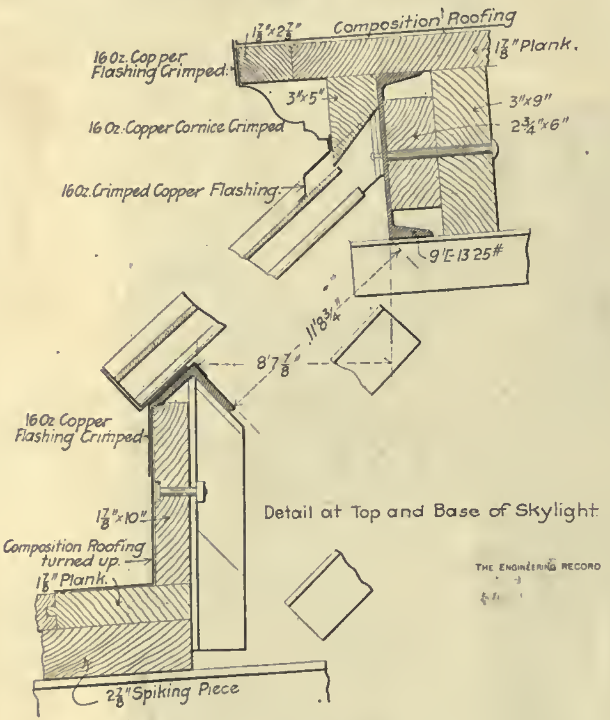
The Ambridge Plant of the American Bridge Company.

Part VIII.—Design and Equipment of Bending and Forge Shop, and Runways for Yard Cranes.

Arrangement.—The 220x240-foot forge and bending shop occupies the most central position in the plant, and is located adjacent to the stock yard between the main bridge shop and the bolt and nut shop. It lies between the main longitudinal surface tracks on two sides and between transverse traveling yard cranes on the two ends, so that materials can be received and delivered in all directions. The general character of construction with two systems of main trusses supported on widely spaced interior columns, a complete system of parallel overhead traveling cranes and special provision for lighting the wide floor area has been carried out in this shop to correspond in general with the other large shops of the Ambridge plant. The spacing of columns and trusses, the character of truss construction, and the systems of bracing and wall details have been studied with special care. An ideal structure for a large square area has been secured with good light, efficient crane service and well arranged floor spaces. The columns are located so as to reduce the span of the roof trusses and afford ample room for ordinary shop operations and the movement of large pieces at the same time that rigidity is secured with a moderate weight of material.

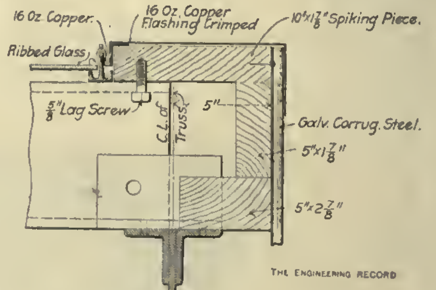
The columns are arranged in five longitudinal and five transverse rows, giving maximum spans of 60 feet and 55 feet 4 inches. In each of the four walls two equi-distant intermediate columns are inserted in every panel. In the end walls the intermediate columns carry only the light loads from the wall bracing. In the side walls all columns are heavier, and are uniformly loaded by the ends of the transverse roof trusses and by the traveling cranes. The three interior rows of longitudinal columns divide the building into four nearly equal aisles. Their tops are connected by longitudinal trusses which support the traveling crane runways and carry the transverse roof trusses. The depths of the roof trusses are proportioned for economical weights, and the top chords are slightly inclined to provide for roof drainage. The bottom chords of the center aisle trusses are at the level of the tops of the side aisle trusses, an arrangement which provides, between the center and side aisle, clere-stories equal to the end depth of the center trusses.

Roof and Wall Construction.—A monitor about 36 feet wide and 200 feet long is located on the center line of the building with light trusses in the planes of the main roof trusses. The roof trusses are X-braced for the whole width of the building with single riveted angles in the plane of the top chords in the end panels and two intermediate panels. This bracing is repeated in the plane of the lower chord, the remaining panels of the lower chord being similarly braced in the bays adjoining the sides of the building. Eight lines of light longitudinal lattice-girders or purlins running from end to end of the building also act as bracing. There are two lines in each aisle, the girders being

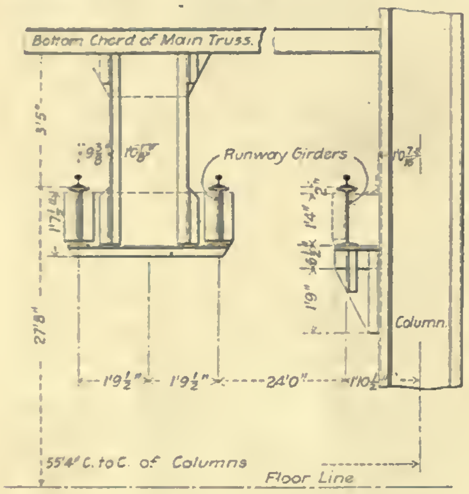


Composition Roofing
$1\frac{7}{8}$"x$2\frac{7}{8}$"
$1\frac{7}{8}$" Plank.
16 Oz. Copper Flashing Crimped.
3"x5"
3"x9"
$2\frac{3}{4}$"x6"
16 Oz. Copper Cornice Crimped
16 Oz. Crimped Copper Flashing.
9" [-13.25#
$11'8\frac{3}{4}$"
$8'7\frac{7}{8}$"
16 Oz. Copper Flashing Crimped
$1\frac{7}{8}$"x10"
Composition Roofing turned up.
$1\frac{7}{8}$" Plank.
$2\frac{3}{8}$" Spiking Piece
THE ENGINEERING RECORD

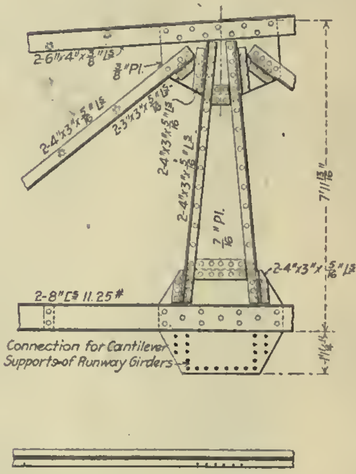
Detail at Top and Base of Skylight.



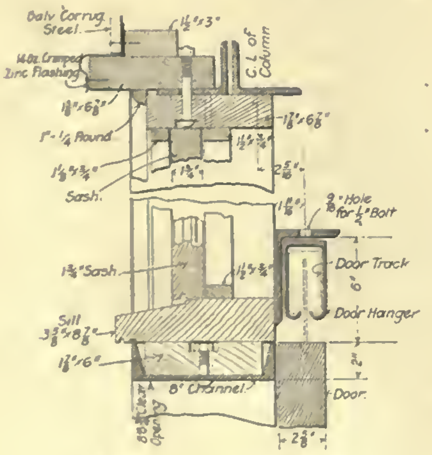
Gable End of Skylight.



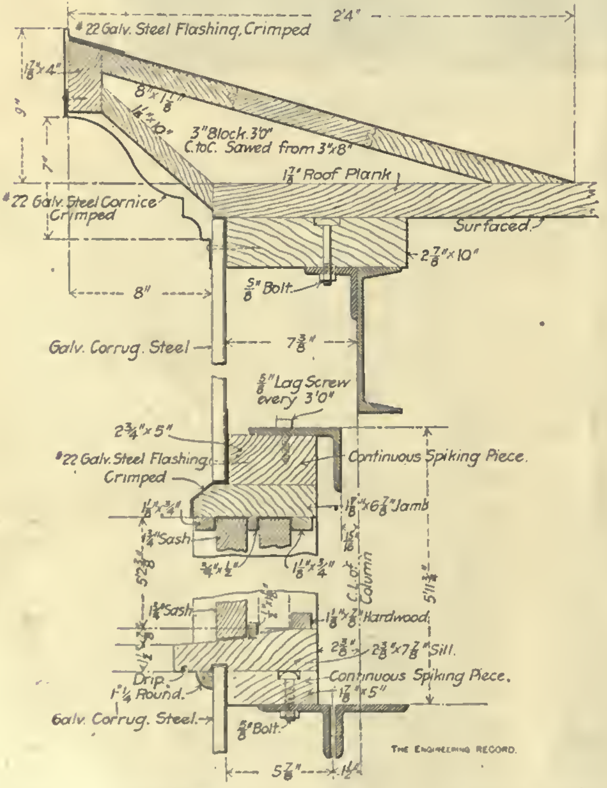
Support of Runway Girders from Trusses and Columns Bending and Forge Shop



Center Panel of Main Roof Truss Bending and Forge Shop

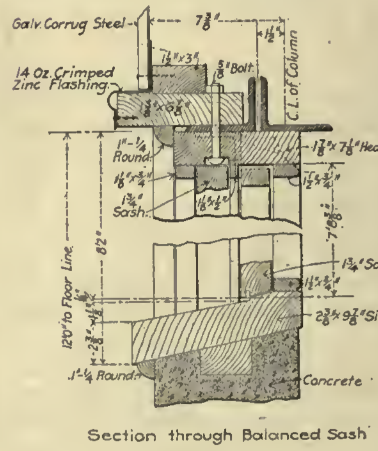


Section through Door Transom.

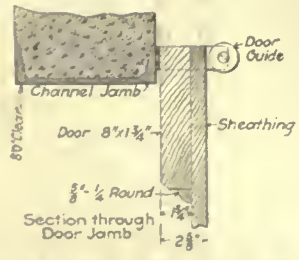


2'4"
#22 Galv. Steel Flashing, Crimped
$1\frac{7}{8}$"x4"
8"x$1\frac{7}{8}$"
3" Block 3'0" C. to C. Sawed from 3"x8"
$1\frac{7}{8}$" Roof Plank
#22 Galv. Steel Cornice Crimped
Surfaced.
$2\frac{7}{8}$"x10"
8"
$\frac{5}{8}$" Bolt.
Galv. Corrug. Steel
$7\frac{3}{8}$"
$\frac{5}{8}$" Lag Screw every 3'0"
$2\frac{3}{4}$"x5"
#22 Galv. Steel Flashing, Crimped
Continuous Spiking Piece.
$1\frac{3}{8}$"x$6\frac{7}{8}$" Jamb
$1\frac{3}{4}$" Sash
C.L. Column
$1\frac{3}{4}$" Sash
$1\frac{3}{8}$"x$\frac{7}{8}$" Hardwood.
$2\frac{7}{8}$"x$7\frac{7}{8}$" Sill.
Drip.
1"-$\frac{1}{4}$ Round.
Continuous Spiking Piece.
$1\frac{7}{8}$"x5"
Galv. Corrug. Steel.
$\frac{5}{8}$" Bolt.
$5\frac{7}{8}$"
THE ENGINEERING RECORD.

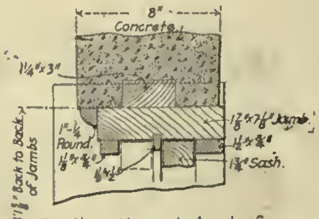
Section through Gable Cornice and Sliding Windows in Gable End



Section through Balanced Sash



Section through Door Jamb



8"
Concrete
$1\frac{1}{4}$"x3"
$1\frac{3}{8}$"x$7\frac{3}{8}$" Jamb
1"-$\frac{1}{4}$ Round.
$1\frac{3}{4}$" Sash.
$4'1\frac{1}{2}$" Back to Back of Jambs

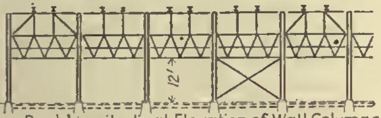
Section through Jamb of Balanced Sash

MISCELLANEOUS DETAILS OF BENDING AND FORGE SHOP, AMBRIDGE PLANT OF THE AMERICAN BRIDGE COMPANY.

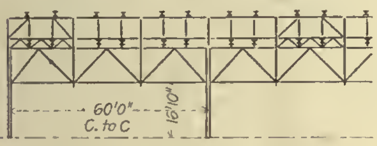
made with depths equal to those of the transverse trusses and connected to them at alternate vertical posts of the latter. These longitudinal trusses and those supporting the transverse trusses carry in each panel of the latter two I-beam rafters flush with the top chords of the transverse trusses on which are supported the 2-inch longitudinal sheathing planks covered with composition roofing. The monitor roof has longitudinal purlins supporting transverse sheathing.

The walls on all four sides of the building, up to a height of 12 feet above grade, are of the Ambridge standard steel and concrete construction with 8x12-foot doors in every third panel and three 4x8-foot windows in each of the remaining panels in the end walls. In the side walls there are fewer doors and the windows are somewhat differently spaced. Above the concrete the side walls have galvanized corrugated steel sheeting 8 feet high, with a continuous row of windows 5 feet high between the top of the sheeting and the eaves. A corresponding row of windows at the same height is carried across the ends of the building. The clere-story of the side aisles has a continuous line of sliding windows of its full height, except for short spaces at the columns. The same belt of windows is carried across the ends of the building. The sloping sides of the monitor are continuously glazed with 2x8-foot sheets of heavy ribbed glass. The lower tier of windows has balanced sash glazed with clear glass. All other windows, except those in the skylight, have sliding sash glazed with 1/8-inch ribbed glass. All the wall surface above the concrete portion which is not occupied by windows is covered with No. 22 galvanized steel with vertical corrugations in sheets 6, 8 and 9 feet long. The doors are made with double leaves heavily paneled, and have glazed transoms over them. The monitor has four equi-distant 60-inch tubular ventilators provided with dampers.

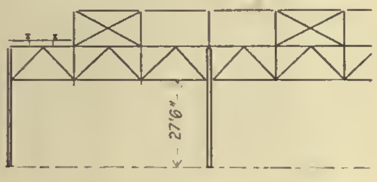
In each aisle of the building there are two full-length parallel runways for overhead trav-



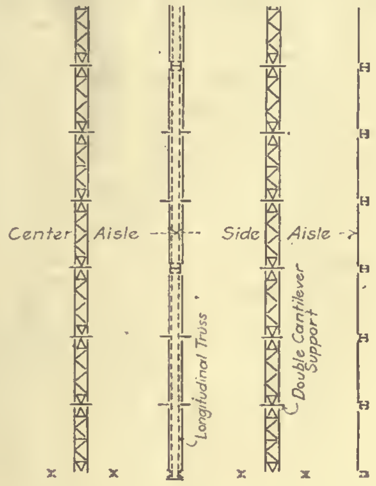
Part Longitudinal Elevation of Wall Columns on Line X-X



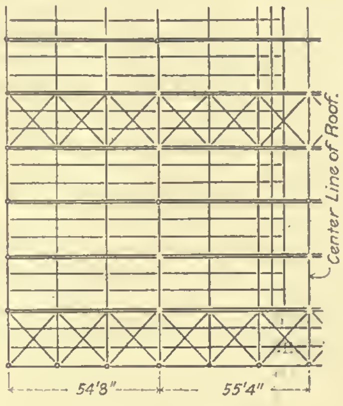
Part Longitudinal Section on Line Y-Y.



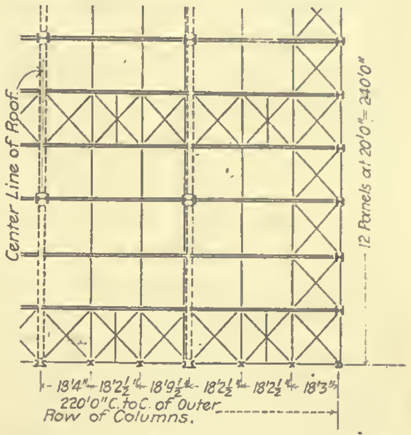
Part Longitudinal Section on Center Line Z-Z.



Part Plan of Crane Runways.



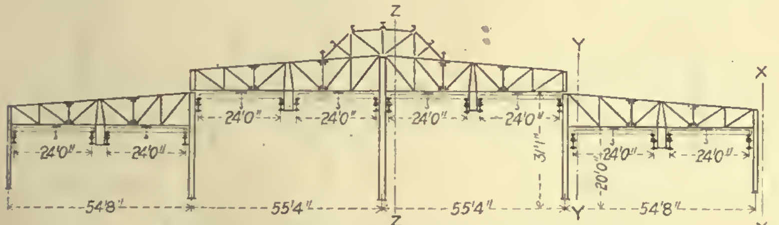
Part Plan of Top Chords of Roof Trusses, Purlins and Bracing.


Center Line of Roof.
12 Panels at 20'0" = 240'0"
18'4"
18'2½"
18'9½"
18'2½"
18'2½"
18'3"
220'0" C. to C. of Outer Row of Columns.

Part Plan of Bottom Chord and Bracing.

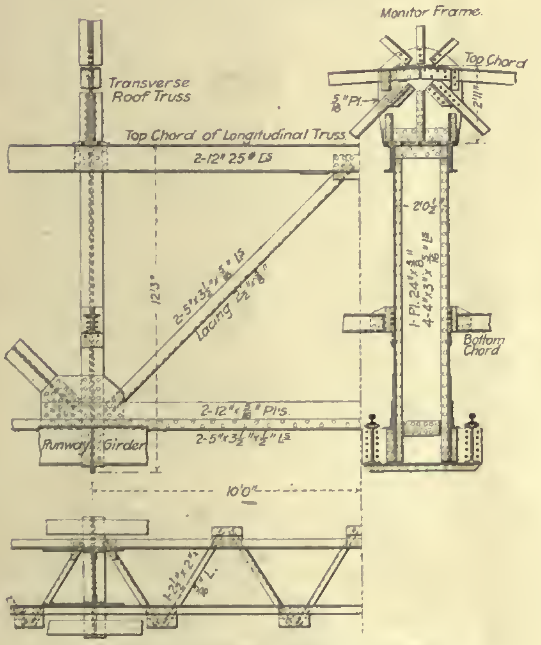
Bending and Forge Shop.

THE ENGINEERING RECORD.



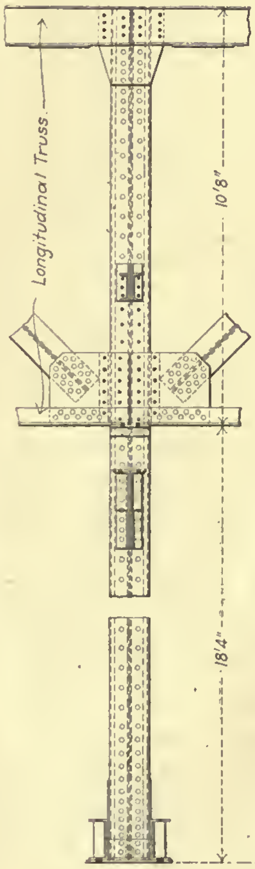
General Cross-Section of Forge and Bending Shop.

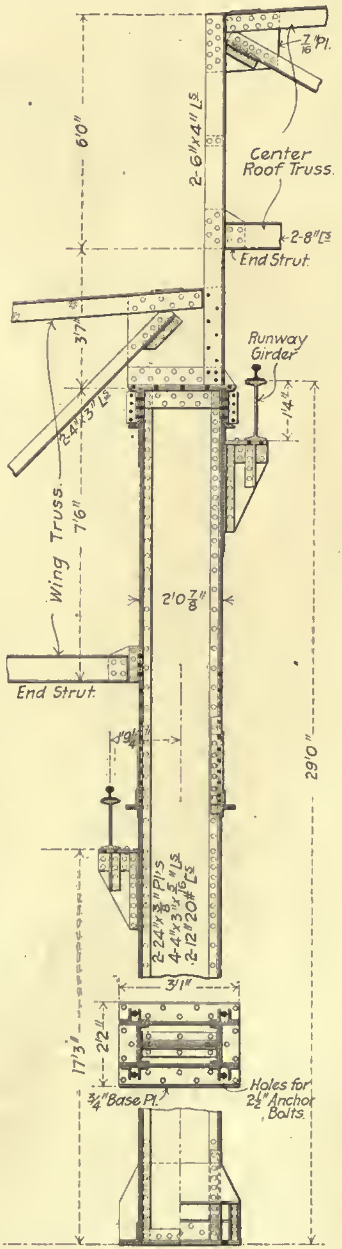
THE ENGINEERING RECORD



Center Panel of Center Longitudinal Girders for Bending and Forge Shop

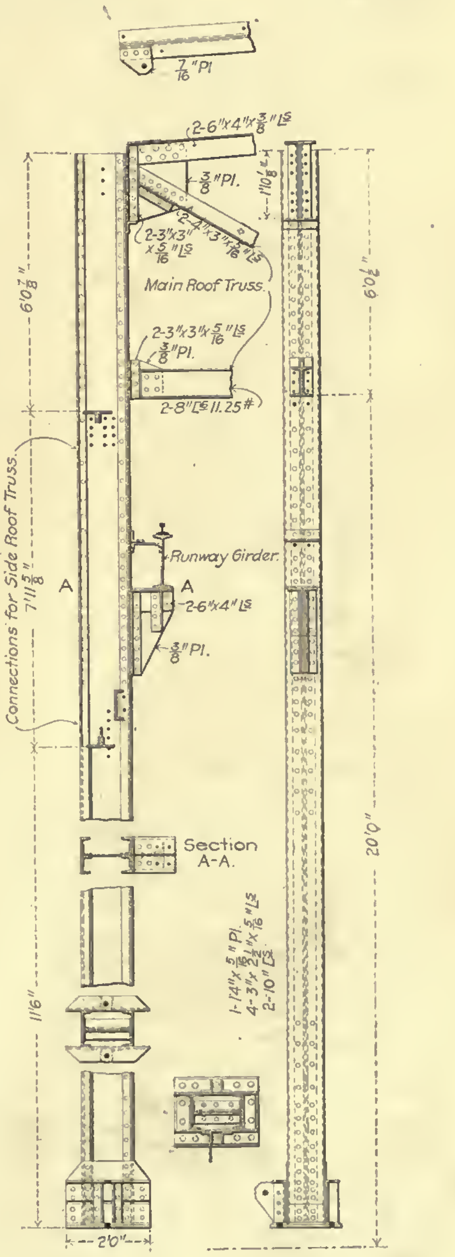
THE ENGINEERING RECORD





Main Column in Bending and Forge Shop.

THE ENGINEERING RECORD.



Main Side Column in Bending and Forge Shop.

THE ENGINEERING RECORD

FRAMING DIAGRAMS AND DETAILS OF COLUMNS AND GIRDERS IN THE BENDING AND FORGE SHOP.

eling cranes, each of them reaching from one side to the center of the aisle. This gives eight sets commanding the entire area of the building. Each runway is now fitted with one crane, and others can be added as required. All the cranes have a uniform span of 24 feet, those in the side aisles have a capacity of 5 tons each and those in the center aisles of 10 tons each. The runway girders are supported at the sides of the aisles on the columns and main longitudinal girders. In the centers of the aisles the pair of runway girders for the two tracks is carried by double cantilever girders in transverse planes, which are suspended about 3 feet in the clear below the lower chords of the transverse roof trusses, as shown in the details. The runway girders are braced together with zigzag lateral angles between the transverse cantilevers.

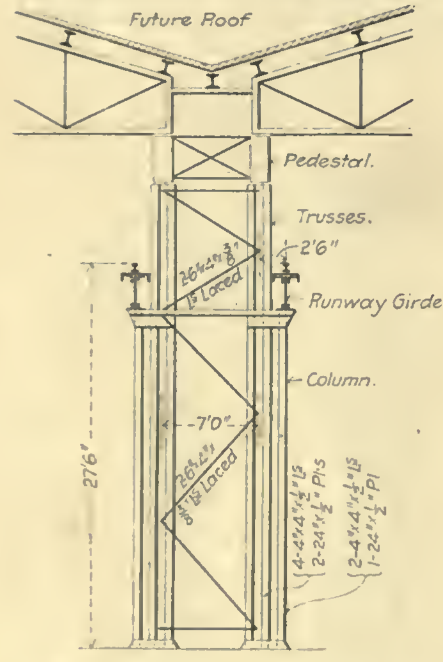
Structural Details.—The main interior columns which carry the longitudinal trusses have I-shaped cross-sections made with a 24-inch web, four 3x3-inch angles and two 12-inch flange channels. They have solid-web brackets riveted to the flanges to support the runway girders. The top chords of the longitudinal girders are seated on the column caps, and the lower chords are field-riveted to the column flanges through connection plates which transmit the full truss loads. The side columns are of similar construction to the interior columns, but have lighter materials and have field-riveted connections for the ends of the transverse roof trusses. The corner columns correspond essentially to those for the other principal buildings which have already been described. They have rectangular sections filled with concrete up to the height of the galvanized iron sheathing, and are made with four vertical angles and three cover-plates which extend to a height of about 15 feet from the base, above which they are latticed on three sides, the fourth side being latticed from top to bottom.

The heaviest members of the framework are the three lines of interior longitudinal trusses. These are of 60-foot span, and have a depth of 10 feet on centers. The top chords are made of pairs of channels latticed with 2x2½-inch angles. The bottom chords are made with pairs of 5x3½-inch angles reinforced in the middle panels by 12-inch plates riveted to their vertical flanges. The verticals have I-shaped cross-sections made with solid web-plates and two pairs of flange angles, virtually forming vertical plate-girders with the flanges field-riveted to the webs of the top and bottom chords and projecting below the latter to carry the traveling crane-runway girders. These girders are 15 and 18-inch I-beams web-connected to special sections of the vertical-post webs, which project beyond the flanges so as to form short double cantilevers carrying the I-beams clear of the trusses. The diagonal members of the truss are zigzag braces composed in the center panels, of pairs of 5x3½-inch angles latticed, and, in the end panels, of double pairs of 5x3½-inch angles latticed to make I-shaped cross-sections.

The trusses have the main connections to the columns field-riveted through the gusset plates at the end of the lower chord, the top chords being continued to engage the column flanges and secure stiff bracing which does not transmit vertical loads. The longitudinal trusses between the wall columns correspond to the latticed purlins, and the traveling crane runway girders are attached to the wall columns, which are 20 feet apart. The main transverse roof trusses are of very simple construction with horizontal bottom chords and inclined top chords, vertical posts and single diagonal members in each panel. The top chords have T-shaped cross-sections made with pairs of 6x4-inch angles riveted back to back with web-connection plates between their flanges. The bottom chords are pairs of 8-inch channels, back to back, with connection plates riveted between them. The web members are pairs of angles riveted on opposite sides of the connection plates and having short connection angles riveted to their outside flanges.

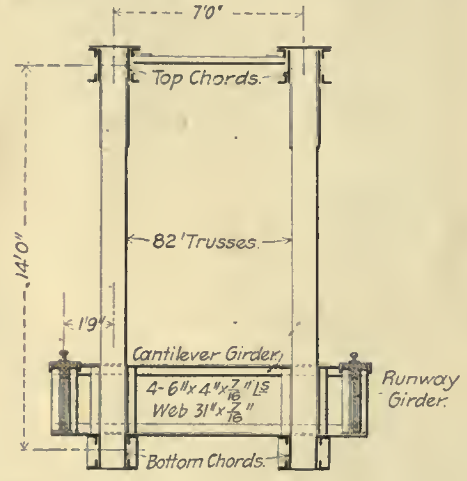
The transverse trusses at columns are made continuous through their connections to the center columns, on which they are supported with pedestals made by extensions of the connection plates at the extremities of the top chord. These pedestals are stiffened with vertical and horizontal flanges, the latter being seated on the column caps, and are shop-riveted to one truss and field-riveted to the other. The intermediate transverse trusses are seated on top of the main longitudinal trusses with pedestals similar to those in the trusses at columns and are connected to the wall columns by field-rivets through the flanges of vertical angles on the end connection plates of the top and bottom chords. In the centers of the main and side aisle trusses there are special vertical members having continuous web-plates and double pairs of slightly inclined flange angles, from which the runway girders are suspended. The lower ends of these web plates are made separate; they are much wider and are long enough to project through and beyond the bottom chords of the trusses, thus affording connections for the short double cantilever girders in the planes of the trusses. In the end walls the transverse trusses are replaced by short sets of zigzag bracing between columns, which may be considered as equivalent to light lattice girders. Those in the center panels are made special to carry the ends of the runway girders with double cantilever supports corresponding to those of the intermediate trusses.

Wood and Sheet Metal Work.—The details of window and door casings, skylights and other wooden trimming for the galvanized steel and concrete walls have been very carefully designed and illustrate the character of shop construction details which have been developed in a large amount of this class of work constructed by the American Bridge Company. In the monitor skylights the principal members of the sloping frames are longitudinal angles and channels resting on the transverse trusses, as indicated in the general diagram. To these are bolted wooden fillers and nailing strips which afford support and fastening for the trim. The latter is made of heavy stuff blind-nailed so as to be thoroughly locked to the steel work; is covered with the composition roofing and galvanized moulded sheet steel, copper-flashed and secured as indicated by the selected details. The ribbed glass is supported on T-shaped rolled steel gutter sash with copper locking strips, as shown in the cross-section. The details of woodwork over the doors are made to secure very



Shipping Yard Crane Runway Columns

The Engineering Record



Support for Traveling Cranes in Shipping Yard

The Engineering Record

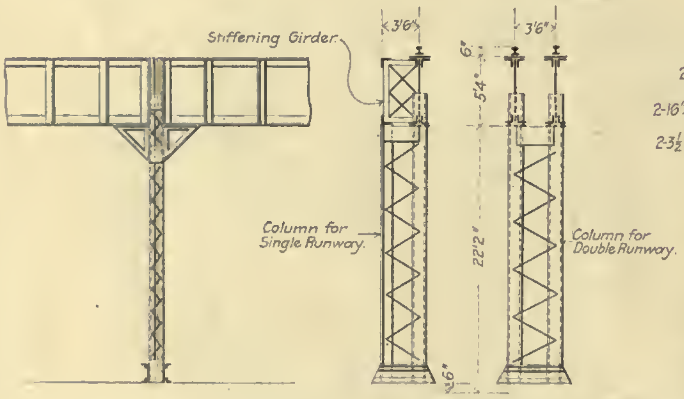
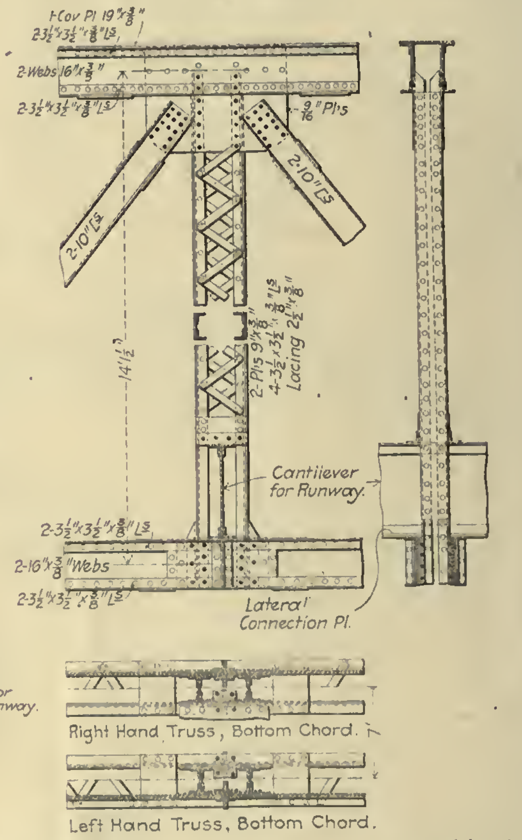


Plate Girder Crane Runways between Buildings

The Engineering Record



Traveling Crane Truss in Shipping Yard

The Engineering Record

Details of Yard Crane Runways in the Ambridge Plant of the American Bridge Company.

solid frames for the transom windows and to be fitted securely and easily to the steel channels and angles of the wall framing. The exposed edges of the caps are flashed with zinc and shoulders are provided for nailing the bottoms of the galvanized iron, the principal woodwork being secured to the steel with countersunk stove-bolts. The lower windows in the concrete walls are keyed in position, as shown, by projecting ribs nailed to the centers of the frame pieces, and are fastened to the framing angles above by countersunk bolts. In the upper part of the wall the frames for the sliding sash windows are countersunk-bolted to the horizontal angles, and the window sills are undercut to receive the upper ends of the corrugated sheathing, which are further secured by fillet pieces. The cornice is made with projecting blocks nailed to the ends of the roof sheathing boards and enclosed with longitudinal strips. The upper side is sheathed at an angle with the main roof so as to form a simple gutter, and the flashing is carried over the ends and protects the edge of the light galvanized steel moulding, which entirely encloses the face of the woodwork and is nailed to the upper part of the corrugated sheathing.

This building was erected by the tower travelers which were afterwards used for the erection of the main bridge shop. The structural steel in it weighs about 1,300,000 pounds. The adjacent bolt, nut and rivet shop is between it and the machine shop. It has the same dimensions and the same design and details, but is made slightly lighter. The total weight will be about 1,250,000 pounds.

Equipment.—The forge and bending shop will be equipped to do most of the heavy bending and all forging for general construction. It will have four 400-ton horizontal forging presses of the Pencoyd type, each with two intensifiers, one triple and one single; two 600-ton Pencoyd vertical forging presses, each with two triple intensifiers, designed for general work, manufacturing clevises and sleeve nuts. They will also be capable of crimping the ends of four 6x4-inch web-stiffener angles at once and will be especially used for this class of work. There will be ten or fifteen blacksmith forges with down drafts, an upsetting machine for 2½-inch screw ends, one double vertical boring mill for loop-ended rods, one Pencoyd hydraulic loop-bending machine, one Acme 3-inch screw cutter, three or four 800-pound steam hammers, one 2,500-pound shear, one 3,000-ton hydraulic press with several series of intensifiers for forging pins, and a temporary equipment of bolt and rivet machinery, to be transferred eventually to a separate shop which will be structurally a duplicate of this shop and will be used for forging, screw cutting and storing all bolts, nuts and rivets used and manufactured at this plant. Both shops will be heated and ventilated by the fan system with overhead galvanized iron ducts and radiators supplied with live steam. The forge and bending shop is equipped with one 10-ton crane in the center runways and two 5-ton cranes in side runways, and has a temporary installation of tools received from other plants belonging to the American Bridge Company, placed here for the fabrication of the structural materials in the Ambridge plant. After the completion of the main bridge shop, this equipment will be removed and most of it will be installed there, but the forging machinery above mentioned will be set up in the forge and bending shop. The rivet bolt and nut shop will have two 5-ton traveling cranes on each runway.

Shipping Yard Cranes.—The shipping yard at the north end of the main bridge shop has an area about 210 feet wide and 636 feet long which will be commanded by three parallel sets of 60-foot overhead travelling cranes, as indicated in the general plan published November 21. Each runway will have two cranes, those in the panel adjacent to the bridge shop being of 5 tons capacity and those in the other two panels of 25 tons capacity. The rails for the 25-ton cranes will be carried on 30-inch plate-girders supported by double transverse cantilevers which rest on the bottom chords of lattice-girder trusses of 70, 82 and 90-foot spans. These trusses are in pairs 7 feet apart on centers, braced together by zigzag lateral angles in the planes of the top and bottom chords. They are supported at a clear height of about 25 feet from the ground on pairs of columns which are braced together with zigzag angles in planes transverse to the runway girders. The trusses are clear of the crane-girders and extend several feet above them. They are designed to carry transverse roof trusses which it is proposed to add in the future to protect the finished product in the yard.

All truss members are built pieces with rectangular cross-sections and riveted connections. The cantilevers supporting the runway girders pass between the flanges of the vertical posts and are seated on the tops of the bottom chords, which have their flanges reinforced at the bearings by vertical web-stiffener angles. The trusses are seated on the column caps with drop ends made by building riveted seats on the projecting ends of the top chords and gusset plates, as indicated in the diagram of side elevation.

The runways for the 5-ton cranes are plate-girders. Adjacent to the bridge shop transept they are 24 inches deep and are carried by brackets on its wall columns. Beyond the transept they are 66 and 78 inches deep and are carried on pairs of light columns separated 5 feet transversely and latticed together, as indicated in the elevation diagram. The girder is seated on the center line of one column and is transversely braced to an auxiliary line of lattice girders on the tops of the other columns, which are calculated to give sufficient transverse stability.

Stock Yard Runways.—In the stock yard, between the main bridge shop and bending and forge shop are five runways, each of 60-feet span, and of capacity to carry two 10-ton cranes. The runway girders are I-beams supported from the lower chords of parallel lattice girder trusses which, with their columns, are similar to those in the shipping yard, already described. These trusses are generally of 90 feet span, and in addition to crane loads are designed to carry future roof trusses, should it be deemed advisable to put the stock yard under cover. There are single 60-foot runways on both sides of the bolt and nut shop, between it and the bending and forge shop on one side, and the machine shop and foundry on the other. These runways are also for two 10-ton cranes. The track rails rest directly on plate girders of 40 to 60 feet span. Running parallel to these girders, about 3½ feet from them, are lattice girders of the same depth, braced to them in the plane of both top and bottom chords. These lattice girders are calculated to give lateral stiffness to the runway girders, and also to carry a future roof when wanted. The columns are made of two built channels with backs out, about 3½ feet apart and laced together. They carry both the runway plate girders and the latticed stiffening girders.

Transfer Gantry.—As all the yard cranes have a uniform span and height and move in parallel directions, provision has been made for their interchange by means of a gantry, like a transfer table, which runs on a track intersecting all the crane-runways. Its height exactly corresponds to those of the runways, and it can be moved from runway to runway so that any crane can be run on to it and transferred to any other panel where it may be temporarily needed. This gantry will consist of two four-wheeled towers on a longitudinal track of 18-foot gauge. These towers are each simple gantries with a clearance through them between the rails which is about 10½ feet wide and 13½ feet high. They carry the opposite ends of a 60-foot bridge span having transverse rails on which the travelling cranes can be run. The rails are provided with massive stops so that the crane cannot accidentally roll off. Each tower has a 10-horse-power Westinghouse motor on top, driving, through miter gears and an inclined shaft, one pair of the wheels on each truck. The estimated weights of structural steel in the yard runways, exclusive of the future roof trusses, is as follows: Stock yard, 1,600,000 pounds; shipping yard, 1,900,000 pounds; between the power house and the eye-bar shop, 670,000 pounds; between the foundry and the eye-bar shop, 670,000 pounds.

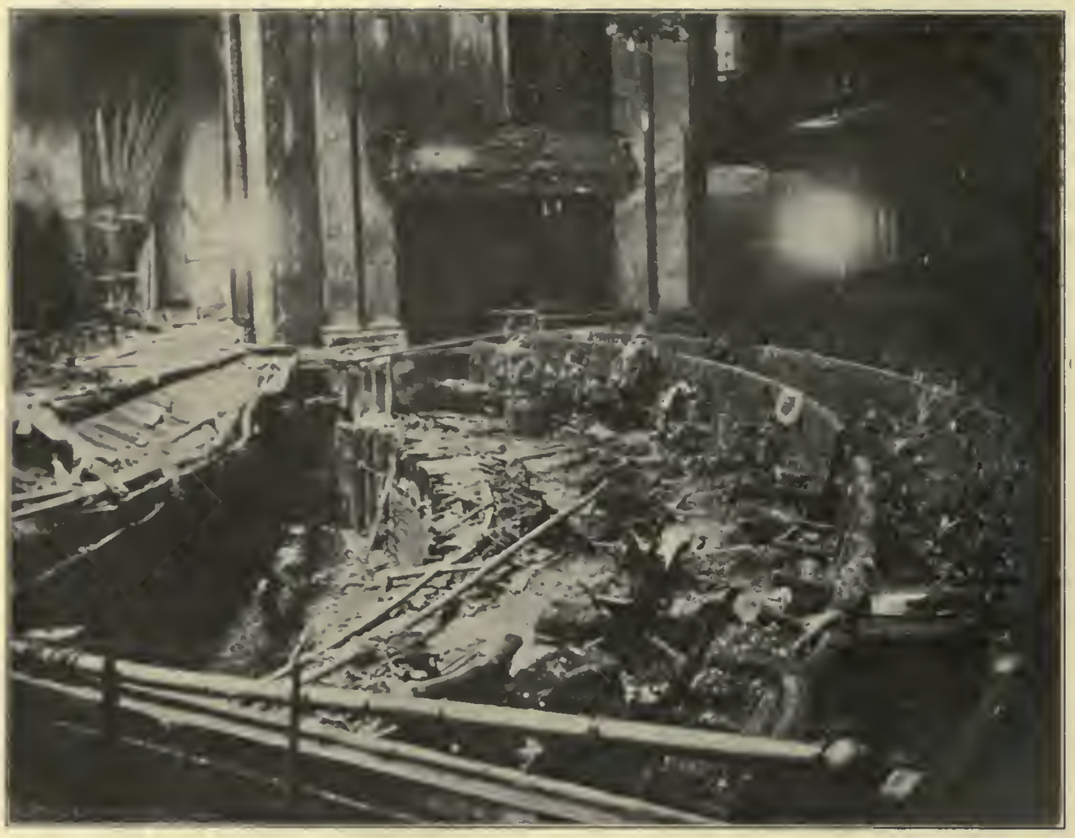
(To be continued.)

The New England Water Works Association will hold its annual meeting at Hotel Brunswick, Boston, Wednesday, January 13. A visit will be made to the Chestnut Hill pumping stations of the Metropolitan Water Works, and papers will be presented on the following subjects: Cost of Waterproofing Concrete Lining of Reservoirs; Mosquitoes, with Suggestions for Their Extermination; Meter Rates.

Long and Heavy I-Beams were recently handled by an ingenious method devised and executed by Lewinson & Company, who were the contractors for the steel work in a butcher's shop on Fulton Street, New York. It was necessary to provide support for a 50-ton brine tank in the third story. The old floors were not strong enough to carry it and a set of five 18-inch I-beams 24 feet long were designed to be seated on the side walls and receive the tank. The beams could not be hoisted through the stair wells nor on the elevator cars, and the side walls were only about 22 feet apart in the clear so that additional difficulties were presented in setting the beams in position. Recesses were cut in the brickwork to receive the bearing plates and in one wall these were cut entirely through. The elevator was lowered to the foot of the shaft and the counterweight rope and the two hoist ropes attached to it were lashed together near the lower ends. A tackle was attached to the lashing and operated to relieve the stress on the bolts which connected the ropes to the car. These bolts were then removed and a steel plate was bolted to the ends of the rope. A hook and clevis was connected to the lower edge of the plate. The I-beams were separately delivered from the street to the first story floor and slings attached to them near the center of gravity were engaged by the hook on the elevator ropes. The elevator machinery was then operated to lift the beam up the shaft, the lower end being guided by a tag line. At the third story the upper end of the beam was revolved down and out through an opening made by removing the sash of an adjacent window. The beam was lowered to a horizontal position and rolled across the floor. One end of it was inserted in the opening through the wall and the beam was pushed through until the other end could be entered in the recess in the opposite wall, where it was seated in the final position and both openings were permanently closed with brick and mortar. All of the beams were similarly set in a rapid and economical manner, after which the clevis plate was removed and the elevator ropes were re-attached to the car.

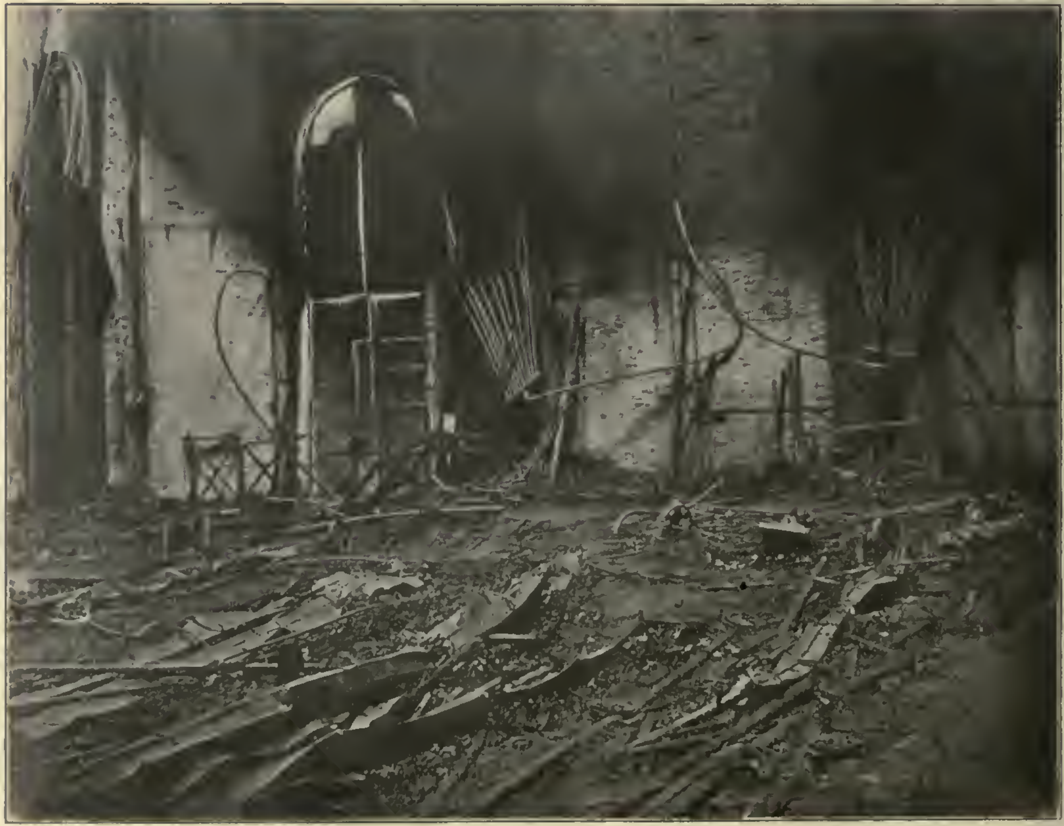
The Structural Effects of the Iroquois Theatre Fire.

The Iroquois Theatre in Chicago was opened to the public on November 23, 1903. It is of modern design and construction. The building has a frontage on Randolph Street of 60 feet and extends back 180 feet to an alley. On the alley the building is 124 feet in width. The general plan of the building is in the shape of an L. The entrance is on Randolph Street, and a space 60 feet wide by 90 feet in depth is used as the foyer. On either side a grand staircase leads up to the first balcony, where there is a landing across the end of the foyer. The stairs extend from this landing in two flights up to a small gallery running along either side of the foyer at the elevation of the gallery in the auditorium. A heavy masonry wall separates the foyer from the auditorium. The auditorium is 90 feet wide by 70 feet deep from the line of the curtain to the back of the building. The stage which forms the other leg of the L is 110 x 50 feet. The south end of the stage consists of six stories of dressing rooms, which are reached by stairs and an elevator. There is a heavy brick wall between the auditorium and the stage. Columns are built in this wall, carrying a 5-foot plate girder which supports the brickwork above the proscenium opening; this girder is protected by several inches of cinder concrete. Mr. Benjamin H. Marshall, of Chicago, was the architect of the building, the Geo. A. Fuller Company, of Chicago, was the general contractor, and The Roebling Construction Company of Chicago furnished the fireproof construction.



View of Auditorium and Musicians' Box.

The fire which produced such an appalling loss of life on December 30 is supposed to have been started by what is termed a "spot" light, at an elevation of about 12 feet above the stage and very near the proscenium opening. Curtains hanging near this light are believed to have caught fire from sparks and the flames were very quickly beyond the control of the stage hands, who had a meager equipment for meeting such an emergency. The fire quickly communicated to all the drop scenes, of which there were a great number used in the production of the play, and the whole stage became a roaring furnace. The asbestos curtain, to be used in such emergencies, was lowered to within some 14 feet of the stage. It then refused either to come down or go up. The exact cause for this is not known, but it is supposed that the enormous draft caused by the smoke and heated air going out into the auditorium forced the curtain against the wall in such a way as to prevent its movement. In the design of the ventilation system, a large ventilator was placed in the roof at the back of the auditorium. Flames and gases apparently rushed toward this ventilator, soon destroying the asbestos curtain and filling the auditorium with gases.



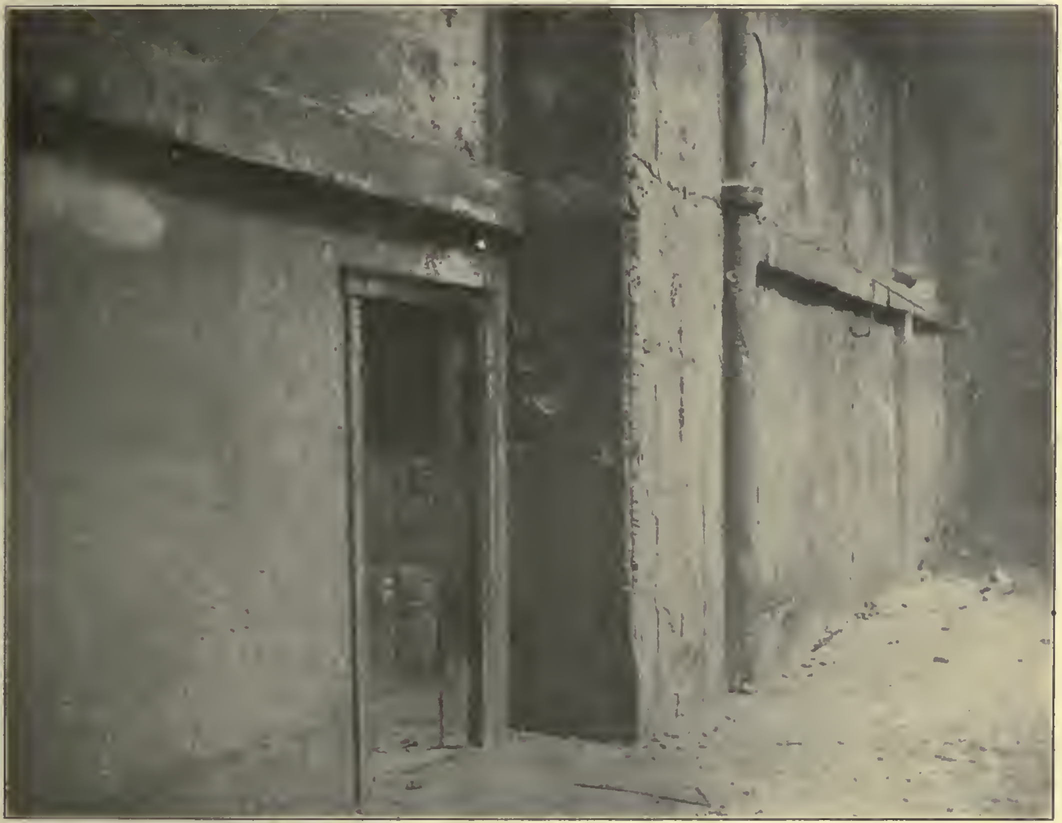
View Looking across the Stage.

The audience immediately became panic-stricken, but practically all who were seated in the orchestra made their escape. Those on the first balcony were far less successful. On the alley side of the balcony there are three doors leading out to a stair fire-escape. These doors were apparently not open during the fire. On the south side of the balcony there are two large exits into the foyer and a small one supposed to be used for the upper boxes, which lead by a winding stair down to the first floor of the foyer. It seems that one opening on this side of the balcony was closed, forcing practically all the people in the balcony to escape through one exit, which is about 9 feet wide and located at the extreme southeast corner of the auditorium. A perfectly straight stairway leads from here down to a place of safety, but it was from along these stairs and the entrance to them that the greatest number of dead bodies were removed. In the top gallery the conditions were quite similar, though it appears from the charring of the doors leading into the fire escape from this gallery that they were opened before the fire was quenched. However, but few people escaped by means of the fire escape on the alley.

The general cause of the hundreds of deaths is assumed to have been suffocation, which must have come very quickly, for many people were found dead in their seats in the position of watching the stage. The doors leading into the fire escape which were not opened were latched by means of a simple arrangement, and it is impossible to determine why they were not opened.

One result of the fire in the building was the burning of the entire scenery on the stage and in the scenic tower. As the play was a spectacular one, the amount of this scenery, of a highly combustible nature, was enormous. That the fire was an extremely hot one is proved by the condition of the exposed parts of the structure. A paint bridge between the first fly galleries at the back of the stage, composed of two small lattice girders, is warped and twisted 18 inches out of line. The heating pipes placed in the stage along the wall are badly twisted and in many cases fallen to the stage. Small iron ladders at a height of 60 feet above the stage on either side are badly sagged from their own weight. A gridiron composed of steel beams, situated 75 feet above the stage, shows evidences of high temperature, some of the beams having sagged as much as 2 to 3 inches.

The damage described above, together with the loss of seats, the decorations in the auditorium and some of the plastering, represents practically all the injury to the structure of the building. All the fireproof floors and roof construction in the building were not damaged by heat or water. The partitions dividing the dressing rooms from the stage, which were subject to severe test by fire and were in a direct line with the fire hose, formed a complete barrier for the progress of the conflagration, though in some cases the last coat of plastering was washed away. The doors through these partitions were destroyed by the fire. To one who examines the condition of the building, it does not seem possible that a fire so fierce and accompanied with such destruction of life, could have produced so slight an effect on the structure of the building. It will require but little more than the plastering and redecorating of the building to restore it.


Effect of Fire on Partitions about Stage.

The three photographs illustrating this article were lent by Mr. A. L. A. Himmelwright, manager of the Roebling Construction Company. The view of the stage shows its north end, where the condition of the steam heating coils bears evidence of the high temperature at this place. The scenic door in the left of the picture is the opening through which most of the water was introduced for extinguishing the fire on the stage. Another view shows the condition of the partition between the scenic tower, or upper part of the stage, and the dressing rooms. This partition was subject to a very high temperature and also received a large amount of water from the fire hose. The condition of the partition is really remarkable in view of the great heat generated by the burning scenery on one side of it, for the last coat of plaster only is off in some spots on its inside. The columns in the partition were covered with wire lath and plaster, and their protection is intact. The condition of the upper part of the door in this view is particularly interesting.

The view of the auditorium is taken from one of the orchestra boxes and shows the condition of the front of this room and also of the front of the stage. The first two rows of seats were entirely consumed and the upholstery burned off the remainder. In the pit in which the musicians were stationed, the Roebling floor is uninjured except where a heavy weight, evidently a counterweight, fell through it.

In the top balcony the upholstery on practically all of the seats was entirely consumed, the front rail along the balcony was badly twisted and broken, but the suspended ceiling and fireproofing of the columns is in no place so injured as to expose the wire lath.

The girder which supported the heavy brick wall over the proscenium arch is about 5 feet deep and is protected with a considerable thickness of cinder concrete back of channel iron and wire lath furring, the whole plastered. The plaster came off, but the concrete is intact. The plaster on the metal framing of the false proscenium arch suspended from the girder, in order to give the effect customary to such portions of a theatre, is lacking in a number of spots. This is probably due to the fire streams which played on it from a short distance.

The Compression Formula, printed on page 24, issue of January 2, should have been $P = 16{,}000 \div [1 + (l^2 \div 12{,}500\ r^2)]$. Through typographical error the coefficient 12,500 was placed on the wrong side of the second sign of division.

Roads for Automobiles and Motor Cars, to run on absolutely straight lines between important places, have recently been suggested in England. The advantages of such roads would be speed, convenience and safety. They would be built on private rights of way, but would not enter the cities at their termini, since the automobiles could use the streets. Entrance to these special roads would be obtained at intersections with highways. Wood, brick, asphaltic macadam or concrete paving is proposed.

Railway Location in Flat Country.

By R. E. Hardaway, Chief Engineer, San Antonio & Aransas Pass Railway.

Construction work on the San Antonio & Aransas Pass Railway started as usual, close on location and location very close on reconnoissance work, an economy well warranted where bonds are drawing interest. The line is to be built from Alice to Brownsville and Hidalgo, the last two places being situated on the lower Rio Grande. The main line distance to be built will be between 165 and 170 miles. The country is remarkably level, the undulations not exceeding fifteen or twenty feet at intervals of 3,000 feet or more, so that 0.3 per cent. gradients are maximum, and so short as not to limit trains, which will pass over them by aid of momentum. Our maximum rate of curvature will probably be 2 degrees. In the first 110 miles we have only three curves, all 1 degree, aggregating 42 degrees or less than one-half degree per mile.

The country is so thickly covered with mesquite, nopal, cactus and other thorny brush for 70 per cent. of the distance as to force reconnoissance work into highways and paths. Between 40 and 70 miles south from Alice there is continuous deep sand, now almost all covered with small trees and grass or weeds. During long periods of drought this sand drifts before the prevailing winds so as to form long or short ridges as much as 30 feet above the average ground. In one place the writer saw the end of a white sand ridge slowly moving over the top of live oak trees 25 feet in height leaving them entirely covered. The problem of preventing these drifts from traveling over the track will be an interesting one. There are not many large ones, however, and they travel slowly. They do not move at all when well covered with vegetation, a fact that suggests probably the best method of controlling them. The cuts are only few in number, ten to twelve feet deep, and will be taken out at slopes of 2 to 1.

The remaining portion of our line is over very fertile soil, mostly firm sandy loam well adapted to the profitable cultivation of vegetables and fruits, which grow to perfection even in mid-winter. Alice is 210 feet above the sea level and about 55 feet above the overflow from artesian strata of nearly pure water which is very abundant in quantity. Twenty miles south of Alice this water overflows in many wells and furnishes a cheap supply for cattle raising and for irrigation for a distance of fifty miles, where the most southern well yet drilled is found. This supply of water is doubtless available all the way to Hidalgo and Brownsville, but the water bearing strata are deeper and wells much more expensive. A constant flow of 200 to 300 gallons per minute can be obtained at a cost of from $1,000 to $2,000 total for one of these wells.

The land is very cheap, $5 to $15 per acre, and is very inviting for homeseekers. Semi-tropical fruits can be raised in great quantity on it. The orange, lemon, pineapple and banana would require some shelter in the coldest weather, at long intervals of time. The country is still in large cattle ranches of from 10,000 to 1,300,000 acres which are very profitable, but the owners are willing to sell off much of their land for small farms to aid in populating and developing the country.

Our location party consists of fourteen to eighteen men, the axemen being increased in number in the heavy brush. This party locates from three-quarters of a mile to 3 miles per working day. The preliminary surveys are made by a stadia party, using only one instrument, a complete transit. One man makes all records of azimuth angles, levels and distances, including side elevations and distances to notable features. This is the third road on which the writer used this method of making preliminary surveys and he considers it most satisfactory and economical. A high-grade and careful man, not afraid of work, is necessary for instrument man, and he should have better pay than other transitmen. He has a rodman, who is an engineer, to assist him with computations, and to run the instrument when necessary. He should also receive better than the average rodman's pay. Another rodman is needed who is at times director of the axemen.

Angles are taken by use of the needle, which is a good one; back sights are taken occasionally only as a check on the needle. In open country the transit is moved ahead of the last point and a distance bearing taken to the rear as well as in front to save time. By intermediate sights all breaks in the surface of the ground of any importance are recorded for profile elevations. A Philadelphia rod is used, a second target being placed near the bottom and clamped 1, 2 or 3 feet above the bottom. The lower stadia wire is placed coincident with the center of this target, then the upper target is run into coincidence with the upper stadia wire. The difference on the rod between the two targets gives the distances when they are between 600 and 1,100 feet, the limit. For distances less than 600 feet, the rod is read as a speaking rod. I consider the distances more accurate than when chained, which fact is due largely to the balance of errors, while the errors in chaining are mostly cumulative.

Twenty-five years of railroad building, during which time the writer has used many instruments, leads him to the conclusion that the Gurley reconnoissance transit costing about $120 is the most useful instrument for general work that can be found. Its portability is of first consideration in value and its accuracy is sufficient for any except extraordinary work. With one of these instruments, using the stadia, the writer closed a meander line seven miles down a river and eight miles around a swamp, within 15 feet, or one foot per mile error.

The line is mapped by latitudes and departures, the angle-turning points being placed in twenty-chain squares, shown on the paper. Pegs are placed at the end of each transit sight and marked 0, 1, 2, 3, etc., and each fifth peg has the distance from zero on the back in feet with two decimals, so that 117.34 would be station 117 + 34 or 11734 feet from zero.

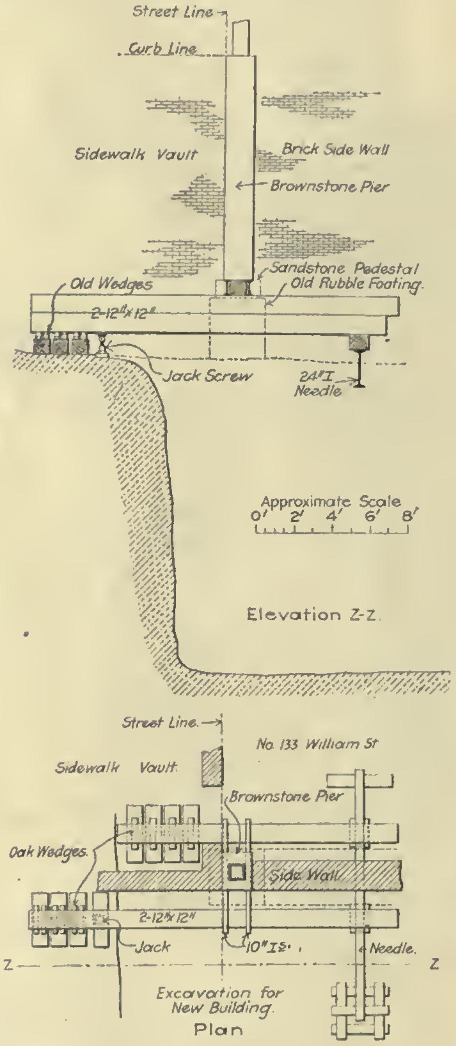
This party operates at less than half the expense of the other, and is extremely light, mobile and easily provided for. There is much less of camp cares and management to engross the mind of the chief of the party, who in the stadia party is often the man who runs the instrument. No man in the stadia party has time to idle away while the axemen cut out the line, and the progress is about the same as the full party with chainmen, leveler, flagmen and the extra team, teamster and cook.

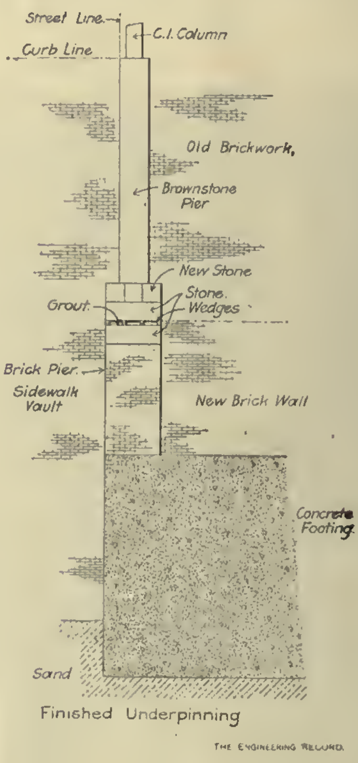
Our work is placed 80 to 90 per cent. in embankment, for the best drainage of the roadbed. Eighty miles of our lines have been located and fifty miles are under construction.

THE HOLLY GRAVITY RETURN SYSTEM of delivering into boilers the condensation in steam piping, according to Mr. E. H. Davis, of Williamsport, Pa., recently president of the Pennsylvania State Street Railway Association, consumed in its operation, in a modern plant of 1,000 kilowatts capacity, where during a test practically 200,000 pounds of water were evaporated in 24 hours, a total of 2,300 pounds of steam in the same time, or about 1.1 per cent. of the steam generated.

Underpinning a Corner Column on a Slender Pier.

The five-story building at No. 133 William Street, New York, has a brownstone front and brick side walls enclosing cast-iron columns. The new building now being erected on the north side of it has an excavation carried so much below the cellar of No. 133 that it was necessary to underpin the side wall and front corner column with new footings carried down in the sand to the bottom of the new excavation. The wall was of good quality and was easily underpinned by the ordinary needle-beam and open-trench method. The corner column presented special difficulty because it was seated on a slender pier composed of a single piece of brownstone about 18 inches wide, 30 inches long and 12 feet high. This pier had a sandstone base about 30 inches square and 11 inches thick with a rubble footing continuous with the footing for the adjacent walls.





Method of Underpinning a Slender Pier Supporting a Corner Column.

A skilled stonecutter was employed to cut away about 8 inches of each side of the pedestal so as to leave room to insert a 10-inch I-beam with its top flange bearing on the foot of the brownstone pier across each side. The cuts were slightly grooved top and bottom so as to give clearance for the flanges and leave as much stone as possible undisturbed for bearing in the middle. In each slot a 10-inch I-beam 6 feet long was set in the plane of the front wall and supported at each end on a pair of 12x12-inch timbers about 20 feet long set one on top of the other as close as possible to the pedestal.

The beams which were inside No. 133 were supported at one end on the needles introduced under the old footing to carry the wall, and at the other end on a grillage of 4-inch transverse planks laid on the floor of the sidewalk vault. They passed through the vault door which had to have one jamb cut a little to clear them. The other pair of 12x12-inch beams, outside of No. 133, were supported at one end on the same needle-beam and at the other end on transverse sills laid on the bank at the edge of the excavation.

All the beams were blocked up above the 24-inch I-beam needle-beam and the street ends were set a little lower and adjusted by pairs of oak wedges. Close to the sills a jack screw was set under the outside beams to give additional control of them. The wedges being driven, lifted the 10-inch I-beams and the corner column so as to release the center part of the pedestal which, with the rubble footing below, was removed.

The excavation was then carried down to subgrade and a new concrete footing 12 feet high was built continuously under the column and the side wall. A brick pier 6 feet high was built on this footing and was capped with a pair of 12-inch granite wedging stones, the upper surface of which received a 10x11-inch granite pedestal stone carefully fitted between the 10-inch I-beams. The steel wedges were driven until the weight of the column was transferred from the I-beams to the new footing. The I-beams were thus released and removed and the places which they had occupied under the edges of the brownstone pier were filled with a pair of 11x12-inch granite stones accurately cut to fit as close as possible. Both these stones and the center stone were set in thick mortar beds top and bottom, and as the outside stones were put in position soon after the center one had been placed, it is believed that the column load is equally distributed over the three parts of the pedestal.

The work was executed by the Foundation & Contracting Company, which was the contractor for the substructure of the adjacent new building. Mr. L. L. Brown was superintendent of the work, and Mr. W. S. Downing, foreman in charge.

Water Supply and Drainage Systems in the Lorraine Hotel, New York.

The Lorraine is a thirteen-story apartment hotel with fronts of 75 feet and 150 feet respectively on Fifth Avenue and Forty-fifth Street, New York. It rises to a total height of 161 feet above the curb and has a basement and sub-basement extending 27 feet below that level. Each floor has an area of nearly 12,700 square feet. The sub-basement is devoted to the kitchens, power plant and mechanical installation, which were described in The Engineering Record of October 27, 1900, when plans of the basement and sub-basement were published, showing the location of the principal tanks and pumps in the water-supply system. The basement contains public toilet rooms, barber shop, a large café and grill-room, and considerable space for storage and for servants' and officers' dining rooms. The first story is occupied by an entrance hall and corridor, parlor, reception, reading and other public rooms. The thirteenth story is chiefly devoted to small rooms for lodging the tenants' servants, and the remaining eleven stories are divided into 150 suites, of which 140 have complete private bath rooms. There are also shower baths for the employes, public toilet rooms and the usual complement of slop sinks, for all of which supplies of hot and cold water are provided, as well as for the kitchens, restaurant, barber shop and other public service and the refrigerating plant and steam boilers.

The drainage system comprises pipes for house and kitchen wastes and sewage and for the disposal of the roof and area water, most of which is discharged by gravity through a 6-inch and an 8-inch line to the street sewers on Fifth Avenue and Forty-fifth Street. The remainder, from those fixtures at the lowest level, is collected in auxiliary tanks and pumped or automatically discharged into the street sewers. Hot and cold water is supplied to all parts of the house under direct pressure from constant pumping through tanks in the sub-basement. Distribution is made on the sub-basement ceiling to all supply and return lines. The mains and tanks are cross-connected so that the house and fire service pumps are interchangeable with those for boiler feed, and so that the refrigerating and steam plants and the fixtures below the second story can all be supplied with raw or filtered water, under tank or street pressure. Drain pipes under the sub-basement floor are of cast iron accessible through the sectional covers of their trenches. Exposed piping in toilet rooms and apartments is of brass nickel plated; all other piping is of galvanized wrought iron with malleable screwed fittings. Changes in direction and fixture connections are made with 45-degree Y-branches and long bends. Vertical lines are supported at the base by hangers or on brick piers and are run in the pipe shaft or in wall chases enclosed by furring and plastering. Exposed risers are bronzed and the stand-pipes in the fire system, the water pipes in the pipe shaft and all cold water pipes exposed to condensation and the outsides of the cold water drums and connections are painted with Devoe's silicate white paint and Truslow's brown cork, screened No. 0, using one gallon to 360 square feet of surface. The valves are of the Fairbank Company's make, and have iron bodies with brass valve-seats, spindles and glands for diameters of 2 inches or over.

Water supply is obtained through two 2-inch taps in the Forty-fifth Street main, and one 1½-inch tap in the Fifth Avenue main. The 2½-inch and 2-inch supplies from them are measured by Worthington meters and are connected to 3-inch pipes, which ordinarily deliver direct to the New York Filter Company's filter of a capacity of 70,000 gallons an hour, and thence through ball cocks to the suction tank. Between the suction tank and the meters there are branches to the fire pump, house pump, feed pumps, feed-water heater, damper regulator, hose cocks, street pressure service and refrigerating plant. The 5-inch outlet from the suction tank is connected to two 7½x5x6-inch duplex Worthington pumps, which are controlled by Ford automatic regulating valves operated by the pressure in the mains. One of the pumps may be used for the house or reserved for fire service, and has a 4-inch outlet, connected to two 3-inch stand-pipes with hose reels and valves on the roof and in the corridors at every story. The other pump is used for the house supply and usually runs continuously at a slow speed. The pumps are cross-connected, and the water from the house pump is delivered to one of the two 1,200-gallon tanks from which all supplies in the upper stories are taken at a uniform pressure sufficient to give 12 pounds at the highest fixture.

The pressure drums are normally one-third filled with air at 80 pounds pressure, admitted through a valve in the upper part as required. The air is compressed by a Westinghouse duplex vertical air compressor, with a 10x10-inch steam cylinder and a 6x6-inch air cylinder, which delivers air also to the steel reservoir tanks of the elevator system. Besides being delivered to the pressure drums and tanks, the compressed air is supplied through a vertical pipe in the elevator shaft having an outlet at every other story, to which a hose can be attached with a nozzle for cleaning the elevator grillework.

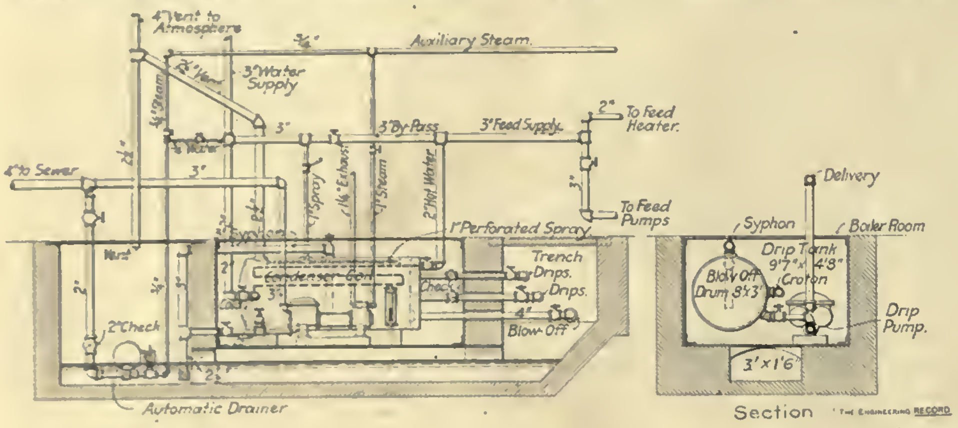
Two 1,000-gallon hot water drums are placed horizontally in the sub-basement, and are normally supplied with warm water from one of the pressure drums. This water is delivered by a 6x4x6-inch Worthington pump drawing from a 5,000-gallon reserve tank supplied with the warmed water from the condensers of the refrigerating plant. The hot water drums are so connected that either can deliver water under tank pressure to the upper stories of the house, while the other can be used to deliver water under street pressure only to the kitchen and laundry and for all other hot water fixtures in the basement and sub-basement. They are cross-connected so that they can be used together or either of them can be used under either pressure. The water in them is heated by steam coils of sufficient capacity to do the work by exhaust steam and the temperature is regulated by Kieley automatic thermostats set to close the steam supply valves when the temperature rises to 150 degrees Fahrenheit. Each of the vertical riser lines to the upper stories has a parallel return branch two sizes smaller, which is connected to it above the highest fixture by a loop with an air cock in the center. Both risers have valved drip pipes through which they may be emptied, and all are connected together and run to the blow-off. The return circulations are branched to a single header, which is connected to the cold water inlet of the hot water drum. Each drum is provided with a safety valve, pressure-gauge and thermometer, is painted and is jacketed with sectional magnesia blocks secured to 2-inch mesh wire netting, plastered 1½ inches thick and covered with painted canvas.

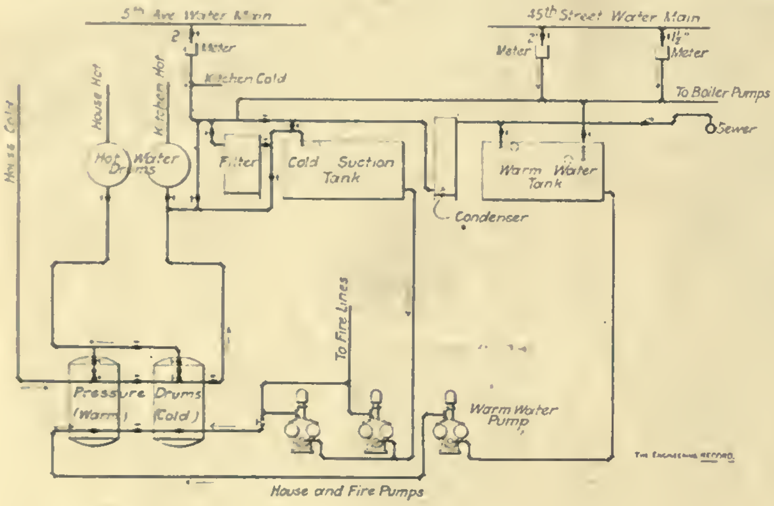
The drums are each 4-foot horizontal cylinders 11 feet long, made with 5/16-inch steel plates having double-riveted longitudinal seams and single-riveted ⅜-inch dished flanged heads in one of which there is a large hand hole. Each tank contains a coil of thirty 2-inch galvanized iron pipes 9 feet long with malleable iron galvanized headers and connections to live and exhaust steam. There are bottom connections with 2½-inch outlets to the cold water supply and 1¼-inch return circulation, and 1-inch emptying pipe led to the blow-off tank, with 2½-inch outlets on the upper side of the tank. Each tank is tested to 150 pounds pressure and is provided with a thermometer and a safety valve set at 80 pounds pressure.

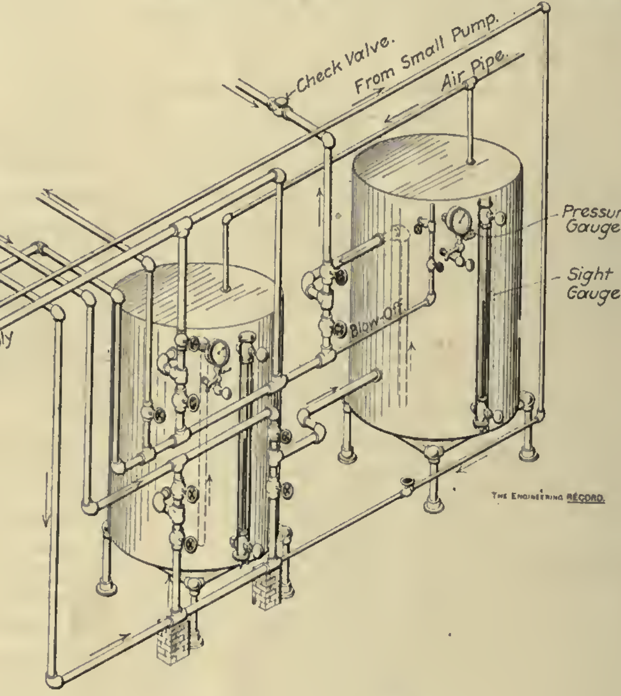
There are two sub-basement tanks, one of which is used for pump suction and is filled directly from the filters, or directly from the meters, and the other acts as a reservoir tank, and is filled through a ball cock by the water which has passed over the closed condenser of the refrigerating plant. The suction tank is 10 feet long, 6 feet wide and 6 feet high, made with ¼-inch steel plates and angles and having 4-inch overflow, 5-inch outlet and 2-inch emptying pipes flange-connected to it. The storage tank is 9x8x9 feet high. Both are painted inside and outside with asphaltum paint and are covered with wooden tops having trap doors over the ball cocks.

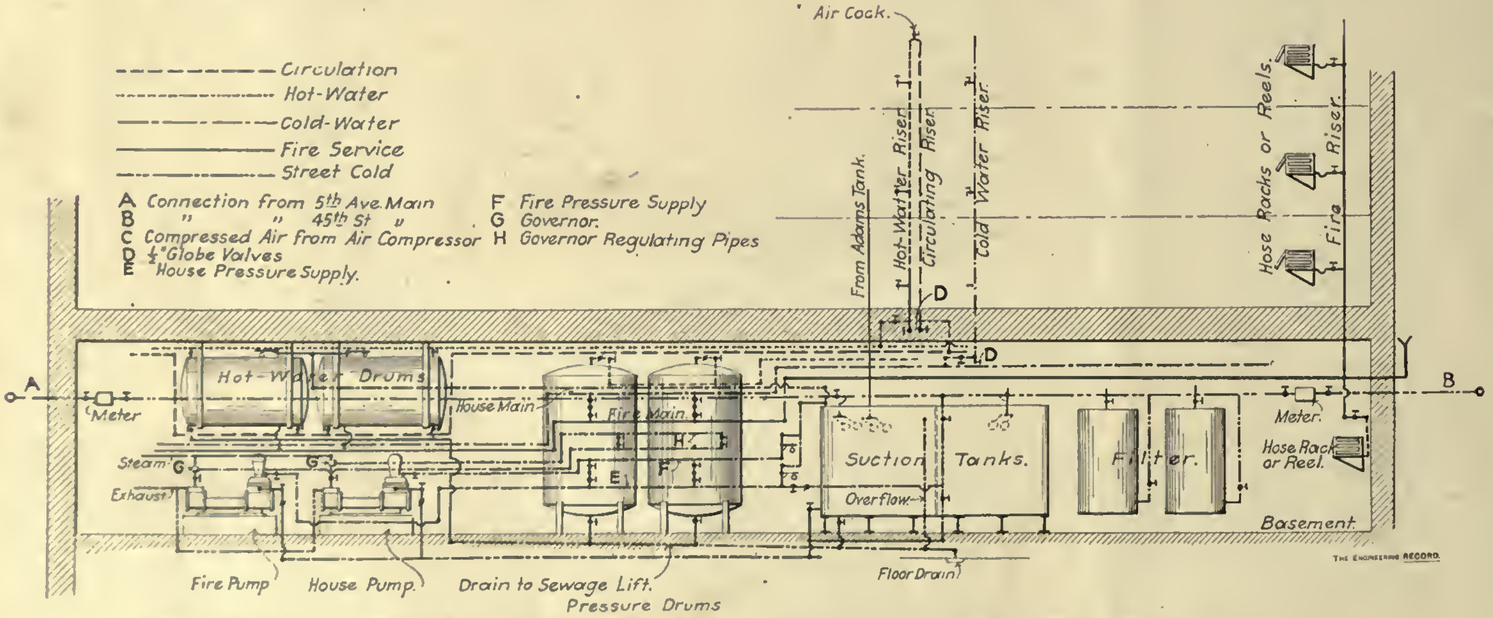
The duplicate pressure drums are 5 feet in diameter and 8 feet high, made of 9/16-inch steel plates with ⅝-inch heads. They were tested to a pressure of 200 pounds per square inch and are painted, but not covered. They each have tapped connections for a 2-inch safety valve, a ½-inch pressure gauge, a ⅜-inch governor pipe, a ½-inch air valve, a 5-inch inlet, a 5-inch outlet and a 1½-inch blow-off. The 12x12-inch manhole opening is reinforced by a ½-inch plate and the 5-inch holes have cast iron pads. All connections to the drums were tested, after completion, to 150 pounds pressure, and the safety valve is set to 80 pounds pressure, but is capable of quick adjustment to 120 pounds for fire pressure. The 8-inch dial Ashcroft pressure gauge is indexed to 15 pounds pressure per square inch, and each drum has a water gauge with brass guard rods, set to show a rise and fall of 4 feet. The 5-inch inlet and outlet connections and the ⅜-inch governor pipe each have an inside leg carried down within 6 inches of the bottom.

The drips from the pipe systems and the emptying pipes from the tanks are connected to the blow-off and drip tank so that the cold waste water may be utilized in condensing the vapors of the hot drips. The blow-off tank, 3½ feet in diameter by 10 feet long, is seated below the sub-basement floor, in a brick chamber, which is drained to the sewer by an automatic Braender ejector, as shown in the cross-section. This ejector has connections by which it may be operated either under steam or water pressure, and is accessible under an iron manhole plate through which a vent pipe is run to the roof. The brick chamber is built larger than is necessary for the blow-off tank and serves as a catch-basin to collect ground water under the sub-basement floor, which is led to it by the course of the pipe trenches. The tank is made of ¼-inch steel plate with double-riveted longitudinal seams and dished heads 5/16 inch thick. It is tested to 150 pounds pressure and is provided with a condensing coil through which the feed water is passed. Its entire contents can be siphoned over into the catch-basin, or discharged to the Forty-fifth Street sewer outlet by a pump or by direct contact with steam pressure turned into the tank. The condensing coil is warmed to about 100 degrees by the waste and drip water, and surplus vapors may be further condensed by a spray of street-pressure water delivered through a perforated pipe in the upper part of the tank. When the contents are cooled so as to prevent any steam from entering the sewer, they are discharged to the sewer by a 3½x5-inch Worthington drain pump with 2½-inch suction and a swing check on the 2½-inch outlet. The suction of this pump is also connected with the catch-basin so as to empty it if desired instead of using the cellar drainer. The tank is fitted with a water-level gauge, and has a 3-inch drain valve to discharge the mud to the catch-basin. It is covered with 2-inch mesh wire netting and magna-bestos plaster with hard finish and two coats of paint. The condensing coil consists of twenty-four 2-inch galvanized iron tubes 8 feet long with galvanized malleable headers.









Some Details of the Water Supply and Drainage Systems in the Lorraine Apartment Hotel, New York City.

The building is fitted with a 20-ton absorption refrigerating plant, installed by the Carbondale Company, which has a cold brine storing and circulating apparatus of extra large proportions. The brine is pumped through coils to the ice-making tank, general cold storage and various kitchen, pastry and restaurant boxes. There are two 7½x4½x6-inch brine pumps. The condenser is of the closed pattern, and there is also a fore-cooler tank which overflows at a temperature of 90 to 100 degrees into the storage tank. The discharge from condenser to suction tank is delivered through a ball cock and when it closes the water in the condenser discharge pipe develops sufficient pressure to open a weighted relief valve and through it discharges directly into the sewer. The arrangement utilizes as much as possible of the waste heat from the condenser by providing tempered water for the hot drums and thus saves direct steam supply there.

The refrigerated boxes are all constructed so as to be operated with a loss of not more than three British thermal units per square foot of exterior surface when the thermometer is 90 degrees Fahrenheit outside. The kitchen and pantry boxes are lined with white spruce without beading, finished with two coats of alcohol shellac and covered with three-ply Giant P. & B. paper on 2-inch studding, sufficiently divided for a dead air space, which is cork-filled; then two-ply paper as above, then 2½x⅞-inch white pine flooring laid diagonally, then 1-inch horizontal and vertical battens forming a second air space, then one-ply paper as above, and outside of all 2½x⅞-inch matched white pine flooring at back, top and bottom and oak flooring at front and sides and doors.

The ice tank has a capacity for making one ton of clear ice in 24 hours, and is fitted with thirty 100-pound 8x15x33-inch galvanized iron ice moulds and served by a portable hoist. The ice is made from water distilled by an apparatus consisting of a steam condenser, re-boiler, skimmer, a silicate and charcoal filter, a re-condenser coil, a sweet-water tank and cooling coil, and having a capacity for two tons of ice per day. Drinking water is purified a second time by a special three-barrel stone filter with a capacity of a hundred gallons an hour.

The soil and waste pipes from all the fixtures in the sub-basement floor discharge into a double Shone ejector apparatus placed in a pit below the boiler room floor level, but open for access. These discharge through a 6-inch pipe to the Forty-fifth Street sewer. The Shone system includes two Westinghouse vertical compression cylinders 8x10x8-inch and a 36-inch vertical steel plate reservoir 6 feet high. As each receptacle fills with sewage, it trips a valve and admits compressed air to the top of the sewage which is thus forced out through a discharge valve to the sewer. The whole of the kitchen drainage and of the help's toilets in the sub-basement are thus handled, the lift being 21 feet. Messrs. Jeremiah O'Rourke & Sons were the architects of the building, and the work here described was designed by Mr. Reginald Pelham Bolton.

William Hubert Burr.

Mr. William H. Burr was graduated as a civil engineer from the Rensselaer Polytechnic Institute, the old school of civil engineering, at Troy, N. Y., in 1872, and has been continuously engaged in the active practice of his profession since that date. Immediately after leaving school he entered the office of a wrought iron bridge-building company in New York, and remained with them for a year, after which he spent a year on the water-works at Newark, N. J., where he was engaged on the construction of a reservoir. In 1875 he became an instructor in the institution from which he graduated and within a year from that time became the head of its department of applied mechanics. He remained in Troy until 1884 combining, during the whole of this period, the active practice of civil engineering with the duties of instructor. In 1884 he became assistant to the chief engineer of the Phoenix Bridge Company, of Phoenixville and Philadelphia, and later became general manager of that company. Under his supervision and direction some of the largest wrought iron and steel bridges of that time were designed and built, including the Chesapeake & Ohio bridge across the Ohio River at Cincinnati, Ohio, then the heaviest truss bridge in existence; the Louisville & Jeffersonville bridge across the Ohio River; the Red Rock cantilever bridge across the Colorado River near Needles, Cal., and the Pecos viaduct in southwestern Texas, the highest viaduct structure in this country. In 1891 he returned to New York City and was engaged in the building of bridges and foundations as engineer and contractor. In 1892-3 he took the professorship of engineering at Harvard University, and in 1894 he became professor of civil engineering in Columbia University, still retaining that position.

Mr. Burr's connection with the public works of the city of New York began in 1893 when he was made consulting engineer to the old Department of Public Works for the construction of the Harlem Ship Canal bridge, which was designed and built under his supervision and direction. After the construction of the Harlem River Driveway had been in progress about a year, the failure of certain portions of the work brought construction to a stop until a board of experts, of which he was a member, could report on its condition. After the completion of this report, in January, 1895, he was made consulting engineer to the Department of Parks in charge of the Harlem River Driveway. The duties of this position extended through the years of 1895-6-7, resulting in the successful completion of the work which has now become one of the famous fast driving courses of the world. During the same three years he was also a member of the board of consulting engineers of the Department of Docks of the City of New York with Mr. George S. Morison, and successively Generals Thomas Lincoln Casey and William P. Craighill, Chief of Engineers, U. S. A. Between 1897 and 1900 he designed and built the City Island bridge, as consulting engineer for the former Department of Parks, and was appointed by the same department to act as consulting engineer in an advisory capacity for the 145th Street bridge now approaching completion.

When it was proposed in 1894 to build a cantilever bridge in two spans across the North River at a site between 59th and 72d Streets, New York, he was appointed by President Cleveland on a board of engineers to investigate and report upon the feasibility of bridging the river at that place with a single suspension span about 3,200 feet in length. The report of the board was wholly favorable to such a construction. Again, in 1896, he was appointed by President Cleveland a member of a board to locate a deep water harbor for commerce and refuge on the coast of southern California. The appointment of this board was practically the result of a controversy between the engineer officers of the War Department and the Southern Pacific Railroad. The harbor was located at San Pedro, one of the ports of Los Angeles, Cal., as had previously been recommended by the army officers.

In 1902 he was appointed by Hon. Wm. H. Hunt, governer of Porto Rico, to examine and report upon the three principal harbors of that island.

When the present Isthmian Canal Commission was appointed in 1899 by President McKinley to examine and report upon the most feasible and practicable route for an interoceanic canal across the Central American isthmus, Mr. Burr became one of its members and still remains so. This commission reported in favor of the Panama route and on its recommendations that route has been selected for an interoceanic ship canal. The beginning of this great work is now awaiting the ratification by the Senate of a treaty between the governments of the United States and the Republic of Panama.

William Hubert Burr.

On December 16, 1903, Messrs. Wm. H. Burr, Rudolph Hering and John R. Freeman were appointed a commission on additional water supply for the City of New York, Mr. Burr being the chairman. This commission, it will be remembered, has reported in favor of an additional supply of 500,000,000 gallons daily to be taken from the Fishkill and Wappinger Creeks on the easterly side of the Hudson, and from the Esopus and Rondout Creeks on the westerly side, the total amount recommended to be made available for the city not later than 1925; the first instalment of about 60,000,000 gallons daily, however, to be available within five years after the beginning of work. This commission also completed a vast amount of investigation work connected with the possible ground-water supply on Long Island and a number of problems regarding the future availability of the Hudson River and other sources. The field covered by this commission was probably the greatest that has ever been undertaken in connection with any single municipal supply.

In addition to his connection with public works, he has continued active practice in civil engineering. He is consulting engineer to Messrs. McMullen & McBean, the successful contractors for the construction of the Rapid Transit tunnel under the Harlem River, by an entirely new method, the invention of Mr. McBean. At the present time he is also acting as engineering expert on the construction of the new Croton dam.

Mr. Burr is a member of the American Society of Civil Engineers and of the Institution of Civil Engineers of Great Britain and other engineering and scientific societies. He has frequently written on engineering and other allied subjects, his three principal works being "Stresses in Bridges and Roofs," "The Elasticity and Resistance of the Materials of Engineering," and "Ancient and Modern Engineering."

THE FRICTION IN BEARINGS OF HIGH SPEEDS of rotation was the subject of an extended study published by Mr. O. Lasche in the "Zeitschrift" of the German Society of Engineers some time ago. With journals of steel, nickel steel and wrought iron running in bearings of bronze, white metal or mercury alloy, he found that with a velocity of rubbing at the journal bearing of 395 feet per second and a temperature in the bearing of about 120 degrees Fahrenheit, the product of the unit pressure and the coefficient of friction was constant, being equal to 0.0028, with pressure expressed in pounds per square inch. In this investigation temperatures varied from 120 to 212 degrees and pressures from 14.5 to 215 pounds per square inch. This means that an increase of the bearing surface, thus decreasing the specific pressure, tends to increase the coefficient, from which it follows that with a given load and a given speed of rubbing, it is a disadvantage to have long bearings and journals of large diameter. For values of the rubbing speed above 395 feet per second, the coefficient was found nearly constant. With increasing temperatures, the coefficient decreased, and between 105 and 212 degrees, the product of the coefficient and the temperature was practically constant. A three-sleeve bearing, one part within the other, used with a 400-kilowatt turbine, running at 3,000 revolutions per minute, was tested. The shaft was 4⅛ inches in diameter and there was a total play in the bearing of 0.014 inch. When 2 gallons of oil were supplied per minute, under a pressure of 70 to 75 pounds, the temperature of the bearing was 113 degrees above the atmosphere.

IN THE DESCRIPTION OF THE CARENA DRY DOCK, published November 14, 1903, the name of the makers of the hydraulic machinery appeared as Bennett Walker & Company; it should have been Tannett Walker & Company, Ltd., Leeds, Eng.

Letters to the Editor.

A New Type of Forms for Constructing Concrete Sewers and Conduits.

Sir:—Considering the interest in concrete sewer construction shown by articles which have appeared in your journal from time to time, it occurs to me that a brief description of a new type of steel cores or centers for constructing concrete sewers and conduits may be of value to your readers The arches of the concrete sewers built in Medford, Mass., and described in The Engineering Record some weeks ago, are of brick, but this change of material in the upper part of the sewer causes considerable delay in the progress of the work, especially on account of the waiting for the concrete to harden. By the use of the forms to be described, it is possible to build up the whole sewer in concrete directly in the trench, thus reducing the cost about 30 per cent. as compared with brick construction, and 10 per cent. as compared with vitrified pipe. Any form of sewer can be built by the proposed method, which may also be adapted to conduits for carrying water or ducts for electric wires. If required, a vitrified pipe invert may be placed in connection with the use of these forms.

For building a concrete sewer, after excavating the trench to the proper dimensions for the outside of the sewer, if the materials will permit, or setting outside forms, if these are necessary, the inner form or center will be set up on a layer of concrete and the concrete to form a complete section of sewer then placed. These centers are made, as indicated in the cut, of pieces of thin steel plate bent to the required forms and held together by clips of the shape indicated. The clips are held in place by filling the spaces inside of them with paraffin or clay. To insure a very smooth interior surface for the sewer or conduit a sheet of heavy paper is to be wrapped around the outside of the form. It is proposed to make the forms in sections about 3 feet long, so that the pieces will be light enough to be readily handled. The pieces of each section will be put together and the clip spaces filled before lowering into the trench. After the concrete has been allowed to harden a suitable length of time, a steam nozzle or other suitable heater may be introduced inside the forms to melt the paraffin, which requires a temperature of only 112 degrees Fahrenheit, or a jet of water may be used to wash out the clay if the clips have been filled with this material. If clay is to be used, it is proposed to perforate the clips so that the clay may be more readily washed out. Of course the paraffin can be recovered and use over indefinitely. After the paraffin or clay has been removed from the clips, the centers can be collapsed and withdrawn through the finished portion of the sewer and taken out through the nearest manhole or other opening. Patents have been granted covering the various features of this type of centers.

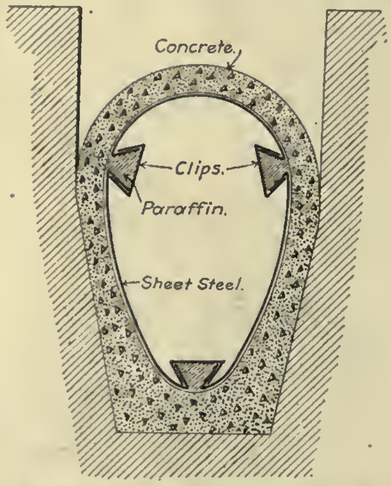
Respectfully yours, Paul S. Knittel.
Brooklyn, December 22, 1903.

Sanitary Section of the Boston Society of Civil Engineers.

Sir:—It may interest your readers to know that a Sanitary Section of the Boston Society of Civil Engineers has been established. This section is formed under a recent amendment to the by-laws of the Society providing for the formation of sections for the consideration of special branches of engineering, such sections to be affiliated with the main Society, but to have a practically independent organization and to include in its membership those who are not members of the Society. It is proposed to include in the membership of this section besides those members of the Boston Society of Civil Engineers who may be interested in sanitary engineering in any of its branches, those who though they may not be engineers, are connected with or interested in the construction or maintenance of sewerage systems, the disposal of sewage or garbage, etc., including commissioners, superintendents, biologists and chemists. At a meeting of the newly formed Sanitary Section held at Boston, January 1, 1904, for the purpose of effecting a temporary organization, Mr. L. M. Hastings was elected chairman, and Mr. William S. Johnson, clerk, and a committee consisting of the chairman, clerk and Freeman C. Coffin, Leonard Metcalf and Charles W. Sherman, was chosen to prepare for a future meeting and to receive applications for membership. I enclose a copy of Section 15 of the revised by-laws of the Boston Society of Civil Engineers, which provides for the formation of sections.

Yours truly, William S. Johnson.
Boston, January 5.

15. Sections.—The Board of Government may from time to time, at its discretion, establish sections for the consideration of special branches of engineering. Such sections shall in all cases be known as "The [name] Section of the Boston Society of Civil Engineers." Each section shall consist of not less than ten members of the Society with such other persons as shall be elected by the section as its members after approval of their applications by the Board of Government.



Novel Forms for Sewer Construction.

A member of a section who is not otherwise a member of the Society, shall be entitled to attend all meetings and excursions, to use the library, and to receive the publications of the Society, to take part in the discussions of any papers on professional subjects or of any business affecting his particular section at any such meeting, but shall have no vote, except in his section.

Papers read before sections and discussions thereon may be reported in accordance with the section by-laws, and shall be published in the same manner and subject to the same conditions as obtain with respect to papers read before the Society.

All sections shall be governed by the Constitution and By-Laws of the Society, so far as applicable, but they shall be entitled to make additional by-laws for their own use and government; *provided, however*, that said additional by-laws be not inconsistent with the Constitution and By-Laws of the Society, and that they be approved by the Board of Government.

The officers of each section shall be a Chairman, Vice-Chairman and Clerk, who shall be elected by the members of the section annually. The general government of each section shall be vested in an Executive Committee, consisting of the President of the Society, the officers of the section, and three additional members of the section who shall be elected annually.

The fees and dues for members of sections who are not members of the Society shall be: Entrance fee, $5.00; annual dues, $5.00, which shall be paid to the Secretary of the Society. The dues for the remainder of the first fiscal year after date of election shall be remitted to members of sections.

Members or associates of the Society may, without election, become members or associates of any sections, under such regulations as may be prescribed by the by-laws of the sections, without the payment of additional fees or dues. Any member of a section upon becoming a member of the Society shall pay the difference between the entrance fees of the Society and the section, but shall pay no dues to the Society for the remainder of the fiscal year after his election.

The Chairmen of sections shall be entitled to be present at the meetings of the Board of Government, but without votes.

Any section may be abolished by the Society by a two-thirds vote of all the members present at any regular meeting, upon recommendation of the Board of Government, due notice of such recommendation having been sent with the notice of the meeting to each member of the Society, and to each member of the section in question who is not a member of the Society; and all members of the section in question shall be entitled to be heard at this meeting. Resignations, forfeiture of membership, or expulsion of members of sections shall be governed by the same conditions and methods of procedure as apply to members of the Society.

Bricks and Paving Slabs have recently been made from waste gas lime at Leeds, England, by the manager of the New Wortley gas works, according to a process invented by Alderman Lowden. Without the addition of other materials, the gas lime was converted into bricks and slabs by the usual methods, and then by another process made ready for use in a few hours. Some of these bricks and slabs have been tested for some months by actual use in a pavement. It is intended, as soon as proper appliances can be obtained, to make slabs 3x2 feet. Even if the bricks and slabs are not adopted for the main streets, it is suggested that they will serve admirably for side streets and for many other purposes. It is contended that by this process the corporation will save the amount of two shillings per ton which is at present paid to a contractor during the greater part of the year for carting the lime away, that it may reasonably expect to make a profit on the manufacture of the bricks and slabs, and that if the highways committee decide to adopt them there will also be a considerable saving in this department, as the cost is much below that of the best ordinary brick, while the durability is greater. This latter statement is made after numerous tests as to the tensile and crushing strength of the bricks, absorption of water, and other qualities. Bricks in a dry state, and also others saturated with moisture, were subjected to 36 degrees of frost, being repeatedly frozen and thawed for a period of a month; and it is stated that not the slightest flaw or fracture was found in any of them. The bricks have also been exposed to the action of sulphurous acid, to show how they would be affected by the corrosive influence of the air in large towns and cities. The report as to this test is that the bricks were found to be affected to only a very slight extent. This experiment is reported in a recent issue of the "Journal of Gas Lighting," London.

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A Great Canadian Irrigation Project.

American contractors will find a statement concerning irrigation in Alberta, printed elsewhere in this issue, an announcement of particular interest. It is not probable that the magnitude of the great enterprise of the Canadian Pacific Railway Company for the reclamation of the territory east of Calgary is appreciated even in Canada. Contractors making a specialty of canal construction will find that this work is one of the largest of the kind ever undertaken. In more senses than one it is an important enterprise, for it will be of much technical interest, it will add a large tract of country to the arable territory of the Dominion and it will be carried on as a private enterprise.

The tract of land in question is about 150 miles long in an east and west direction and 60 miles wide, and is traversed by the main line of the Canadian Pacific Railway. The soil is first-class and during most seasons furnishes good summer range for cattle. Although its climate is milder than that of the great wheat belts further east in Assiniboia and Manitoba, to which American farmers have been emigrating in large numbers during recent years, it suffers from a small annual rainfall of only 11 inches. The railway company was originally allotted the alternate or odd-numbered sections in each township along this portion of its line as a part of its land subsidy grant, but it refused to take them on the ground they were unfit for settlement without irrigation. Ultimately, in satisfaction of the balance due it on its subsidy, the company agreed to take these sections if it was also granted the even sections and those set apart for school endowment. In this way it acquired a solid block of three million acres, which is the area it is now proposed to reclaim by the construction of extensive irrigation works.

For the greater part of three years a large engineering corps has been working on reconnaissance and preliminary surveys of the canals and the land to be served by them. As a result of this work, Mr. J. S. Dennis, M. Can. Soc. C. E., the company's superintendent of irrigation, expects that about 1,500,000 acres, about one-half of the whole area, can be irrigated at an ultimate cost of between four and five million dollars. It has been recognized that such an enormous undertaking demands the most careful preliminary work. There is no political pressure to rush construction through at the earliest possible moment, and everybody connected with it has appreciated the fact that it is much easier to change plans on paper than to reconstruct works executed at great expense. Irrigation in Alberta is not an experiment in any sense, for there are already about 160 canals and ditches, with a total length of 400 miles, which are now carrying water. But the country presents certain features which render the irrigation problem a somewhat different one from that of the United States, and for this reason the construction of the Canadian Pacific works will proceed by sections and be thoroughly tested as it proceeds. Southern Alberta is a semi-arid country only in the sense that its annual precipitation shows marked fluctuations from year to year and from one cycle of years to another. During wet years, such as the last three, irrigation is unnecessary and this condition has a marked effect on the return which irrigation undertakings will yield. It limits the possible capital charge per acre for water in a very marked way.

Actual construction of the first section of the works will begin in a short time. The water is to be obtained from the Bow River, which bounds the block on the west and partly on the south. It is a stream heading in the Rocky Mountains to the west and carries from 3,000 second-feet at extreme low water to perhaps 40,000 second-feet during floods. The first work will be the construction of a main canal 20 miles long, 60 feet wide on the bottom and carrying 10 feet of water. Some 85 miles of secondary or distributing canals have also been located. The completion of this portion of the project, at an estimated cost of about $1,300,000, will make it possible to irrigate an area of 300,000 acres and render available for grazing and dairy farms a contiguous area of about 400,000 acres. If this portion of the project proves successful, the main canal will have its capacity doubled, several large natural depressions will be converted into storage reservoirs and a second canal will be constructed to take water from the Bow River about 80 miles downstream from the first intake. These works will render about 1,500,000 acres suitable for cultivation and make the remaining 1,500,000 acres of non-irrigated land suitable for grazing and dairy farms.

An enterprise of such magnitude has rarely, if ever before, been undertaken by a railway company directly. The careful manner in which it has gone ahead with its investigations and prepared its plans without government assistance and subvention is refreshing. For this reason, if for none other, it is to be hoped that the company's undertaking will result in making a large area, now almost entirely devoted to wandering cattle, the highly productive seat of a large and prosperous agricultural population.

The Owensboro Rate Decision.

If any doubt has existed in the minds of The Engineering Record's readers regarding the views of the United States Supreme Court concerning the power of cities to fix rates for car fares, water supply, lighting and other public services, there is no longer any reason for such uncertainty. In the case of the City of Owensboro v. Owensboro Water Works Company, it has been decided without any dissenting opinion, that the rate-making power lies with the city authorities. The question was brought directly into the issue between the parties and answered plainly. On account of its great importance, the facts of the case, as stated by Judge McKenna, 24 Sup. Ct. Rep. 82, merit careful scrutiny.

The Owensboro Water Company was incorporated in 1876, built works for public and private supply in this Kentucky city, and operated them under an ordinance passed by the city. In 1899 the company sold its franchise and plant to the Owensboro Water Works Company, after the city had passed an ordinance approving the sale and had granted the latter company a twenty-five year franchise and had vested it with all the rights and privileges of the original corporation. The new owners spent large sums on improvements and extensions of the plant.

The city has been incorporated since June, 1893, under a general law of Kentucky containing the following clause: "The repeal of any law by the provisions of this law [the charter] shall not in anywise be so construed as to affect any right or liability acquired or accrued thereunder by or on the part of the city, or any persons or body corporate. This law shall not in any manner affect any right, lien or liability accrued, established or subsisting under and by virtue of previous charters or amendments thereto, or ordinances passed thereunder; but such right, lien or liability shall be enforced and such action or proceeding shall be carried on in all respects as if this law [the charter] had not taken effect; nor shall this law be in anywise so construed as to affect the right or liability acquired or accrued under previous charters or amendments thereto, or ordinances passed thereunder on the part of the city or any persons or body corporate."

Prior to 1893, the city was incorporated under a charter giving it power "to make, establish and regulate wells, cisterns, reservoirs and pumps, and to provide for the furnishing of the city and the inhabitants thereof with water and gas." The corresponding powers under the present charter are expressed as follows in Section 3,290 of the Kentucky Statutes: "The common council . . . shall, within the limitations of the Constitution of the State and this act, have power by ordinance . . . to provide the city and the inhabitants thereof with water, light, power, heat and telephone service by contract, or by works of its own; . . . to make regulations for the management thereof, and to fix and regulate the prices to private consumers and customers." Under this provision the city passed an ordinance establishing a schedule of rates, which the company has since endeavored to have the courts reject as a violation of both the State and Federal Constitutions. The company claims that it would be compelled to operate its plant at a loss were such rates upheld.

According to Judge McKenna's opinion, the legality of such an ordinance fixing rates can be settled by a consideration of a single one of the sections of the contract between the company and the city. By it the company was "given power and authority to make and enforce as a part of the condition upon which it will supply water to its consumers, all needful rules and regulations not inconsistent with the law or provisions of this ordinance." Attention is drawn by the court to the statement that this power is only a part of the condition on which the company will supply water. The other part is manifestly the payment of rates, the regulation of which is not mentioned in the contract directly. This strict interpretation of the wording of the section seems a legal quibble to the lay mind, but it is really of little importance in the light of another portion of the court's decision.

It will be noticed that the contracts must not be inconsistent with the law. A number of previous decisions of the Supreme Court are cited to show that this means not only the law as established at the time of the contract, but also the law as it might become. Particular attention is called to an opinion by Chief Justice Waite in which it is said: "This power of regulation [of rates] is a power of government, continuing in its nature, and if it can be bargained away at all it can only be by words of positive grant, or something which is in law equivalent. If there is reasonable doubt, it must be resolved in favor of the existence of the power."

The court has accordingly decided that the present charter of the city gives it power to fix rates and that nothing in its contract with the company precludes the exercise of that power. No decision is passed on the contention that the rates fixed by the city are unreasonable. This depends on many questions of fact and of values to which the lower court where the case was first tried gave no attention and on which it expressed no judgment. The case has accordingly been remanded to the circuit court for such proceedings.

This decision is one which is bound to operate injuriously to cities. No comment is necessary on the validity of any decision by the highest tribunal of the country. All that can be done is to point out its effect. There can be but one result of such a decision and that is to deter capital from undertaking public-service works which are highly necessary. Laying aside the fact that municipal trading is not a success, except in isolated cases, there is the strongest need in most cities of certain works which must be built and managed by private corporations. There are few cities in the country where the tax limit is not approximately reached long before the streets are properly built, sewerage systems constructed, schools equipped, fire and police departments organized and hospitals established. The country is so new that it will be many years before the essentials of urban life are provided in a suitable manner. For this reason certain classes of public service must be turned over to private control. These call for heavy expenditures for construction and operation, and capital will not be forthcoming for them without an assurance of its security. Anything which impairs this security tends to diminish the character and amount of service such companies will render. And it is difficult to conceive of a cause which will repel capital more certainly than a law that makes it possible for one party to a contract to change its conditions at will. The fact that the charges a city can establish must be just improves the situation very little, for if a company must always be ready to go to law to establish the unjustness of rates proposed by a city council it will be perpetually on the anxious seat. Moreover, the opportunity for the wholesale blackmail of public-service companies which this decision renders possible is unpleasant to contemplate.

The Concrete Work of the Buffalo Breakwater.

The Buffalo breakwater is one of the most important interior harbor works yet completed under the supervision of the Corps of Engineers, U. S. A. This arises not so much from the magnitude of the work or the great commercial interests affected by it, nor, again, from the fact that the harbor protection which it affords is against probably the most severe exposure on the Great Lakes, but from the rational development exhibited by the design of the works during the different stages from inception to completion. Boards of engineers and engineer officers of unusual experience, like Col. Thos. W. Symons, have devoted to it careful study directed by continuous experience with the conditions under which the work has been conducted and must be maintained. In the earlier and some of the later operations large quantities of concrete were used while the latest portions of the work exhibit mounds of excellent cross-section of gravel and rock fragments.

A complete statement of all features of this work and its various stages of development is set forth in a valuable paper by Mr. Emile Low, printed in the November "Proceedings" of the American Society of Civil Engineers. While there are a number of features of this notable work worthy of extended comment, it is certain that the treatment of the concrete portion is of unusual interest.

This concrete work was begun in 1887, when it was determined to remove a part of the cribwork partially destroyed by a storm in 1886 and replace it with a combined concrete and stone masonry construction. This reconstruction contemplated a natural cement concrete core covered in the one case with cut stone masonry and in the other with Portland cement concrete about 3 feet thick, molded in place. Sixteen years ago the making and putting in place of either Portland cement concrete or natural cement concrete was in its infancy compared with concrete practice of the present day, although the intervening period is in reality but a short one. The Portland cement then available was of foreign manufacture and that used in the present case was an English product. The concrete was mixed and handled on a floating plant subject to the instability caused by waves. The proportions employed in this Portland cement concrete were closely 1 volume of cement, 1 2/3 of sand, 4½ of pebbles and 4½ broken stone, giving 1 volume of cement in a total volume of ingredients of nearly 12. The natural cement used for the interior of the masonry mass, protected by the Portland cement or stone covering, had about 1 volume of cement in a total of 15 volumes. Both of these concretes are far from being rich; indeed they are decidedly lean mixtures, but even at that time the advantage of a well balanced mass was apparent to the responsible engineer of the work. Voids between the broken stone were well filled by the pebbles, although it is doubtful whether the cement filled the remaining voids. It was a well considered though lean mixture and the results justified the judgment exercised in balancing the materials. The details of the mixing were, however, not such as are commonly employed at the present time. The cement was mixed wet into a rough paste on the platform, after which the pebbles were first thrown into a receiving box for the concrete ingredients, then the sand and cement paste were thrown in together, after which the broken stone was added. The whole mass was then treated to five to ten revolutions of a cubical mixer.

It is in reality a matter of little consequence whether the first contact of the different ingredients is in a dry or wet state, provided the whole is given sufficient admixture, although the present practice is in the direction of assembling the ingredients dry. Five to ten revolutions of the cubical mixer would be considered scarcely satisfactory now, when twenty such revolutions are not uncommon. The cost of this concrete, made by the labor forces of the engineer officers in charge, was $6.77 per cubic yard for the Portland cement and $5.62 for the natural cement concrete. This included only the cost of the materials and the labor required in handling them.

The next portion of the work, practically a continuation of that first undertaken, was executed by molding concrete blocks and then putting them in place, and it was done in 1888. The ingredients of these concrete blocks were about in the proportion of 1 volume of cement, 1 1/3 of sand, 4 of pebbles and 4 of broken stone, making a total of about 1 volume of cement in the total of 10 1/3 of ingredients. The process of mixing this concrete was practically the same as that employed for the concrete work of the preceding year. This concrete was materially richer than that employed at first and the total cost, including the material, labor and molds was estimated at $11.29 per cubic yard of Portland cement concrete.

The difficulties attending the prosecution of such work on a floating plant prompted a change of plan in that used for producing and putting in place the next lot of concrete, especially after the heavy wind storm of 1889, which was the most severe ever known at Buffalo. The force of this storm is indicated by the fact that 346 of the manufactured concrete blocks, each weighing 7½ tons, were washed overboard from the banquettes of the breakwater. Pile platforms, each about 90 feet square, were built at suitable points immediately adjacent to the work and measures were adopted to mold the concrete in place. The proportions on which the production of the concrete were based remained the same as for the blocks made in 1888, viz.: 1 volume of cement in about 10 1/3 total volumes of the ingredients. The cost of this concrete mass proved to be $9.12 per cubic yard for material and labor. The increased richness of the mixture is made apparent by the increased price over that of the first Portland cement concrete made.

Further work involving the fabrication of concrete blocks was done in 1890 and 1891 and the improvements in the plant prompted by previous experience showed its effect in the reduced cost during those two years, which was $8.21 per cubic yard as against $9.12 in 1889.

In 1898 and1899 additional concrete work was recommended and begun by Major Thomas W. Symons, who was the engineer officer in charge of all the remaining work up to a few months ago. The operations involving the use of concrete covered the displacement of the worn-out timber superstructure by a new superstructure consisting of an interior space filled with rubble, completely covered by a monolithic Portland cement concrete structure molded in place, American Portland cement being employed. The monolithic concrete exterior rested on concrete blocks having the composition of 1 volume of cement, 2 volumes of sand (one of which was of fine screenings from the stone crusher), 2 volumes of gravel and 2 volumes of broken stone, making a composition containing 1 volume of cement to a total of 7 volumes of ingredients. The monolithic concrete shell deposited in place had a little different composition, 1 volume of cement, 2 volumes of sand (one of which was of fine screenings from the stone crusher), 2 volumes of gravel and 3 volumes of broken stone, making 1 volume of cement to a total of 8 volumes of ingredients. In this construction of 1899 and 1900, the last concrete of the entire work, the sand and cement were mixed dry and thrown into the mixer with the dry pebbles and broken stone, the cubical mixer still being used with a hollow shaft to admit the requisite water. In this latest work the number of turns of the mixer was 15 to 18 instead of about half that number, as in the first concrete made.

These gradual developments in the concrete production at Buffalo are instructive, and exhibit the progressive character of the engineering management. The extremely lean concrete of the earlier work gradually changed until the last proportions employed nearly doubled the amount of cement introduced in a cubic yard of the final material. The proportion of 1 volume of cement to 7 or 8 volumes of the total well balanced ingredients is probably a little richer than is needed in most concrete construction, but it probably will not yield a stronger material than is required in the exposed Buffalo breakwater.

The excellent feature of a well-balanced mixture has characterized all of this concrete production, and during 1899 and 1900 the improved practice of using fine crusher screenings for half of the sand is also found. This is highly interesting in being abreast of the best concrete practice of the present day on other works of equal magnitude and importance, and is commended to the careful consideration of the committee of the Merchants' Association, who have been considerably exercised over the use of fine crusher screenings at the Jerome Park reservoir in the City of New York.

It does not appear in Mr. Low's paper that the latest practice of using a wet concrete was employed in this work. As ramming is constantly referred to, it is to be assumed that the concrete mixtures employed were rather dry than wet. With the leanness of the earlier mixtures it is probable that somewhat better results might have been reached with a greater degree of wetness and more turns of the cubical mixer.

Highway Construction in Maryland.

The third annual report of the Highway Division of the Maryland Geological Survey is one of the most encouraging documents of the kind that has been received in a long time. It is evident on careful reading of its interesting pages that there has been aroused in that state an appreciation of the value of well-built roads and of the proper methods of carrying on the improvement of highways, which will have a lasting influence. Of all the states where such work has been undertaken, Maryland was considered by some usually competent judges to be that in which there was the least chance of success. The Engineering Record never held this view. A state which years ago had as fine highways as the country could show, where the value of good roads is quickly demonstrated by a few samples in each county, which is peopled by inhabitants whose pride in their beautiful land is traditional, is surely one which needs only the incentive of tactful work by a few competent and enthusiastic men to place the building of good roads on a satisfactory basis. It is no longer possible to doubt the success of the last three years' work by the Geological Survey. When sufficient interest has been aroused for people to come forward with private subscriptions to help out public appropriations for such improvements there is little chance for argument concerning the opinion of Maryland on this subject. Such subscriptions have been neither few in number, nor confined to a single county, which indicates the widespread interest in the subject.

Now that the people of the state have fairly embarked on the project of improving their roads, questions naturally arise concerning the best method of conducting such work. If the experience elsewhere is worth anything, and it certainly is of much value, the surest way to obtain a cordial co-operation of all taxpayers is to build in every place where many people gather from the surrounding country a short section of road of a character suitable for use elsewhere in the vicinity. These short sections serve as models, which all in the neighborhood have an opportunity to observe in good and bad weather. They demonstrate better than any amount of argument and any number of reports the value of the services a highway engineer can render. The best and most economical method of securing such model roads is to have them constructed under the supervision and control of some central authority, like the Geological Survey in Maryland. In this way it will be assured that each piece of work will be done not only without unnecessary expense, but also in the manner best adapted to the conditions and materials of the vicinity. After a rather close watch on the construction which the Maryland Geological Survey has been carrying on, The Engineering Record is of the opinion that its work in the past gives conclusive proof of its ability to conduct this model road building in a particularly good manner. The work should be largely paid for by the state, and for this reason, also, it is proper for a state organization to be in charge of it.

These model roads are by no means the only opportunity for instruction of which advantage should be taken. It has been found in other states that much good will result from the hearty co-operation of the county authorities with the official or officials in charge of state highways. In the report under consideration there is abundant proof that the people in many sections of Maryland have become aware of the value of trained engineering supervision of road work. It has been found in that state, as other states have learned before, that better results are obtained by allotting the funds raised for highways for certain definite improvements and putting the work under someone able to secure really good results for the money. It is impossible to mix politics intimately with such undertakings and secure good results. Road construction is apparently one of the simplest classes of public work; to the observer it seems to involve only grading, dumping broken stone or gravel on the graded surface and then sprinkling and rolling. But it really requires a large amount of experience and a wide acquaintance with the properties of different materials. It needs a knowledge of the amount of work each healthy laborer should do per day and of the capacity of machinery when well handled. Every state where such work has been carried on under the supervision of state officials can furnish instances of the great loss in time and money which has resulted through the well-meaning attempts of inexperienced people to undertake good road building. If Maryland will only investigate what has been done in other sections of the country and will only learn by enquiry how much money has been lost in the manner indicated, there can be no question but what it will strengthen the power in the hands of its Geological Survey and place the supervision of construction of state-aid roads under its charge. The work has been so successful up to date that it is to be hoped no step will be taken which will diminish rather than increase the influence of the bureau which is largely responsible for the success. The same observation holds true of the county road improvements. Their success will depend on the degree to which they are placed in charge of trained men. It is not a question of politics at all, for the money raised by the taxpayers should be spent for good roads and not to bolster up somebody's political fences. It makes no difference who builds the roads so long as they are well built, and it would be the highest type of political strategy for a man of influence to throw the weight of his prestige toward the construction under trained men of just as many miles of good roads as the county can afford. The experience of the last three years in the state has shown that more returns from the same sum are secured when the work is done under experienced men than under the old system, and those who take advantage of this fact and make it part of their platform are shrewd. It is in this sense only that politics should mix with the construction of improved highways.

Notes and Comments.

Lock No. 9 on the Kentucky River was tested successfully on December 3. The contract for the lock and the dam was taken by the Sheridan-Kirk Contract Company in June, 1901, and while it is not yet finished vessels can use the lock when absolutely necessary. Concrete has been used for the masonry and the gates are steel. The work is under the charge of Lieut. Col. E. H. Ruffner.

Double-Track Curves for single-track roads have been adopted on the electrical railways of the Appleyard Syndicate. According to the "Street Railway Journal," great attention has been paid to securing the longest possible tangents on these lines, and with high-power headlights the chances of a collision on the straight track are very slight. The use of double tracks on the curves is comparatively inexpensive, as the lines are built mainly on private right of way.

Rock-Crusher Dust is to be allowed in the concrete for the new masonry dry-dock at the Brooklyn Navy Yard. As the controversy over the use of this material for mortar and concrete is attracting so much attention among engineers, the clause in the specifications covering the use of dust is here reprinted: "Fine crushed granite trap, gneiss or other hard, durable rock screenings acceptable to the civil engineer in charge may be used in lieu of sand [for mortar and concrete] where the latter is specified. Crushed granite screenings or siliceous gravel not exceeding ¼ inch in any direction shall also be used for granolithic as hereinafter specified. The screenings shall include all chips and dust which pass a ¼-inch screen, provided that not over 30 per cent. by weight shall pass a screen of 2,500 meshes to the square inch."

Plant of the Columbus Power Company, Columbus, Georgia.

The city of Columbus, Ga., is an example of a thriving municipality which owes its existence very largely to the natural advantage of proximity to a large water-power. It is located in a fertile cotton region and at the head of navigation on the Chattahoochee River, and has on that account a leading cotton shipping business; it also stands opposite a remarkable series of shoals in the river carrying a large amount of water. The Chattahoochee River drains a watershed of something like 3,500 square miles, and while it has the disadvantage common to most of the rivers of this section that it must pass great, quick-rising floods, it possesses a low-water flow that has encouraged several comparatively large power developments. Its channel for a long distance approaching Columbus is lined with precipitous rock banks confining the water in a way that causes quick changes of level, but otherwise favors impounding the water for successive utilization or periodic storage. For a distance of 34 miles above Columbus, that is, to West Point, Ga., the power possibilities of the river may be apprehended from the fact that in this stretch there is a fall of 362 feet, 120 feet of this occurring in the last four miles above navigable water. This last fall is distributed in a number of shoals which have long been harnessed to a greater or less extent, notably by the Eagle & Phenix Mills. The low-water flow is probably 1,000 cubic feet per second, so that there are available in the immediate vicinity of the city for the 120-foot fall, some 13,500 gross horse-power. The average power, however, for the four miles of river in question would seem to be about 75,000 gross horse-power, this calculation based on observations made at West Point for the State geologist under the direction of Mr. B. M. Hall, hydrographer, during 1896, which was a dry year. These figures, compiled in a bulletin issued by the Geological Survey of Georgia, indicate that the average flow for that year was about 4,650 cubic feet at West Point, or, allowing 18 per cent. increase for the tributary streams between the two places, about 5,500 cubic feet at Columbus. The flood water is sometimes ninety times greater than the low water.

The power plant that is the subject of this description was built by the Columbus Power Company to furnish electric power for public sale and to drive a mill constructed on the Georgia bluff of the river. The plant, which has been in operation for about three years, is located at a shoal known as Lovers' Leap, just beyond the limits proper of Columbus, and it was planned to obtain a head of 40 feet, so that when there is a multiplicity of plants on the river above it or the number of storage dams are sufficient to regulate the discharge of the river, an average of 25,000 horse-power can be approached. The development is of the class in which the power-house is located at one end of the dam, so that the forebay is impounded by the dam and power-house structure and no penstocks are necessary. This, however, applies to the main power-house or power-house No. 1. The power utilization for driving the mill has been made without employing electricity, the power delivered by the wheels being transmitted to the mill by means of a rope drive. The power-house for this purpose, No. 2, is located a short distance downstream from power-house No. 1, and is supplied with pressure water by means of penstocks let through the bulkhead wall, which extends from house No. 1 to the river bank. In both cases tail water is discharged into the excavated river bed beneath the houses and reaches the main current a short distance below, the tail race channel being separated from the main stream by a wing wall formed by the rock excavation from the tail race. Power-house No. 1 is designed to develop 8,900 horse-power in six units and No. 2 about 3,000 horse-power, mainly in two units. Half of each installation is in place.

The dam is an interesting structure of boulder concrete masonry with a cut stone spillway surface. It stands at an average of about 33.5 feet above the stream bed, bringing its crest to elevation 138.5 and it has a length of 975 feet 8 inches with a rollway 727 feet 8 inches long. The dam was first built with a trapezoidal section carrying flashboards at the top, but during an unprecedented flood on December 29, 1901, when the water rose 10 feet 2 inches above the level of the top of the flashboards, two portions gave way and the dam was subsequently rebuilt without flashboards in accordance with the cross-section given in an accompanying drawing. The outline of the original dam is indicated in the drawing. Carrying the masonry to the former level of the flashboards, a new spillway was added and the dam has now a depth at the bed of the stream of 41 feet 6 inches as against 23 feet 6 inches, the depth of the old dam. The downstream surface has a batter of 9½ inches per foot, while for the former dam it was steeper, being 6 inches per foot. The rollway has a curved surface of approach, on a 5½-foot radius, which runs into a surface leading to the downstream fall, having a radius of 16½ feet at the crest and of 34 feet beyond. The rock is granite, quarried largely from the river, the pieces varying in size from spalls to 5 cubic yards. The large stones were placed in the concrete with not less than 4 inches of concrete between the boulders. The concrete was made in the following proportions: 3 parts sand; 1 part Atlas Portland cement; 5 parts broken stone not larger than 2½ inches in diameter. It will be noticed that the crest of the rollway is of concrete and here a richer mixture of 1:2:4 was used.

Columbus Power Plant at Left; Mill Plant at Right.

Power-house No. 1 is 137 feet long and 52 feet wide and stands at the end of the dam at an angle of 103 degrees with it. It rests on heavy stone masonry foundations, the upstream portions of which form the heavy bulkhead which is continued beyond the power-house into the river bank. This bulkhead is pierced by the six openings for the six units which will form the ultimate installation of the plant, a smaller opening for the exciter units and a large opening for the penstocks leading to power-house No. 2. The openings in the bulkhead for power-house No. 1 are short flumes or chambers in which are set the turbines, and the back end of each of these wheel chambers is closed, as usual in plants of this type, with a heavy plate or cover of cast-iron and steel, on the other side of which is the main generator room. The power-house proper is thus really located immediately beyond the bulkhead containing the wheel chambers and spans the beginning of the tail-race, into which the wheels discharge by draft tubes inclined through the masonry of the bulkhead from the wheel chambers. The interior view of the station thus shows a row of alternators, which are direct-connected to the wheels, and presents an unusually pleasing aspect owing to the uniformity of apparatus and the general interior finish. The walls above the windows, which are unusually large for a water-power plant, are of brick and the upper parts are painted white, the lower parts and the inner side of the roof are painted drab, and the steel members of the roof trusses are black. At the middle of the station there is an extension 43½ feet wide, giving the room at the center a width of 45 feet. This was provided for the switchboard on the main floor, switching apparatus below and lightning arresters and other devices above, where the transmission lines leave the building. The roof is of the ridge form with a hip over the switchboard addition, and monitors are provided for both the main and hip roofs.

The bulkhead is 31 feet thick from the stream bed to the level of the wheel chambers. Above this it is 21 feet thick and on the ledge of 10 feet remaining are erected the racks and gates controlling the flow of water to the wheel chambers. The racks are of the usual construction supported on a framework of I-beams, giving the racks an inclination of about 12 degrees with the vertical. The wheel chambers have a depth equal to the width of the upper part of the bulkhead, 21 feet, and are built with concrete floors, stone walls and brick roof arches 2 feet thick on a 6-foot radius. The gates to the entrance of the wheel chambers are of planking and are lifted by hand by means of a rack and pinion. The gates have cast-iron guides, bolted through the masonry to the cast-iron head at the downstream end of the wheel chambers.

Each of the main wheel chambers contains a pair of horizontal 39-inch Hercules turbines made by the Holyoke Machine Company. They discharge into the same draft tube. The center of the wheels is 15 feet below normal head water level and 25 feet above normal tail-water level. Under the total head of 40 feet each pair of wheels develops 1,484 horse-power at 200 revolutions per minute. Each draft tube is 7½ feet in diameter at the turbine casing and expands to 10 feet at the discharge end. It is embedded in concrete in the bulkhead wall, but the exposed surfaces of the masonry are faced with brickwork which, as indicated in the accompanying drawings, is partly in the form of a horizontal arch in the discharge chamber, that is to say, an arch of which the elements are vertical. The discharge chamber in each case is 16 feet wide and has a brick arched roof carried by piers 4 feet thick. The piers and the arches support the floor and machinery in the generator room. On the assumption of 80 per cent. efficiency in the turbines, it will be seen that 410 cubic feet of water are passed per second, which gives a velocity of flow into each wheel chamber of 3¼ feet per second and through each draft tube from 9¼ to 5.2 feet per second. The bottom of the discharge chamber was excavated to give a depth of water under normal conditions in the tail-race of 10 to 15 feet.

View of the Dam in Process of Reconstruction. (Looking from Georgia into Alabama.)

Each pair of wheels is direct-connected to a two-phase alternator built by the Stanley Electric Manufacturing Company. At present three of these are installed. Each machine has a rated capacity of 1,080 kilowatts at 6,000 volts and driven at 200 revolutions gives current at 7,200 alternations per minute. Each is joined to the wheel shaft by a flexible leather coupling of the star shape. Under present demands two of the machines suffice, leaving the third as a reserve. Ordinarily one of the units is run under constant gate at the turbine, while the other is controlled by a governor made by the Schenck Governor Company, of Meriden, Conn., which takes up the variations of the load by means of gate movements on the second pair of turbines. To the governed alternator a Queen recording tacheometer is attached, this as a safequard in the question of speed, as most of the motors driven by the station are of the synchronous type. Both generators are started a little before 6 A. M. and one is shut down at 5:30 P. M., and the other at 11 P. M. During the noon hour one-half to two-thirds of the load is dropped and a similar drop takes place at 5:30 P. M., if, when the mills close, a few of the mills are run overtime; otherwise the load drops to one-sixth, being largely a demand for lighting.

There are two exciters each directly connected to a single 18-inch Hercules wheel located in a chamber 4 feet wide at the end of the station nearest the dam. Each exciter, which is of the Eddy design, has a capacity of 60 kilowatts at 75 volts running at 450 revolutions per minute. They are at present operated at 60 volts and each generator takes at the present normal running from 70 to 80 amperes for the field current. During May the output of this plant was about 1,350 kilowatts, so that power required for the field is less than 1 per cent. of the total. The modest requirement of energy for the field is in part due to the fact that the load is nearly all of synchronous motors, except for some lighting. The comparatively few asynchronous motors in use are small and do not cause a noticeably lagging load. The exciters are operated under the control of mechanical governors. The main generators have an efficiency of 96.4 and 96.5 per cent. and it is stated that the temperature rise in the armature coils has never been more than 15 degrees above that of the room. This statement applies to a case where the load was seven-eighths of the rated and the room temperature 99 degrees. The generator room is served by a 10-ton hand power travelling crane built by Chisholm & Moore, of Cleveland, and running the entire length of the room.

One of the interesting points in connection with the hydraulic equipment is the provision made for operating one of the flood gates in the dam by means of oil under pressure. Above the flood gate there is attached to the dam an hydraulic lift which consists of a large heavy cylinder and piston for lifting and lowering the flood gate by hydraulic pressure. The cylinder has an inside length of 8 feet 10 inches, diameter of 15 inches and walls of 2¾ inches thickness and each head is connected by piping carried along the top of the upstream face of the dam to the power-house. The piston carries a rod which is attached to the gate. Black Virginia oil is used, oil rather than water, so that difficulties due to freezing are obviated. The system is designed for 750 pounds pressure and the piping is extra heavy with malleable fittings. Pressure is maintained by a Stillwell-Bierce 1x6-inch triplex pump belt driven from one of the exciter units.

One of the features of the plant is the arrangement of the switchboard. When entirely completed this will consist of ten marble slabs erected to form three sides of a polygon, so that the switchboard attendant standing toward the center of the polygon can readily see all panels from the one position. Two sides of the polygon are at present installed and when the remaining three alternators are in place the third section will be erected. Another of the valuable features of the plant is the provision of large cement-lined conduits under the floor of the station for the passage of conductors. These are virtually tunnels running lengthwise of the building, one under the generator room and the other under the switchboard ell, both painted white, lighted by incandescent lamps and almost large enough for a man to walk through. The wires and cables are neatly arranged on supports, which are creosoted wood easily distinguished against the white interior.

The section of the switchboard at the right consists of three generator panels. Each of these is divided into three parts, the uppermost carrying the indicating instruments, the middle the circuit breakers, and the bottom instruments employed for the field current. The indicating instruments comprise two ammeters, one for each phase, and one voltmeter with the usual plug switch. There is also a pilot lamp and a synchronizing lamp. The circuit breakers are of the oil brake type used as switches and each is of the double throw pattern. as there are two sets of bus bars. On the bottom panels is a field ammeter and a rheostat wheel. An interesting point in this connection is the use of a small pulpit facing the switchboard, containing three rheostat wheels. Each of these is connected by shaft and gear under the floor with the gearing actuated by the rheostat wheel on the generator panel, so that the field current can be regulated either from the pulpit or from the switchboard. The connection of these two wheels is indicated when the operator moves the wheel on the pulpit, as the wheel on the switchboard turns simultaneously with it.

The center section of the switchboard contains a panel for the exciters and space for three feeder panels, of which two are now in position. The exciter panel at the upper part contains a voltmeter and two ammeters, these for the two dynamos; at the middle two three-pole single-throw switches, one for each machine, including the equalizer connection; and at the lowest, the field rheostat controller. Each of the feeder panels is similar to the generator panel except that it also has two ground detectors and two recording wattmeters.

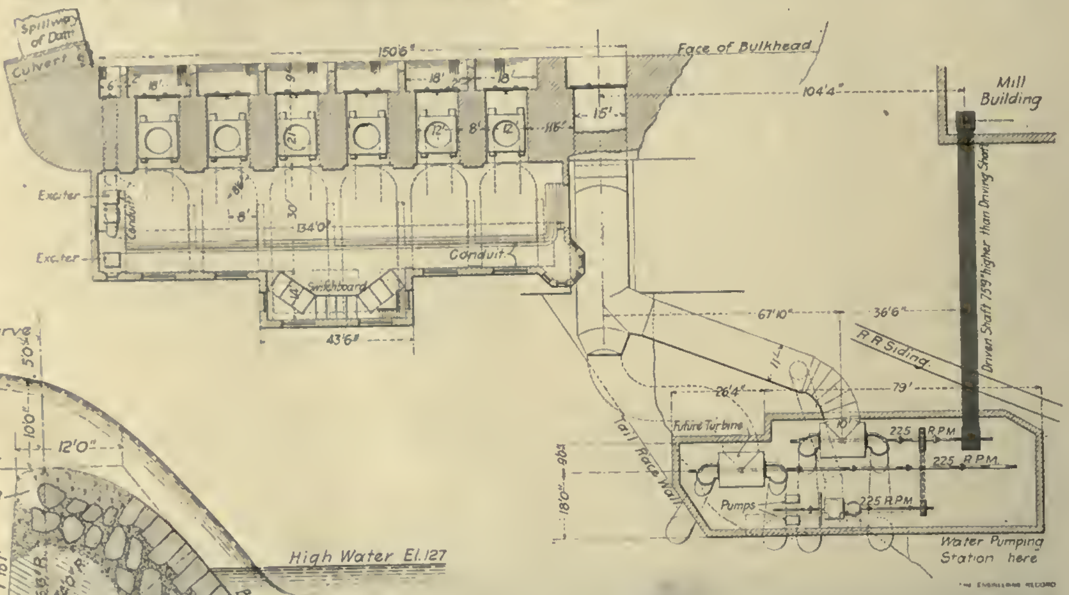
As already stated, the power from the plant is delivered largely to synchronous motors. Two of the largest motors driven by the plant are located about 1,500 feet distant in a comparatively new mill erected by the Columbus Manufacturing Company. One of these is of

600 horse-power capacity at 225 revolutions per minute and the other of 400 horse-power at the same speed. Each is started by an independent induction motor spur-geared to it, these operated from the plant through transformers, which step down the pressure to 575 volts. The pressure at which the synchronous motors are designed to run after the synchronous speed is reached is 5,500 volts. Exciting current is obtained from a 9-kilowatt 125-volt dynamo belt driven from the main shaft. The synchronous motors are placed in line with each other, the switchboard faces them, the transformers are located in a separate room and the power plant generally for this mill presents a very fine appearance. The motors drive large sheaves carrying a European rope drive for the mill proper. The electric apparatus in this plant is of the General Electric manufacture and the switchboard is equipped with standard apparatus.

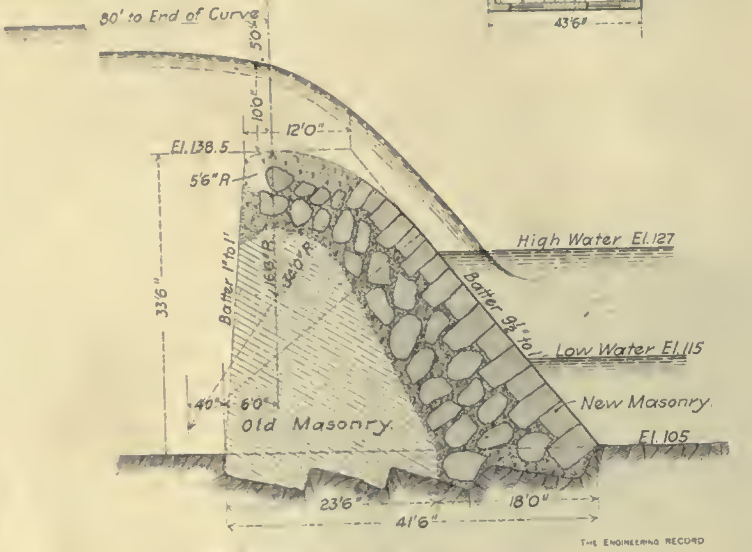
Power-house No. 2 was erected to furnish power direct to the plant of the Bibb Manufacturing Company, whose mill is located on the bluff above Lovers' Leap, and to furnish light and water to this mill and the mill village. It contains space for two pairs of large water wheels and one smaller one, all of which are supplied with water from the forebay by a 15-foot steel feeder pipe brought through the bulkhead alongside the inner end of power-house No. 1. This feeder passes underneath the entrance to power-house No. 1, and is divided into two branches, one 10 feet in diameter, and the other 11 feet. Each branch is planned to conduct the water to one of the large pair of wheels, and the larger penstock in addition serves the single wheel through a branch pipe 5 feet in diameter. Power-house No. 2 is located about 40 feet below power-house No. 1 and about 100 feet below the forebay; the penstocks are accordingly short, and they are supported on brick piers 6 or 7 feet apart and 3 feet thick, with a rock fill between piers. The comparatively complex run of pressure piping and draft tubes resulting is indicated in the accompanying drawings. Each pair of the larger wheels, which are 36-inch horizontal Hercules wheels, is designed to drive a horizontal shaft at 225 revolutions per minute; one of the units has been installed and is capable of developing 1,500 horse-power, which is transmitted to the Bibb mill by means of a rope driven on the American system installed by the Dodge Manufacturing Company. The single wheel is a 24-inch horizontal turbine and is used to drive the water-pumping machinery and the lighting generator.

The rope drive for this mill is an interesting one. The receiving shaft for the power transmission is 60 feet higher than the driving shaft and approximately 116 feet from the center of the driving sheaves. Altogether there are about 7,000 feet of rope carried in the drive, consisting of 30 wraps of 1½-inch manila rope. The driving sheave in the power-house has a wooden enclosure fitted with window glass, while the transmission line between plant and mill is protected with a sheet-iron covering. This is stiffened by lateral angle irons which also serve to discharge rain sideways so that it does not fall in a continuous stream toward the power-house. The turbines are controlled by a Schenck governor to maintain a constant speed. The second unit to be installed is to have a capacity of 1,000 horse-power and the driving sheaves in the rope tower are mounted on quills with this idea in view, so that various drives can be shut down while allowing others to run, the drive in the mill building being of the usual class in which floors or departments are made independent. The quills are carried on an 8½-inch forged shaft which runs at 300 revolutions per minute. These various sections of rope transmission are provided with the usual electric tell-tales so that any defects can be located and electric push buttons are conveniently placed on each floor of the mill to signal the power-house for stoppage of machinery.

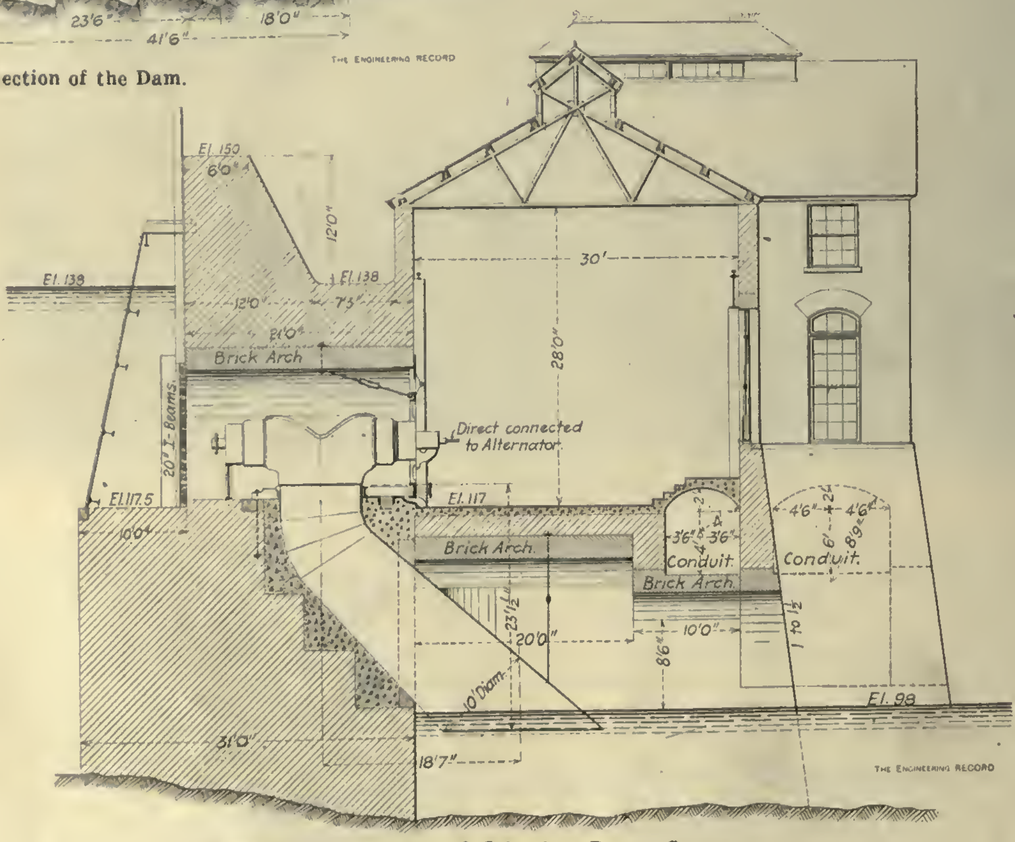
The single wheel in power-house No. 2 has a capacity of 225 horse-power and drives a shaft from which the rest of the machinery is driven by belt. This includes a Stanley lighting unit of 150 kilowatts capacity giving three-phase alternating current at 250 volts and 75 cycles, running at 1,000 revolutions per minute, a Holyoke rotary duplex fire pump, and a centrifugal pump and a triplex pump for the general water system. The Stanley machine is excited from a Northern Electric dynamo of 2 kilowatts capacity and 120 volts belted to the generator.



The Plants for the Columbus Power Company and the Bibb Manufacturing Company, Columbus, Ga.



Cross-Section of the Dam.



Cross-Section of Plant of Columbus Power Company.

The lighting system for Bibb City and mill is controlled from a switchboard in power-house No. 2. There are eight feeders all told, five for mill lighting, one for arc lighting, one for the village houses and one for the office and boiler house. Each of the feeders is controlled by a three-pole single-throw switch. The switchboard contains panels for the generator and standard instruments throughout. There were

101 houses in Bibb City in May for the mill operatives, each of which is supplied with water and electric light free of charge. It will be interesting to add that the rent of the houses is based on the number of rooms and is 25 cents per room per week. Power-house No. 2 has white brick walls with a slate-color wainscoating around the bottom and the under side of the roof is drab with a black striping on the roof members, which are of timber.

The water-works comprise a large centrifugal pump for drawing water from the wheel case of the Bibb mill unit, a Deane triplex pump for lifting the water to the tank on the bluff and a New York filter of 300,000 gallons daily capacity. The centrifugal pump is only used when the pressure of water in the wheel case is insufficient to pass the water through the filter, which carries 5 feet of sand. Besides the filter there is the usual settling tank and clear water basin and from this the Deane pump, which has 6x8-inch plungers discharges to the storage tanks. One of these is of 100,000 gallons capacity for the general water supply of both the mill and the village, another is of 35,000 gallons capacity for fire purposes, and a third is of 5,000 gallons capacity, situated in a tower of the mill and used for flushing purposes. The fire tank is of course connected independently to the fire pump. The large general storage tank is about 233 feet above the pump and the smaller tank about 50 feet lower than the large one. The discharge pipe from the pump has two branches, one to each tank. The flushing tank is provided with a large float gauge which is visible from the pump house and six or eight times a day the tank has to be filled. For general purposes between 60,000 and 70,000 gallons are pumped twice a day and the pump is operated on the branch that leads to this tank about two hours at a time. The centrifugal pump and both the filter and settling tanks can be by-passed at any time. The fire pump has two shafts which carry grooved wheels for friction driving.

The plant was designed by Mr. William C. Whitner, chief engineer of the water-power development for the Virginia Passenger & Power Company, of Richmond, as chief engineer, and was constructed under the direction of Mr. William S. Lee, Jr., now chief engineer of the Catawba Power Company, near Rock Hill, S. C., as resident engineer. The officers of the company when the plant was erected were as follows: H. M. Comer, president; J. F. Hansom, G. Gunby Jordan, E. T. Comer and John Hill, directors. Mr. H. A. Tibbs is engineer of the electrical department. The dam and power-house were erected by the Hardaway, Jones Company, of Columbus. The cost of the development completed will be about $450,000, or $50 per horse-power.

A Concrete-Steel Factory Building with Fifty-Two-Foot Roof Girders.

The Central Felt & Paper Company's factory at Borden Avenue and Dutchkill Creek, Long Island City, N. Y., is a one-story building 312 feet long and from 52 to 112 feet wide, built entirely of reinforced concrete of the Wight-Easton-Townsend Company's system. It was originally designed with brick walls and wooden roof trusses of the slow burning type, but after the pile foundations and brick chimney were built it was decided to make it fireproof throughout, and reinforced concrete construction was adopted at an estimated cost 15 per cent. greater than that of the original design, because it was computed to be cheaper than any other absolutely fireproof system. This change reduced the estimated insurance premium to about one-twentieth of what it would have been with the original design and an additional sprinkler system, which is not contemplated in the present structure. The construction is special in the character of wall and floor slab reinforcement, in the arrangement and proportions of steel in shear, in the provisions to eliminate irregularities of workmanship and in the system of falsework.

Moulds and Falsework for Girders and Columns in a Concrete-Steel Factory Building.

The site is a fill on soft mud, in which the foundation piles are driven to satisfactory frictional resistance without penetrating to hard bottom. The piles are in clusters, capped about 5 feet below grade, with concrete footings on which the piers are built of concrete without reinforcement. These footings are about 16 feet apart longitudinally and about 33, 44 and 52 feet apart transversely; they support reinforced concrete columns, which in the sides of the building are integral with the walls, and form one longitudinal row through a part of the building. The columns carry one upper floor, the curtain walls and the roof girders, but do not carry the lower floor, which is a 6-inch layer of concrete on the leveled and rammed earth. The flat roof slopes about 1:48 and is divided into panels about 16 feet square by the reinforced concrete transverse girders and longitudinal beams.

The 6-inch exterior walls carry no loads except their own weight and the adjacent edges of the roof slabs, and were made of very wet concrete of 1 part Atlas Portland cement, 2 parts sand and 5 parts fine cinders. They are carried down a few inches below the surface of the ground and are supported from the piers on girders of reinforced concrete, built integral with the wall. There is a cellar under the 65x142-foot beater room, and the floor of the latter is partly carried by the outer walls which here have steel tension rods built into them, as shown in the elevation, so as to virtually form wall girders. In general the walls are reinforced with vertical sheets of lock-woven steel fabric, close to the inner surface, which are folded back in U-shaped cross-section at window openings. Sheets of the same material, bent to U-shape, are also embedded in the wall concrete under window sills, and horizontal tension rods reinforce the upper parts of the walls, enabling them to act as beams to carry the edges of the roof slabs over window openings.

The interior columns, from 14 to 20 inches square, are made of 1:2:4 stone concrete reinforced in each corner by one vertical steel rod, from ¾ inch to 1¼ inches in diameter. In each face of the column 3/16-inch tie rods, about 12 inches apart vertically, are looped tightly around the vertical rods. Over the piers the thickness of the wall is increased 4 inches to make 12x16-inch buttresses, which are virtually wall columns reinforced by vertical steel rods like those of the interior columns.

The beater room floor is proportioned for a live load of 200 pounds per square foot and has a continuous concrete slab 7 inches thick reinforced with two sheets of lock-woven fabric. The upper sheet is bent from the upper side of the slab at the ends of the 11-foot spans to the under side in the center. The under sheet is horizontal and about ½ inch from the surface of the ceiling. At the ends it is bent to follow the outline of the girder and wraps part of three sides of the latter.

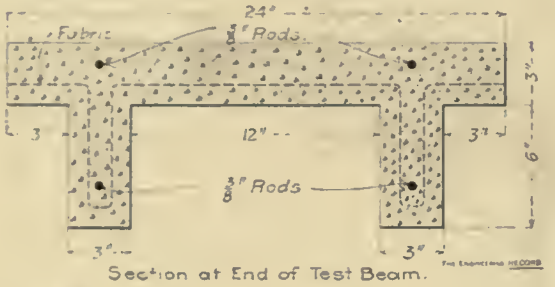
The roof is proportioned for a live load of 40 pounds per square foot and has a continuous slab of concrete from 4 to 6 inches thick with two sheets of steel fabric reinforcement. It is supported on longitudinal beams carried at the ends and middles of transverse girders, dividing it into panels about 16 feet square in the clear. The 38x44-foot engine room roof and the 44x43-foot boiler room roof are each divided into nine equal square panels by two longitudinal and two transverse girders. Three of these panels have their surfaces covered by steel-concrete tanks 12 and 14 feet deep and are sub-divided by a single transverse and longitudinal girder through the center of each. The sides of the tanks are made with reinforced concrete slabs and vertical beams, corresponding to the floor construction, and the adjacent main girders have special reinforcement, as shown in the sectional elevations. In these cases the compressive stresses in the girders were greater than the compressive strength of the concrete and the latter was reinforced by horizontal straight steel rods in the upper flanges in addition to the bars in the lower flanges.

The cutting room roof has a 4-inch slab supported on two lines of 8x12-inch longitudinal beams carried on 15x30-inch transverse girders about 12 feet apart on centers. The beater room roof has 10x24-inch transverse girders about 16 feet apart on centers which carry 6x12-inch longitudinal beams at their center points. The machine room roof has 15x30-inch transverse girders 16 feet apart supported on the wall columns 50 feet 2 inches apart in the clear. These girders are said to be the longest concrete beams ever built and are considered by the contractor to be very satisfactory. When the falsework was removed no imperfections were discovered and the girders were rigid and did not deflect sensibly. They are reinforced by top and bottom flange rods and verticals, arranged as shown in the isometric sketch, and carry two equidistant lines of 6x10-inch longitudinal beams with bottom flange reinforcement rods, as shown in the small sketch. All rods have the ends bent to form anchor hooks and are wired at intersections. All beam and girder reinforcing rods are wired together to make skeleton trusses before they are put in the moulds, and are set in place as rigid frames. The lock-woven steel fabric is used chiefly for reinforcing the walls, the floor and roof slabs and around window openings. It is made with transverse wires of No. 9 gauge 6 inches apart and longitudinal wires of No. 10 gauge, 4 inches apart. At intersections the wires are locked together by a piece of No. 10 wire.

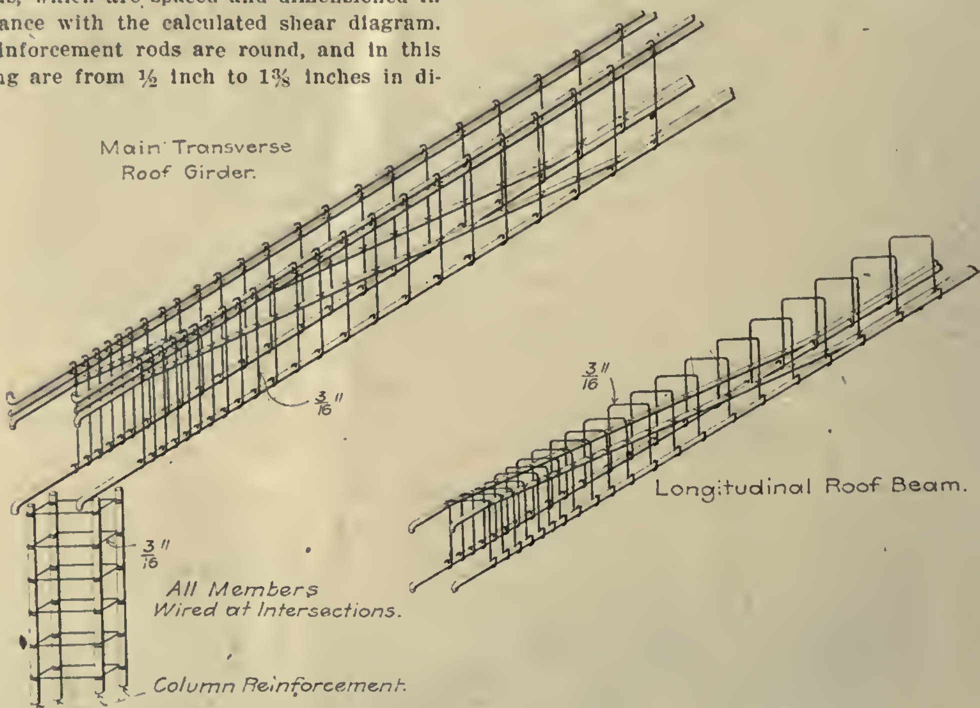
The system of construction may be briefly described as follows: It is assumed that stone and cinder concrete have ultimate compressive strengths of 52,000 pounds and 36,000 pounds per square foot respectively, and they are proportioned to work in compression only, at a maximum stress of one-sixth the ultimate strength. Steel rods are proportioned to take all the tensile stresses in beams and girders, the bending stresses in columns, and sometimes part of the compressive stresses in girders; they are assumed to have an ultimate strength of 80,000 pounds per square inch and are dimensioned for a maximum working unit stress of one-quarter the ultimate strength. The adhesion between the round steel rods and the concrete is assumed to be sufficient to develop the full ultimate strength of the rod in a length of about twenty-six diameters and no special provision is made to lock the bars to the concrete except by bending all ends. The girders are designed to have all shear resisted by vertical rods, which are spaced and dimensioned in accordance with the calculated shear diagram. All reinforcement rods are round, and in this building are from ½ inch to 1⅜ inches in diameter. Wherever there are horizontal reinforcement rods in both top and bottom flanges of the girders they are connected by vertical shear rods without horizontal ties. Wherever there are no top flange compression rods the bottom flange tension rods are connected by U-shape rods with the loops horizontal and the vertical legs down. In all cases the vertical shear rods are 3/16 inch in diameter, are spaced from 4 to 18 inches apart to conform with the intensity of the shear and are tightly secured to the horizontal reinforcement rods by being curled once or twice around the latter at both ends. The 3/16-inch horizontal column ties are made in four pieces, one on each side, in each plane, with vertical spacing about equal to the diameter of the column. The building contains about 100,000 pounds of soft steel rods and harder steel fabric of an ultimate strength of about 90,000 pounds per square inch, and about 1,000 cubic yards of concrete.

The system of falsework is designed so that it can be removed quickly and easily without injuring the concrete and so that nearly all of it will be available for use again. The interior columns were built in moulds having three continuous sides and one sectional side, as shown in the sketch. The three long sides were simple panels permanently nailed together, and the fourth side is made of short transverse boards successively nailed across the open face, from the bottom up, as the concrete is rammed in place, thus always giving free access to the interior to place the cross ties and ram the concrete. Before the concreting was commenced, the cross ties were all temporarily assembled on the upper ends of the vertical rods and held there until the layers of concrete were successively rammed, when the corresponding sets of ties were slipped down on the surface, another section of boards nailed across the open side, more concrete filled in to the top edge of the board and so on.

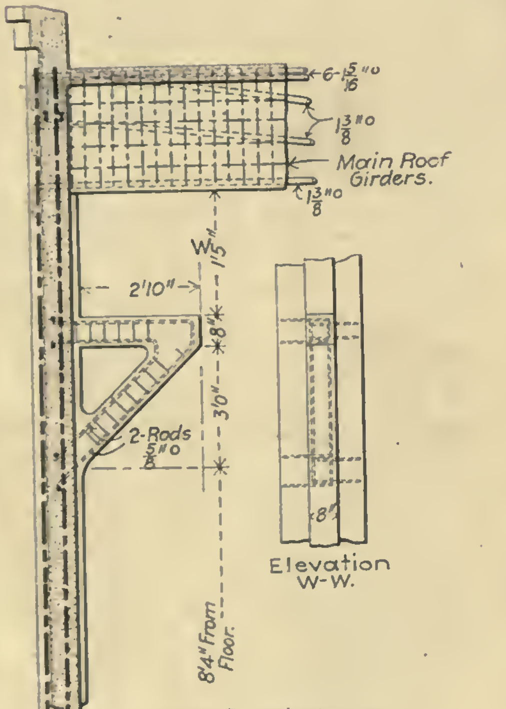
Each panel of the wall moulds consisted of two separate vertical side pieces 3 feet high and about 16 feet long, reaching from buttress to buttress. For the first course they were seated on the carefully leveled and rammed



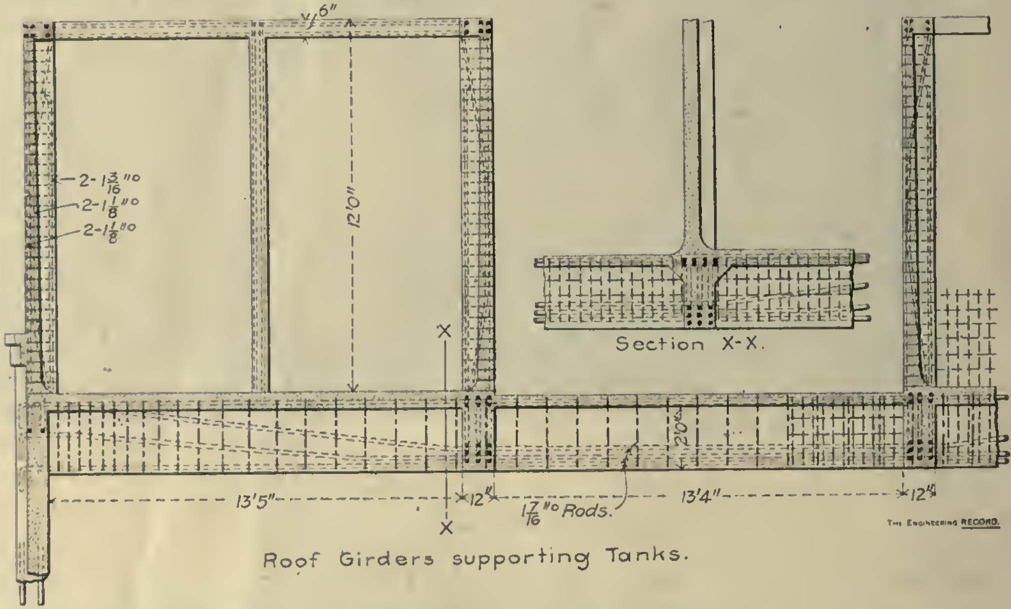
Section at End of Test Beam.


Main Transverse Roof Girder.
3/16"
3/16"
Longitudinal Roof Beam.
3/16"
All Members Wired at Intersections.
Column Reinforcement.

Steel Reinforcements ready to be put in Concrete Moulds

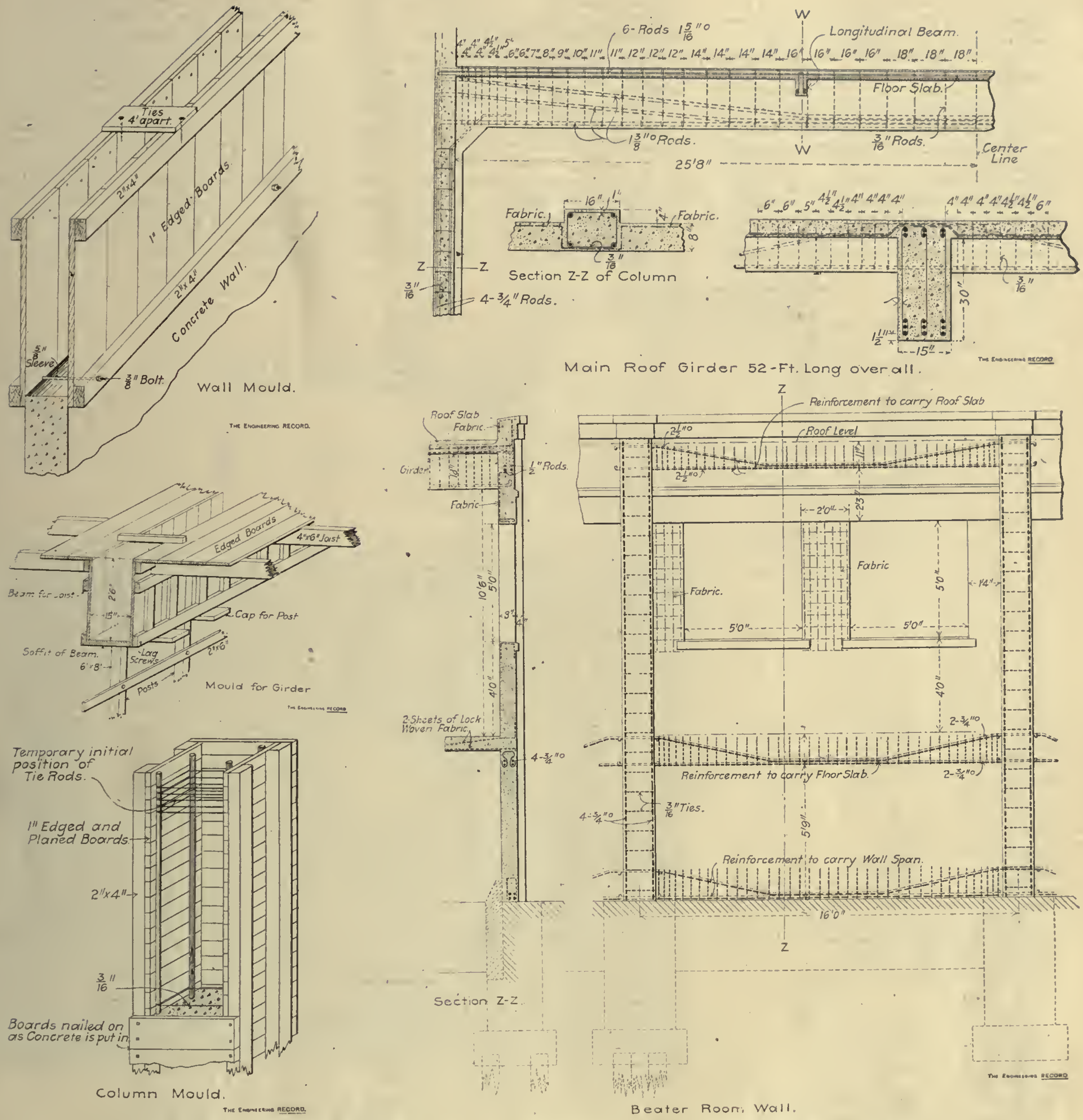


Wall Bracket.



Roof Girders supporting Tanks.

Steel Reinforcement and Special Structural Features of a Concrete-Steel Factory Building.



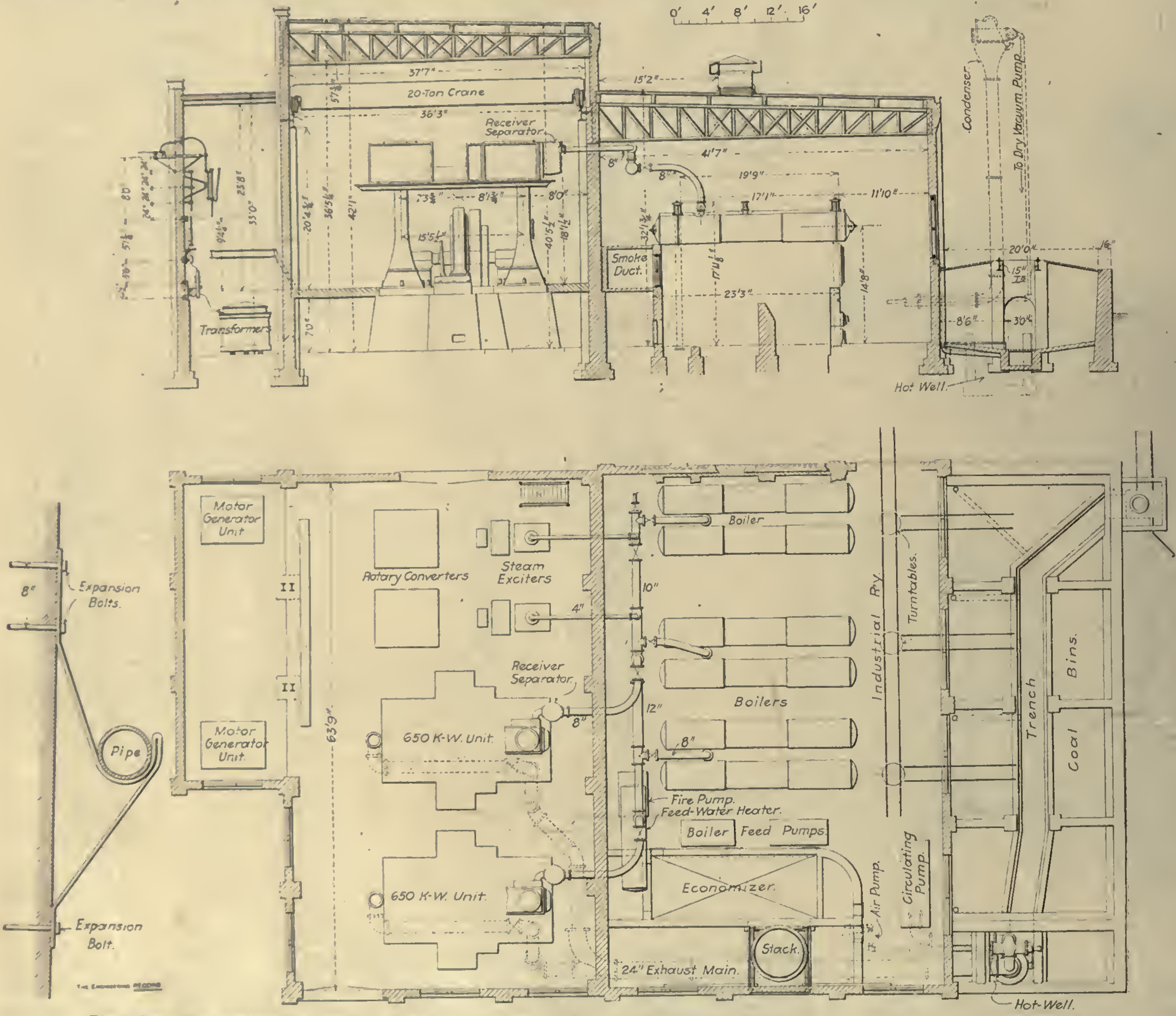
Wooden Moulds and Details of Girder, Wall and Column Construction in a Concrete-Steel Factory Building.

ground and securely braced by inclined or horizontal struts inside and outside of the building. After the concrete had set for three days, the moulds were loosened and lifted until the lower edges were 2 inches below the top of the concrete. In the new position they were supported by horizontal bolts through their lower edges, across the top of the concrete; the upper edges were tied together by transverse wooden strips nailed to them about 3 feet apart, and they were braced to the falsework supporting the roof and column moulds. Care having been taken in starting the walls to exact line and dimensions it was easy to keep the tops of the moulds plumbed as they were raised from time to time and thus maintain the walls in true vertical planes. The adhesion between the side pieces and the concrete was so great that it would support them safely after the bolts were removed, but was not great enough to make it difficult to remove them by tapping or prying, so that they were easily moved up for the successive courses of concrete by two or three men at each panel. The bolts passed through sleeves which were left permanently embedded in the walls. At first iron pipes were used for this purpose, but afterwards it was discovered that pasteboard tubes were equally efficient and much easier to trim and point after the moulds were removed.

The beam and girder moulds were made, as indicated in the sketch, with the bottom piece separate and easily detachable from the vertical side pieces, both being independently supported on transverse cap planks of vertical 6x8-inch falsework posts from 6 to 8 feet apart on the center lines of the girders. The bottom pieces were single longitudinal planks from 1 to 3 inches thick and the side pieces were made of 4x⅞-inch vertical boards thoroughly nailed to 2x4-inch top and bottom horizontal timbers. A third 2x4-inch horizontal piece near the top received the loose ends of the transverse joists carrying the longitudinal boards for the bottom of the floor slab mould. Vertical strips under the ends of the joists transmitted their loads to the lower flanges and to the post caps. The lower edges of the side pieces were temporarily screwed to the bottom pieces and the upper edges spaced by occasional cross pieces from which the reinforcement rods were suspended before concreting was commenced. The first boards of the horizontal platform were nailed to the edges of the side pieces and to the ends of the joists; the other boards were laid in place loose. After the floor slab concrete had set about 7 days, the floor joists were revolved 90 degrees to lie on their flats on the side pieces and the floor boards followed them down to a position 4 inches below the ceiling. A few days later the side pieces of the beam and girder moulds were unscrewed and easily removed, leaving the bottom pieces in position undisturbed for about three weeks longer. Then they were dropped 1 inch by removing fillers (not shown in sketch), from the post caps, and were allowed to remain in that position another week. This system enabled the concrete to be stripped so that it could be rapidly strengthened by freer atmospheric action and at the same time retained support to insure safety in case of any unusual imperfection through flaws or carelessness. In very cold weather the interior surfaces of the moulds were painted with heavy black oil to act as a filler and prevent the adhesion of the concrete to the wood. All the moulds were easily removed from the concrete and were used over again to such an extent that only about one-third as much timber was required for this one-story building as would have been needed otherwise, and much of that was suitable for use on other work after this contract was finished.

The concrete was mixed by hand, made very wet and delivered to the different parts of the building in wheelbarrows. All principal reinforcement rods were wired together and fixed accurately in place in the moulds before concreting was commenced and held there in such a way that the ramming of the concrete would not disarrange them. In building the walls wherever concreting was stopped longer than usual, the horizontal surface was thoroughly brushed with a wet broom, washed with a hose and slushed with thin neat cement mortar before concreting on it was resumed the next morning. This process was followed only when an interval of more than one day elapsed between the different sections of concrete. When the interval was only over night it was found unnecessary to make any special treatment of the joint as the old and new concrete bonded together satisfactorily. Concreting the floor slabs was always stopped over a floor girder and the edge was left at a slope of about 40 degrees. If work was resumed within 12 or 15 hours, the new concrete bonded satisfactorily with the old. If through any accident a long delay was necessary, the edges of the old concrete were swept, washed and slushed as previously described. In all cases the old and new concrete was additionally bonded together by the reinforcing fabric, which was built into the junction of all different members in the building.

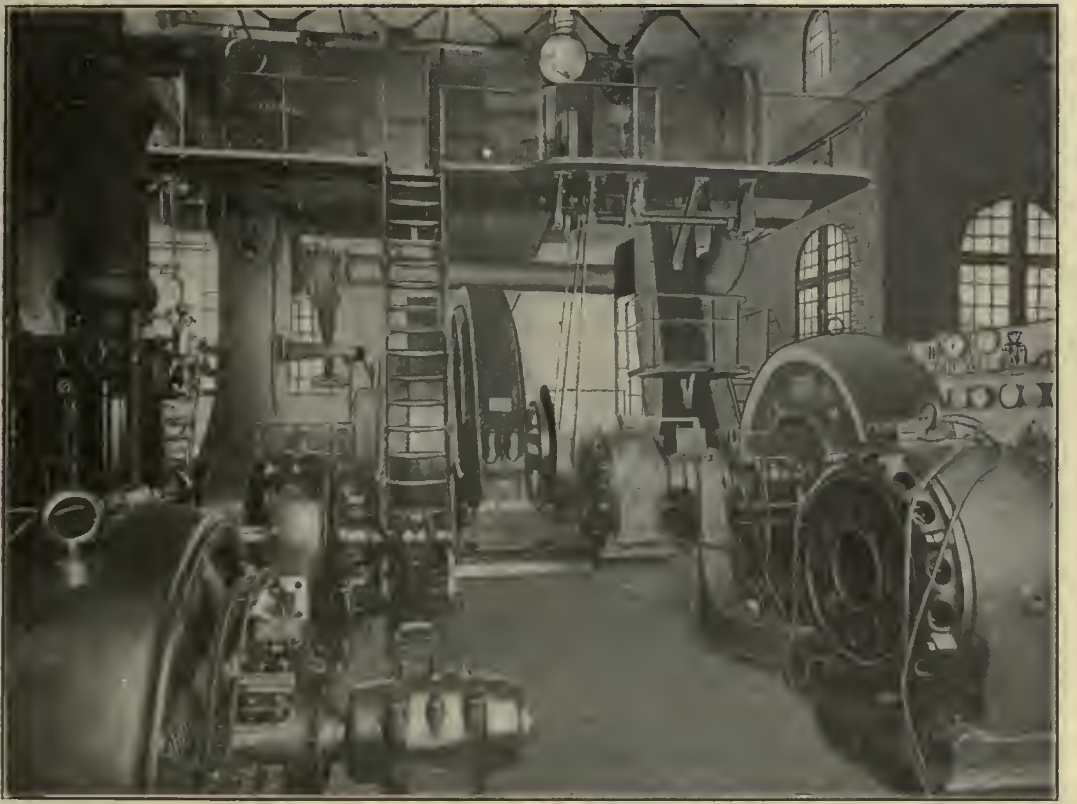
Some of the floors were built in cold weather, when the concrete would freeze solid over night. In these cases, after the building was completely enclosed, salamanders were put inside and the rooms warmed above freezing and kept about a week at a temperature of from 55 to 60 degrees Fahrenheit, after which the falsework was removed and the concrete was apparently in perfect condition. The experience of the contractors is that at a temperature lower than about 55 the setting of the cement is simply retarded and that the concrete suffers no other injury by frost than the delay in setting. Therefore if supports are properly maintained, it will set and give unimpaired results after the low temperature has ceased.



Plan, Cross-Section and Pipe Bracket Detail of the Power Plant of the Rochester & Eastern Rapid Railway, Canandaigua, N. Y.

The Wight-Easton-Townsend system of construction as applied to this building is especially designed to secure three principal advantages: first, to have the steel reinforcement accurately set in its permanent position in the concrete in exactly the position and manner designed by the engineer without involving the necessity of skill or thoughtfulness on the part of the concreters and without danger of displacement through carelessness; second, to afford the least possible chance for voids in the concrete, thereby insuring the best adhesion between the concrete and the steel and the most efficient preservation and protection of the latter; third, to provide accurately for the shearing stresses by special steel rods which will relieve the concrete of all shear. The contractors consider this the most difficult feature of the design and that the different methods adopted to provide for it constitute the essential features of variation between most of the various systems of reinforced concrete construction.

To verify the construction, the contractors made a private test of three special beams built at the building with the cross-section here shown. Their strength was computed on the assumption that the stone concrete had an ultimate strength of 52,000 and the cinder concrete of 36,000 pounds per square foot. One of the test beams was made of 1:2:4 stone concrete mixed dry and thoroughly rammed; the others were made of 1:2:5 cinder concrete mixed very wet and puddled rather than rammed in the moulds. They were supported on, and the bent ends of their tension rods were anchored into, massive concrete piers with footings below the surface of the ground and heavy batters on the sides towards the centers of the spans. The beams so placed had a clear span of 20 feet and were loaded by sand bags uniformly distributed over the whole surface.



Engine Room of the Rochester & Eastern Rapid Railway, Canandaigua, N. Y.

The beams all behaved in a similar manner, the first cracks appearing on the under side at the center when the load corresponded within 2 per cent. to the computed amounts. These cracks were succeeded by vertical cracks about midway between them and the abutments, and after the appearance of the latter cracks, the concrete commenced to crush in the middle of the upper side of the beam; the beam was then considered to have completely failed, but after this the loading was continued in an unsuccessful attempt to entirely rupture it. The beam gradually settled to a total deflection of about 15 inches, the concrete being entirely destroyed in the center and the reinforcement rods exposed but not broken. The latter were estimated to have stretched nearly 3 inches in their total length and to be thus perceptibly reduced in diameter without any visible rupture of their adhesion to the concrete. The results obtained from the beams, which were rammed in several layers and those filled in one layer and puddled showed no practical difference. Mr. Francis H. Bent and Rossiter & Wright are the associated architects, and the Wight-Easton-Townsend Company is the contractor.

A Modern Electric Railway Power Plant, Canandaigua, N. Y.

A new electric power station of 1,300 kilowatts capacity has recently been built at Canandaigua, N. Y., that is noteworthy from the complete character of its equipment for a plant of its size. It is of the type having boiler and engine rooms located side by side, with an extension for the electrical transmission controlling apparatus at one side of the engine room. One of the conspicuous points of the design is the arrangement of coal storage. The station is operated condensing, both an economizer and a feed-water heater are employed for warming the boiler feed and an induced-draft equipment with a short smokestack serves the boilers. The plant was constructed for the Rochester & Eastern Rapid Railway, which is now operating a new electric interurban line between Rochester and Canandaigua and is extending it to Geneva, so that connections can be made for continuous electric transportation from Rochester to Syracuse.

The power house is built with brick walls, on concrete foundations, and has a tar and gravel roofing supported by steel roof trusses. The general dimensions and characteristics of the plant are indicated in the accompanying plan and cross-section. In the boiler room there are 1,124 horse-power in boilers, with space at one end for the economizer and induced-draft fans and circulating, dry vacuum, fire and feed pumps. The room has a area of about 2,800 square feet, or 2½ square feet per boiler horse-power. In the engine room there are two main generating units, rated together at 2,100 horse-power, and the engine room has a floor area of 2,535 square feet, so that including the auxiliary apparatus there in place, which comprises two steam-driven exciter units and two rotary converters, there are 1.2 square feet of space per indicated horse-power. Taking the station as a whole, there are 5,940 square feet of floor space, showing 2.83 square feet per indicated horse-power of the main generating capacity.

The concrete work in foundations and basement walls consists of crushed stone, sand and Lehigh Portland cement. In the brickwork pressed brick, light buff in color in the exterior surfaces, was used, laid in Portland cement mortar. The average thickness of the walls, including the party wall between engine and boiler rooms, is 18 inches. The floors are of steel and concrete throughout. The engine room is spanned by a 20-ton power crane built by the Reading Crane & Hoist Works, having a span of 36 feet 3 inches and a lift of 22 feet.

The boilers are of the water-tube type, built by the Aultman & Taylor Machinery Company, three all told. One is set singly and the two others together. They have a rating of one horse-power for 10 square feet of heating surface and the total grate area of the plant is 227.43 square feet, showing a ratio of heating to grate surface of 49.4 to 1. They are hand fired from side-open cars run on narrow-gauge tracking, furnished by Mr. Arthur Koppel, of New York. The tracking system, as indicated in the plan, connects with the coal bins which extend along the outside boiler room wall. The boilers are operated under induced draft, as stated; the products of combustion are conducted from the boilers in a brick duct supported above the floor behind the boilers and are drawn either through or around the economizer, according as to whether it is in use or not, by means of two fans which discharge through the short stack. The fans are of the full-housed centrifugal type, built by the New York Blower Company, of Bucyrus, O., and have wheels 85 inches in diameter. These are planned to discharge 40,000 cubic feet of air per minute when run at 250 revolutions per minute, and are driven each by a simple vertical 8x8-inch New York Blower engine of 16 horse-power. The stack was erected by the New York Central Iron Works Company, of Geneva, and is of ⅜-inch iron, 5 feet 9 inches in diameter and 24 feet long. Assuming one fan working, under normal conditions, it may be of interest to note that the discharge velocity is about 1,500 feet per minute, and the velocity in the smoke duct back of the boilers, with an allowance for the reduction in temperature in the economizer, is 1,880 feet per minute.

The coal storage bins are of concrete, four in number, built against the boiler room. They may all be placed in communication by a central gangway and three of them are reached through doorways in the boiler room wall, through which the coal car is run on a short lateral track. The bunkers are crossed by a standard gauge track by which coal is delivered from the steam railroad, and on each side of this track is a plank roofing over the bins. A rough approximation would indicate that there is storage space for about 250 tons, when fairly well filled.

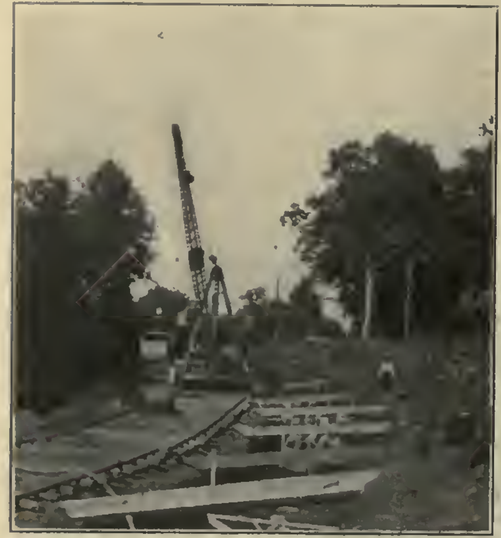
The steam piping was built for a pressure of 225 pounds per square inch and the header consists of flowed steel, the flanges throughout are tongue and grooved, and Walworth valves are employed. The boilers feed into the side of a steam header supported overhead at the rear of the boilers and the engine connections, the two for the exciters and as well as the two for the main engines, are taken from the top of the header and passed through openings in the partition wall. The engine foundations are not carried downward much below ground level, but the engines are supported high relative to the boiler room, and the engine steam leads to the large engines are carried horizontally in the engine room. In both these and the boiler leads, however, the connections with the header are made in curves on a 4-foot radius, and a single valve is placed in each connection close to the header. The header itself is also fitted with valves, to cut off the part corresponding to any boiler. Wherever possible the condensation in the high-pressure lines is drained back into the boilers; otherwise the water is led to a receiver in the engine room basement, where the water is returned to the boilers by means of an automatically controlled steam pump.

Each of the main engines is of the Williams vertical cross-compound pattern and was built by the Quincy Engine Works, of Quincy, Ill. The live steam supply to each of these, as also to the exciter engines, is equipped with a Cochrane receiver-separator. The engines have a rating of 1,050 horse-power at a speed of 150 revolutions per minute, a steam pressure of 150 pounds and a back-pressure of 2½ pounds absolute. Their cylinder dimensions are 22 and 43x32 inches. Each of them is direct connected to a Westinghouse alternator mounted between cranks. This has a capacity of 650 kilowatts and its output is three-phase current at 3,000 alternations and 390 volts. Each of the exciter sets consists of a Westinghouse 37.5 kilowatt 125-volt direct-current dynamo direct connected to a 9 and 15x9-inch vertical compound Westinghouse steam engine. Besides the exciters the engine room contains two 300-kilowatt rotary converters for supplying direct current to the local sections of the electric railway. Behind the switchboard which stands across the opening to the ell, or extension, for the electrical apparatus are four 500-kilowatt transformers for raising the voltage for transmission of the current to the various substations. The switchboard contains nine panels, two for the main generators, one for the transformers, four for the rotary converters, one for the direct-current railway feeders and one for the two exciters.

The condenser is a 24-inch elevated-cone jet-type of condenser placed outside of the boiler room, at one end of the line of coal bunkers. It is shown in dotted line in the cross-section illustration, though it should show only in a cross-section looking in the reverse direction. It is of the Worthington make, furnished with both circulating and dry-vacuum pumps, and is required to condense 60,000 pounds of exhaust per hour. The pumps are located in the boiler room, near the condenser. The circulating pump is a duplex compound, 14 and 20x19x15 inches in cylinder sizes, and the vacuum pump, 8x16x12 inches in size. The circulating water is taken from Canandaigua Lake through a pipe line some 212 feet long, and the discharge pipe from the condenser is submerged in a hot well which has an overflow into a trench carried back into the lake underneath the coal bins, which have a wood flooring over the trench.

The injection pipe, which is of cast-iron 16 inches in diameter, has a vertical air chamber immediately above the strainer foot-valve at the lake and a similar air chamber near the circulating pump. The pipe line for the supply to the boiler feed pumps may also be referred to in this connection. It runs from the lake and is carried by the feed pumps to the fire pump. It is of cast-iron to the power-house and wrought iron within it. To the feed pumps it is 8 inches in size and in continuation to the fire pump, 6 inches. There is an air chamber at the foot-valve and one at the fire-pump. To the pipe are connected the village water system, through a meter, and the condenser hot well. The main exhaust line is carried on cast-iron rollers on brick piers. The rest of the steam piping, generally, is hung from the roof trusses or supported by brackets of which a drawing is given.

For the operation of the various pumps and the fan engines, there is an auxiliary system of live-steam piping. This begins at each end of the main header and is brought forward in the boiler room and joined together across the boiler fronts, forming a continuous ring main around the boiler room. There are two boiler feed pumps, of the Deane type, 9x5¼x12 inches in size, with outside packed double plungers and one fire pump, this 14x8½x10 inches; the former placed between the economizer setting and the adjacent boilers, and the latter in the space underneath the smoke duct. The fire pump is of the plunger and ring pattern and has a capacity of 600 gallons at 125 pounds steam and 100 feet per minute piston speed. The feed water is delivered normally through a feed-water heater and through the economizer, but each of these can, of course, be by-passed. The feed-water heater is of the water-tube type, 36 inches in diameter and 14½ feet long, furnished by Messrs. William Baragwanath & Son, of Chicago. It is supported overhead in the rear of the boiler room and receives the exhaust from the pumps and exciter engines. The economizer, which was built by the Green Fuel Economizer Company, consists of 32 sections of 10 tubes each, 9 feet high and 4 9/16 inches in diameter, and presenting 3,840 square feet of heating surface.



Trench Excavating Machine.

Trench in Stiff Earth.

The contractors and engineers for the railway and plant were the Comstock-Haigh-Walker Company. The steam piping was installed by Messrs. W. T. Hiscox & Company, of New York.

The Conduit of the Jersey City Water Supply Company.

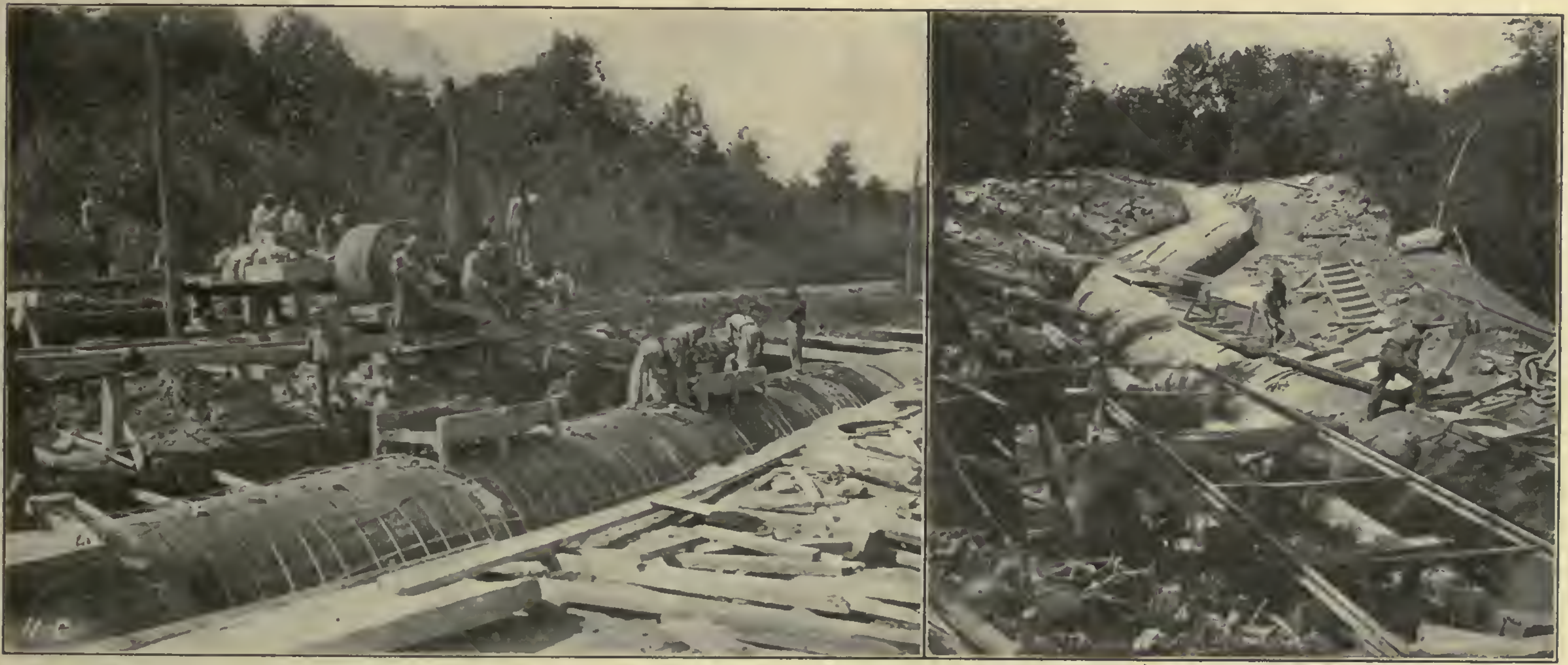
Part II.—Concrete-Steel Construction.

There are four stretches of masonry conduit, including the Hook Mountain and Watchung Mountain tunnels. Hook Mountain tunnel was excavated by the company by day labor, but the trimming and lining has been done under contract by Mr. Harold Bouton, of Jersey City. A contract for Watchung Mountain tunnel was made with the Hudson County Contracting Company, of Jersey City, recently reorganized as the Metropolitan Construction Company of Jersey City, which is now completing the lining. The tunnels penetrate sound trap and sandstone, requiring timbering only at the portals and at one place where water came in pretty freely—perhaps 200 feet altogether in the total length of both tunnels. No unusual difficulties were encountered and no novel methods of construction employed. The cross-section of the lining used for Hook Mountain tunnel is shown by an accompanying drawing; that for Watchung Mountain differed slightly in the invert, and in several places, aggregating somewhat more than 200 feet, four rings of brick were used. The brick side walls and arch were built first and after they were completed the concrete invert was placed continuously beginning at the higher end of each tunnel.

Excavation for the cut-and-cover conduit was begun in 1900 by sub-contractors under the original contract with Mr. Flynn, considerable portions of the trench being opened that year. When the undertaking changed hands, as described in previous articles, the cut-and-cover work was divided into four contract sections, all of which were let to the Eastern Construction Company of New Jersey, Mr. Fred J. Gubelman, M. Am. Soc. C. E., president. The contract for Section 4 was sublet, however, to the Cement Paving & Construction Company, of Jersey City. No work was done on Sections 3 and 4 by the original contractor.

Operations were begun by the Eastern Construction Company last May. The difficulties on Sections 1 and 2 were materially increased by the condition into which the partially excavated trenches had fallen by reason of their standing open for the intervening two years. On Section 1 a number of short drifts or tunnels aggregating 1,541 linear feet had been made through shale rock to avoid deep cuts, but it seems now that continuous open cutting would have been more economical in the long run. The sheeting and bracing, some of which even when first placed was none too good, had suffered by the exposure, and, for about 400 feet in one place, had been set so as to make the trench a foot too narrow. Widening and rebracing a wet trench from 22 to 38 feet deep, in woods, through soil containing large boulders and fine running sand, with the bank loaded with the previously excavated materials, is not a particularly enjoyable piece of construction, but it was successfully accomplished. In this and other trench work on this section a Jackson hoister and excavator, built by Mr. G. D. Grannis, of Syracuse, N. Y., was found very useful. The materials on this section were mostly shale rock, clay, gravel and fine sand, containing considerable water. The phenomenal wetness of the season added not a little to the difficulties of the work on all the sections.

On Section 3, 9,896 feet long, located largely along a rough steep side-hill along which a construction road had to be cut before other operations could be undertaken, three special steel stiff-leg bull-wheel traveling derricks were used. These derricks, one of which is shown in an illustration, were built by the Lidgerwood Manufacturing Company, of New York, had platforms 12x30 feet, mounted on six-wheel trucks, had 40-foot latticed steel booms and traveled on 10-foot-gauge tracks laid alongside the trench. These derricks handled one-cubic-yard steel tipping buckets, into which the materials were shoveled in the trench. The materials were principally gravelly clay and boulders. On Section 2, 2,600 feet long, there was a great deal of rock excavation, largely trap: the material above the rock was mostly clay. Section 4, 3,640 feet long, also encountered considerable rock, but there was also much clay and fine sand, and water caused no little annoyance. A fourth Lidgerwood excavator and a stiff-leg derrick were used on this section. In the bottoms of the wet trenches box sub-drains were used and holes were left into the invert of the conduit at intervals of about 50 feet to permit the filling of the drain after the conduit was finished. Wherever the box drain was used the invert was reinforced with sheets of expanded metal laid continuously. At the easterly end of Section 3 the gravelly clay was of such a nature that the deep trench could be cut with almost vertical sides and would stand for months, and the bottom could be formed exactly to the shape required for the conduit, as can be seen in one of the views. Excavated materials, except rock, were used almost wholly for refilling and embankments; the rock was used to some extent for this purpose also. The embankments have slopes of 1 on 1¾ with a minimum depth of 2 feet above the arch of the conduit.


Concrete Conduit of the Jersey City Water Supply Company: Mixer, Shoveling Boards and Steel Rods; a Finished Reversed Curve.

Accompanying drawings show the principal types of conduit construction, Portland cement concrete reinforced with Ransome steel rods being used everywhere excepting in the drifts on Section 1, in the concrete lining of which no steel was used. About 90 per cent. of the conduit in open trench was built of the type designed for stiff earth and rock trenches, this section being used for all depths of cover up to about 10 feet. A few pieces, amounting to 826 linear feet, where the cover was about 15 feet, were built with the arch 8 inches thick at the crown and the side walls 14 inches thick at the springing line. The reinforcement consisted of cold-twisted ⅜-inch square steel rods bent to the form shown in drawings, spaced 1 foot apart, and ¼-inch longitudinal twisted rods placed 2 feet apart and wired to the transverse rods. The transverse rods were made of such lengths as to extend 1 foot below the bottom of the outside forms, below which the concrete was built against the hard earth or rock sides of the trench.

For lengths of a few feet in a number of places where the bottom of the trench was in soft earth, a bed of concrete 6 inches thick at the middle and from 8 to 18 inches thick at the sides, according to conditions, in which sheets of 3-inch mesh No. 10 expanded metal were embedded, was placed as a foundation for the conduit. On 420 feet of foundation embankments the base of the conduit was extended, as shown, and reinforced with ⅜-inch twisted steel rods. In both soft earth and embankment types of conduit the transverse reinforcing rods completely encircled the bore of the conduit. In these cases, of course, the rods were made in two or more pieces and their ends were lapped 1 foot and wired together. In other places also a rod might consist of more than one piece if the ends were lapped 1 foot and wired together. This system of reinforcing was adopted after receiving alternative bids on three systems in the tenders for the main contract, including two kinds of mesh fabrics. But very little difficulty has been experienced in keeping the rods in their proper position in the cross-section by exercising a little watchfulness as the concrete was being placed.

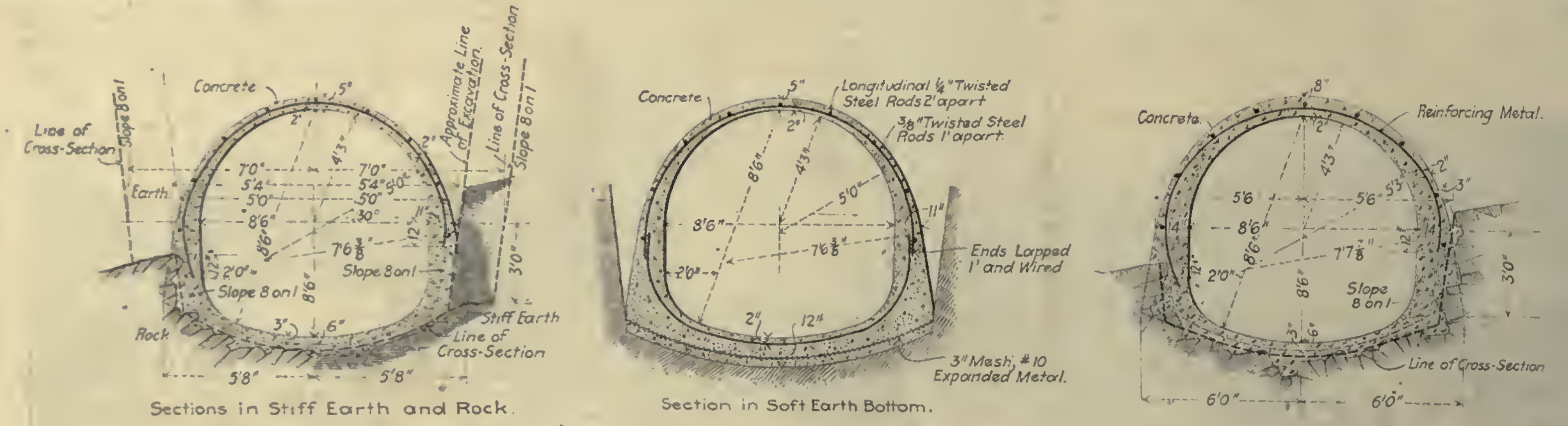
The concrete was made of one part Atlas Portland cement and seven parts sand and ballast, for the conduit in open trench, and eight parts for the linings and drifts, the mixtures being balanced so as to make a dense mass. The proportions were fixed by volume, 100 pounds of cement being assumed to occupy 1 cubic foot, and the sand and ballast being measured as shoveled into boxes in the usual way. The ballast was broken trap rock, and the run of the crusher was used. The crushers were set for 2-inch stone, but, owing to the character of the rock, pieces several inches long and sometimes wider than 2 inches, would occasionally pass. Such pieces were rarely thrown out, except from the thinnest part of the arch, but when kept properly distributed in the mass were considered advantageous rather than otherwise by reducing the voids in the aggregate.

All cement was furnished in carloads to the contractor by the Jersey City Water Supply Company at the most convenient points of railroad delivery, the contractor being required to give the company a written order on or before the fifteenth of each month covering the amounts and details of the deliveries to be made during the next succeeding month. It was stipulated, however, that the deliveries should not exceed the equivalent of a certain maximum average number of barrels per working day. The contractor was held responsible for the proper care and use of the cement, and any injured after delivery to him by reason of neglect or carelessness on his part, and all cement used in work rejected by the engineer was charged and will be deducted from the final estimate. It was provided that any cement found to be below standard at the time of delivery should be credited if returned to the company in carload lots, at the point of delivery. The contractor was required to furnish the engineer at the close of each day's work, a report in writing stating the number of barrels or bags of cement used during the day for each and every class of work, and also the number of batches of mortar and concrete. These various requirements were clearly stated in the specifications.

Good sand was found at several places along or near the trench, and with few exceptions but short hauls were necessary to get it to the works. A rock-crushing plant consisting of two portable crushers made by Julian Scholl & Company, of New York, driven by Erie City Iron Works engines, was set up at a convenient place on Section 2 and furnished practically all stone required on this section and Section 1. For Section 3 a similar plant was installed, while for Section 4 the broken stone was obtained mostly from outside parties. The teaming of sand and broken stone was sublet to various local parties, but the Eastern Construction Company found that it could save money by buying and furnishing for this purpose some thirty of the 1½-cubic-yard dumping wagons made by the Watson Wagon Company, of Canastota, N. Y., since their use insured greater uniformity and better measure in the size of loads, payment being made per load, with a proportionate price for partial loads. These wagons also furnished a readier means for checking and estimating quantities as well as greater convenience in handling the materials.

All concrete was mixed by machine, seven Ransome portable drum mixers being used on Sections 1, 2 and 3, and one Ransome and one Smith mixer on Section 4. These mixers were set beside the trench and, on Sections 1 to 3, delivered the concrete through iron chutes to dished shoveling boards standing on six legs on top of the forms, as shown in the illustration. The concrete was mixed very wet, the mortar being of the consistency of thin mush, and was considered just right when it would just flow with the chutes sloped 1 vertical to 8 horizontal. Of course, the chutes had generally more pitch than this, and, when necessary to get the slope, the mixers were raised on blocking. Coal scoops were used for shoveling the concrete from the watertight dished boards into the forms and were found not only to be more economical than shovels in moving the concrete more rapidly, but they better preserved the proportions of mortar and water with the ballast. The large proportion of water used in mixing was taken up by the cement in setting. During warm weather the concrete, after removing the forms, was covered with a few inches of earth, and sprinkled three times a day for two weeks, provision for sprinkling having been made in the specifications. Special two-wheel end-dumping steel measuring barrows were used for sand and stone and dumped the materials directly into the mixer. On Section 4 side-dumping special wooden measuring barrows were used. Tamping bars and forks were the tools for working the concrete properly against the forms; it was too wet for ramming.

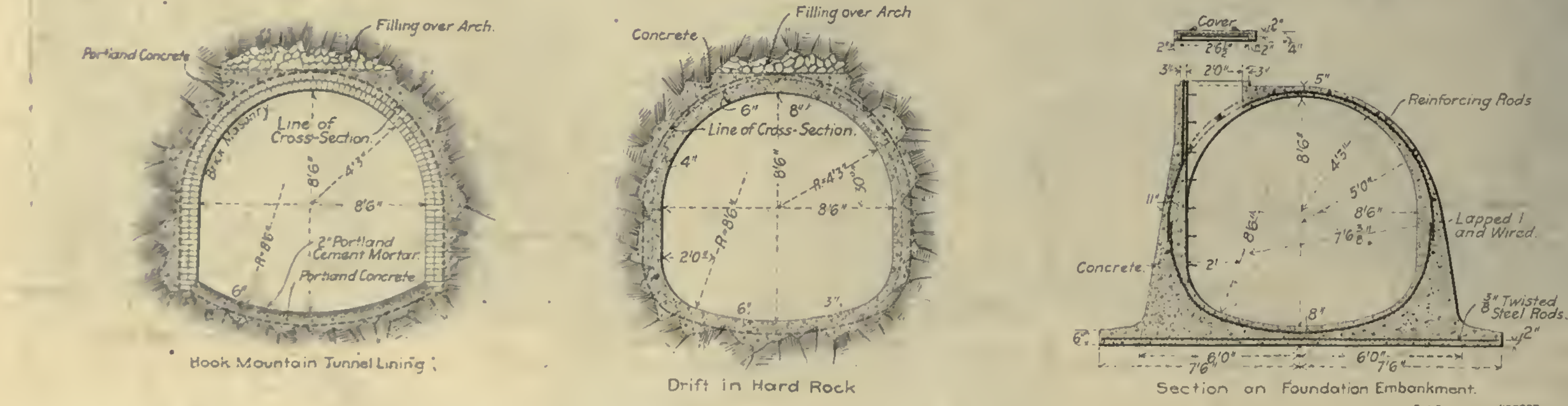
The types of centers employed are well shown by some of the views, those on Section 4 being covered with thin sheet steel. All of them were made in sections 12½ feet long consisting of eleven parts of such a weight—about 200 pounds—as to be readily handled. The specifications required that the conduit should be built in monolithic sections not exceeding 20 feet in length, but sections 50 feet long were used wherever the top of the conduit was not over 18 inches above the undisturbed ground. It was further stipulated that if necessary to secure smooth surfaces the concrete should first be deposited in the invert and lower part of the side walls, with its inside face at least 1 inch back from the finished surface, and that immediately afterwards the forms for the invert should be placed and the space between them and the concrete poured full of a very wet mixture consisting of one volume of Portland cement, one volume of sand and one volume of very fine crushed stone. This method was never tried, but as it was apparent that it would require more time for the construction than the urgency of the case would permit, the invert was formed by screeding, being finished by troweling while the mortar was plastic, and the two bottom parts of the centers were not used. No outside forms were employed for a width of about 5 feet on top of the arch. The centers were usually left in place about forty-eight hours. Occasionally they were greased with cheap vaseline cut with kerosene. Towards the close of the work, when some of the centers were no longer needed, the ⅞-inch lagging taken from them was used for the forms for several of the small gate chambers.



Sections in Stiff Earth and Rock.

Section in Soft Earth Bottom.

Heavy Section in Rock



Book Mountain Tunnel Lining

Drift in Hard Rock

Section on Foundation Embankment.

Concrete Conduit of the Jersey City Water Supply Company: Typical Cross-Sections in Open Trench, in Tunnel and on Embankment.

The general method employed in construction may be briefly described as follows: Forms were set for a given section to be built, making a continuous inner mould for the conduit, except for about 6 feet in the lowest part of the invert. These forms were supported on 6-inch cubes of concrete, which were built into the work. Each 12½-foot section of the inside forms had a scuttle about 2 feet square at the crown of the arch. After having been set, the forms were then greased and the Ransome rods placed in position. Wherever the trench was near the required width, no back forms were used. The concrete was first deposited on the outside and by means of tamping bars, was forced under the forms until it appeared on the inside and filled the entire space between the ground and the forms. Concrete was then thrown through the scuttles and the invert screeded into shape. The scuttles were then closed and the work of making the concrete shell was continued. Back forms in sections about 12½ feet long and 2 feet in width were added as the work progressed wherever the width of the trench made them necessary, until the concrete had been all placed, except about 5 feet along the crown. The crown was formed without the aid of the outside form. Special care was taken to keep the forms clean, the whole duty of one laborer being to scrape off the fresh concrete whenever work was shifted from one part of the section to another.

The concrete is very dense and free from voids, weighing 156 to 160 pounds per cubic foot. This was well shown in the fragments of about 200 linear feet of conduit ruptured during the flood of October 8 and 9, when one side of the trench for a short distance on Section 3 filled with water while the other side was drained through a side trench, the conduit acting as a dam. A portion of the invert only about ten days old was forced upward and then the upper parts of the side walls and the arch were crushed in. The reinforcing rods were broken in most instances observed rather than being pulled out of the concrete. At the end of each day's work a groove was formed in the face of the concrete all around to bond with the following concrete. Fine cracks have girdled the conduit at many of these joints, but nowhere else, as far as noticed. However these cracks do not seem to be serious and will probably be silted up soon after the conduit is put into service. The reinforcing rods extend across these joints. Little or no brushing and plastering of concrete surfaces has been done, but the interior of the conduit is smoother than average brickwork in similar construction, and it is claimed that the coefficient of roughness will be less than that of riveted steel pipe of the same size.

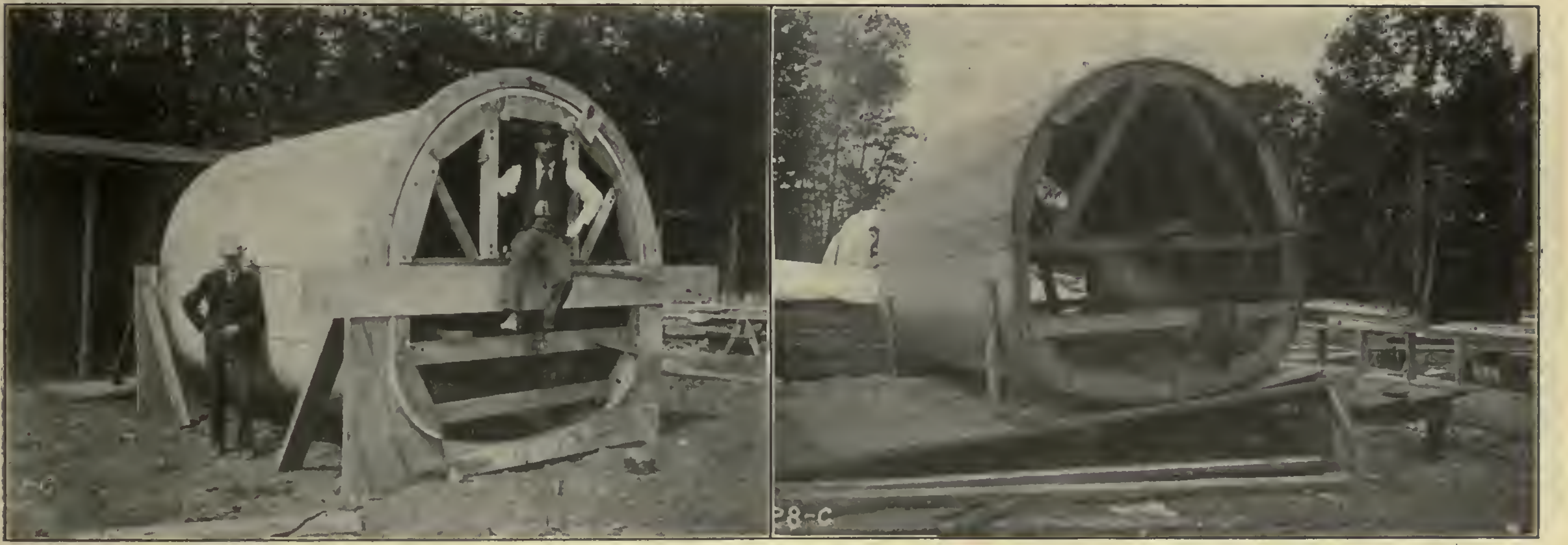
At Third River, on Section 4, the conduit was carried across the stream on a bridge of concrete reinforced with expanded metal. The bridge consists of three arches, two of 8 feet and one of 18 feet span, and contains overflow chambers from which the water can spill into the river. The concrete was composed of one volume of cement to seven volumes of sand and ballast. The structure presents a neat appearance just as exposed by removing the forms, without troweling or other finish. Square manholes of the dimensions shown in one of the drawings were formed on the conduit at intervals of about 500 feet. These have as covers flat reinforced concrete slabs with a projection

2 inches wide and 2 inches deep on all sides of the bottom to fit over a similar projection at the top of the manhole. These covers are buried to a depth of about 2 feet by the embankment, but their positions are indicated by markers. A number of small streams are carried beneath the conduit by syphon barrel culverts, of concrete, with a rectangular chamber 3½x6 feet inside at each end, the one on the inlet end having a sump 2 feet deep. Several overhead culverts were also necessary. These are rectangular concrete troughs 2 feet deep and from 2 to 4 feet wide resting on the arch of the conduit and having suitable aprons of dry stone paving at each end. One large free-draining culvert which was required beneath the conduit is of concrete; it is 5 feet wide and 3 feet high inside, the top being an arch of 12 inches rise, 6 inches thick at the crown.

This conduit is a noteworthy example of modern steel pipe and reinforced concrete construction; the arrangements for controlling the flow of the water at the connection with the East Jersey conduit and at the place of distribution are particularly interesting.

But perhaps the most notable feature of the concrete construction was the rapidity with which it was executed, which accounts for the otherwise unnecessarily large equipment which the contractor provided. Trial sections of the concrete conduit were begun about July 1 and by the middle of that month three mixers were in operation. Other mixers were added from time to time as the trench could be gotten ready, the last one being started about the middle of August. After construction was commenced, the rate of progress was rapid until completion. Between July 25 and November 14, 18,500 feet of conduit were built. On one section, in 65 days, excluding Sundays and holidays, but including days on which it stormed, 2,586 feet of conduit were constructed by a gang of 38 men, an average of 39.8 linear feet per day. By October 21 the contractor had built all the conduit except two short pieces held open by order of the water company and a short length in the deep cut on Section 1. On November 10 there remained to be constructed only 20 feet held open in one place to accommodate other work and 100 feet at Watchung tunnel which cannot be completed until after the tunnel lining is finished. As stated early in this article, the contractor did not begin operations of any kind until in May, and there now remains to be done, when suitable weather returns in the spring, only comparatively small parts of the grading and clearing-up.

Mr. J. Waldo Smith is consulting engineer, Mr. E. W. Harrison, chief engineer, and Mr. William B. Fuller, resident engineer, for these works. Mr. F. J. Gubelman gave his constant personal attention to the construction in behalf of the contractor.



Concrete Conduit, Jersey City Water Supply Company: Forms Used on Section Four and on Sections One to Three.

A System of Hot-Water Heating by the Use of Steam.

A hot-water heating system that has apparently met with marked approval in Europe, judging from the numerous important installations of it on the Continent, is that invented some years ago by Capt. A. B. Reck, of Copenhagen, Denmark. The water from the radiators of the warming apparatus is returned through tubes in a so-called reheater, which employs steam as the heating medium, around the outside of the tubes, and the water then passes to the expansion tank, located in the usual elevated position, and thence to the flow lines leading to the radiation surface, completing the circuit. The interesting point, however, is that the riser from the reheater to the expansion tank, before connecting into the tank, is carried through a small condensing apparatus and through a circulator, so-called, the offices of which are as follows:

The circulator is essentially an enlargement of the riser in which a steam pipe terminates, so that steam forced into the water can heat it above what it was in the reheater. Besides the water pipe rising from the reheater, a steam riser is also extended from it, from the steam space, and the water riser connects into the bottom of the circulator, while the steam riser terminates within it at the upper part. It will thus be seen, as may be noted in passing, that the steam and water systems are brought into communication at this point. The top of the circulator is connected into the bottom of the expansion tank, by a pipe that has already been referred to as a part of the water riser, and from the bottom of the tank is dropped the main flow line. The circulator is supported a few feet below the expansion tank, and the column of water represented by the connection between circulator and tank is overbalanced by the column represented by the flow pipe from the bottom of the tank to the flow mains, the establishment of this relation, as a means for accelerating circulation, being the object of the apparatus. To take care of the water added to the water system by the condensation of steam in the circulator, an overflow pipe is attached to the expansion tank, leading to the water space of the steam boiler, assuming that a low-pressure boiler is employed for steam generation. In order to keep the system at a low pressure and to get rid of the air collecting in the top of the tank, which is covered, the overflow pipe or connections thereto are fitted with an air valve. Owing to the possibility that the overflow pipe may at times become filled with vapor or steam, the pipe is not continuous to the steam boiler, but the condenser mentioned is inserted, being a device by which this steam is condensed by the water rising from the reheater. The condenser is usually located close to the circulator.

As to the action of the apparatus some general statements were made recently in a paper read before the Institution of Heating and Ventilating Engineers, by Mr. C. Ingham Haden. When the steam pressure in the boiler or supply pipe exceeds the pressure due to the height of the column of water from the circulator to the water line into the expansion tank, the steam will make its way into the circulator and mix itself directly with the hot water ascending from the reheater through the main rising pipe.

The result of the admixture of the steam with the water in the circulator will be, he explained, that the water is caused to boil in that part of the rising pipe above the circulator, so that numerous steam bubbles will be contained in the water column ascending through the said pipe. The temperature of the water in this pipe depends greatly on the pressure of the steam penetrating into the circulator, so that the steam pressure is normally maintained just sufficient to cause it to enter the circulator. The condensation in the reheater is, of course, returned to the boiler.

It will be seen that as long as the pressure in the boiler is kept so low that the steam cannot enter into the circulator, the apparatus will work as any ordinary hot-water apparatus, the difference being that the hot-water boiler is replaced by the steam boiler and reheater. The property of the circulator that is emphasized is that it can be used in the morning in moderate weather or when any sudden fall in temperature takes place, owing to its capacity to accelerate the circulation. It is asserted that when the Reck circulator is fitted to a hot-water heating apparatus, the hot water will circulate say four times more quickly through mains and pipes than without it, and that as a result the sectional area of the piping need only be one-fourth as large, containing, therefore, one-fourth the quantity of water. In brief, the points that are regarded as the principal features of the system are quick heating and small piping.

Details of the Williamsburg Bridge Towers.

The general features of design and the important operations of construction and erection for the new East River bridge, officially known as the Williamsburg bridge, across the East River, between the new bridges No. 3 and No. 4, have been abundantly described by about thirty articles published in The Engineering Record as the work has progressed during the last six years. The structure has now reached such an advanced stage of completion that its present appearance, in most respects, is that of the finished structure. The character of the steel work is of special interest on account of the great capacity of the bridge—much larger than that of any other long-span yet completed—its height, and the development of massive members designed in accordance with the most advanced American practice. The special features have been recorded in the illustrations of the design published by this journal. In many cases these have appeared at considerable intervals as the different parts of the work were put under contract. The illustrations were necessarily condensed so as to permit the presentation of the whole large structure, and therefore many of the details which were actually shown could not be emphasized so as to especially display their many interesting features. Since the completion of the different portions of the work, many of the special connections can be seen to advantage in the structure, and The Engineering Record has secured some special photographs of these for the purpose of illustrating some of the typical features which can be thus observed at a glance without the effort necessary to read the separated or complex drawings.

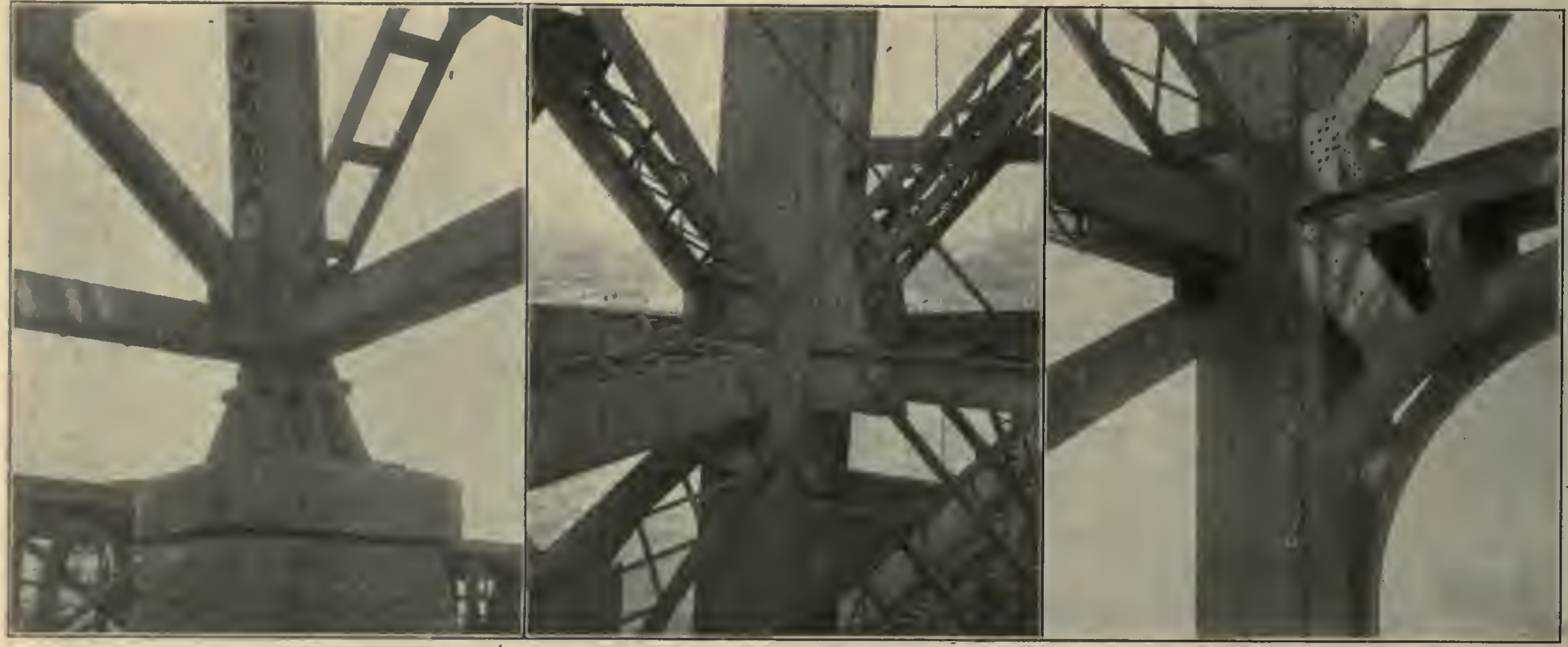
The main towers are much the largest steel bridge towers ever built and their massive construction and great rigidity is evident from the accompanying detail views which show several of the principal connections. These towers were described in The Engineering Record of February 12, 1898, and their erection was described May 5, 1900. They are about 310 feet high above the tops of their piers; about 125 feet long; 45 feet wide over all at the base, and about 100 feet long and 20 feet wide at the top. Each one carries four main cables and one end of the 1,600-foot suspended span, and one end of the 300-foot approach span. The tower weighs about 3,000 tons, and consists essentially of an upper and lower portion. The lower portion is about 100 feet high and is made of two separate towers seated on independent masonry piers and connected at the top by a system of transverse girders and portals. Each half of the tower has four vertical columns braced together on all siles.

The horizontal braces between the tower legs are made with pairs of built channels with their flanges turned inwards and latticed. The diagonal braces have I-shaped cross-sections made with two pairs of large angles riveted together back to back and latticed. Both horizontal and longitudinal braces are field-riveted at the ends between pairs of jaw plates in the planes of the column webs or of their cover plates. At intersections all the diagonal members are mitred and are field-riveted to flange connection plates. The columns have closed rectangular cross-sections made, in the lower sections, with two 48x⅞-inch cover plates, two 32x⅞-inch inside cover reinforcement plates, two 46x⅞-inch web plates, two 29½x⅜-inch outside web reinforcement plates and four 8x6x¾-inch flange angles. They are stiffened by horizontal transverse diaphragm plates about 10 feet apart which are pierced with manholes to allow access to the interiors of the columns in one of which an iron ladder is provided.

The lower section of the column about 20 feet long is battered to an extended base 8 feet square, and the sides are stiffened by two inner vertical ribs 2 feet wide on each side. The two sides of the lower part of the tower are connected below the roadway level by transverse trusses and heavy arched portal frames. The eight columns are vertical up to this point and their tops are capped with horizontal steel plates on which beveled castings are seated to receive the feet of the upper portions of the columns, which are battered both longitudinally and transversely, but are parallel in the transverse planes.

The construction of the members is similar to those in the lower part of the tower, except that the two pairs of columns on each side of the center line are connected above the sidewalk by heavy portal struts and at the tops by plate girders carrying the saddles. The two sets of columns are also connected over the roadway by deep transverse girders and portals. The sidewalk portals are virtually double plate-girders with a transverse connecting diaphragm and open panels in the web. They are connected to the column webs by vertical flange angles, as indicated in the illustration of an outside tower column, which also shows a portion of a column splice and the connection of the longitudinal bracing and a transverse diagonal. The illustration of an inner column above the roadway is made from a photograph looking from the center of the tower towards the river, at the connection at the upper side of the main portal girder and shows the knee-brace connection which stiffen the web members of the portal and the heavy rectangular diagonal strut above it. The illustration of the outside column is taken from a point near the center of one group of four columns and shows the typical connections of horizontal and inclined transverse and longitudinal struts for an outer column above the roadway. The scale may be judged from the dimensions of the horizontal struts, which are each made with 24-inch vertical plates, and the diagonals, which are made with pairs of 6x3½-inch angles.

The top flange of the latticed portal girder in the other illustration is made with a pair of 18-inch web plates and two 6x4-inch angles. The diagonal strut above it is made with four 6x4-inch angles. The portal girder over the sidewalk is made with 6x4-inch angles in the top flange and curved 6x8-inch angles in the bottom flange, and the adjacent longitudinal horizontal strut is made with 24-inch web plates and 3½x3½-inch flange angles. The adjacent ends of the two 300-foot land spans on each side of the river are carried by steel towers about 86 feet high from the top of the masonry to the pedestal seats. These towers are substantially double, each being composed of two symmetrical halves united by a pair of transverse plate girders and curved portal struts at the top. Each half has two bents each composed of two posts battered in vertical longitudinal planes. Each post has an open rectangular cross-section made with two 24-inch web plates, one 27-inch cover plate and four 4x4-inch angles. The lower ends are milled square and are seated on cast-steel base plates with beveled top flanges about 30 inches high, each base plate being supported on a separate granite pedestal. The four sides of each half of the tower are braced with horizontal and diagonal transverse and longitudinal struts corresponding in their design and connections with those described for the main towers. These towers were illustrated and described in this journal February 19, 1898.



Williamsburg Bridge, New York: Foot of Column, Approach Span Tower; Typical Intersection and Portal Connection, Main Towers.

A French Cantilever Bridge without a Suspended Span.

The 528-foot span suspension bridge across the Sâone at Villefranche, France, has recently been replaced by a three-span cantilever bridge 521 feet long between anchorages, which is supported on the old abutments and on two new channel piers having pneumatic caisson foundations. The bridge carries a 23-foot highway, a railroad track between the trusses and a 10-foot cantilever sidewalk on each side. It has two side spans 150 feet long and a center span 220 feet long on centers. There is no suspended span and the main trusses are continuous over the piers from the abutment anchorage to the center of the channel span. The trusses are riveted girders with vertical members and diagonal ties in one direction only. The bottom chord of the center span is a segment of a circle of 188 feet radius, which gives it a rise in the center of 4.7 feet above the tops of the piers. The bottom chords of the side spans have the same radius so as to be symmetrical with the center span at the pier, but at the abutments are tangent to a horizontal line 3.44 feet above the tops of the piers. The top chords of all spans are segments of parabolic curves, those of the side spans being tangent to the horizontal at the abutments. The trusses are 32 feet deep at the piers and 9 feet deep in the center of the middle span. The roadway is graded from about the centers of the abutments to the center of the truss in the middle of the river. The main vertical post over each pier is a rectangular closed member 6½ feet wide. The floor-beams are lattice-girders or plate-girders according to the depth of the truss and they support a solid buckle-plate floor and pavement.

The most interesting feature of the work was the erection which was executed by a combination of methods provided to avoid any obstruction of navigation between the anchorages. The anchor arms are 150 feet long, weigh 164 tons each without the floor plates and part of the wind bracing and were erected on the opposite banks of the river beyond the abutments. Each one was mounted on four sets of rollers, two sets seated on the abutment and the other two sets 34½ feet beyond them. The anchor end of the span was counterbalanced by a load of about 12 tons and the span was hauled toward the center pier by windlasses and tackles attached to the shore ends of the trusses and to the abutments. When the trusses projected about 56 feet on one side of the river and 62 feet on the other side, the overhanging ends were seated on falsework towers built up from the deck of a 158-ton boat moored below it. The bearing of each span on the tower was made with four jacks; two of them were hydraulic to compensate for the displacement of the boat and the other two were screw jacks to adjust the level of the pier seat. The boats were guided by four anchor lines wound on windlasses as the span advanced, and the launching was successfully completed at a time when there was neither wind nor current to contend against. As the moving lower chord which was supported on the stationary roller bearings was curved, it was necessary to provide an adjustment by which the height of the latter could be constantly varied. Each bearing was, therefore, made with a pair of wheels set in a horizontal frame which had a center pivot on the top of a hydraulic jack. The rollers were thus enabled to conform to the curve of the chord and to be raised as the deeper portions of the truss passed beyond them.

The center span was erected from pier to pier by the ordinary cantilever method by the use of simple overhanging movable derricks. The final adjustment of the heights of the connecting members in the center panel was made by increasing the thickness of the bed-plate on one abutment and by decreasing the diameter of the rollers on the other abutment. The truss pieces were then finished to fit the panel and were assembled without difficulty. The total weight of the bridge is 1,478,220 pounds and the cost was about $110,500. A description of the bridge was published in the "Genie Civil," of October 31, 1903.

Williamsburg Bridge: Foot of a Column of the Main Tower.

Exports of German Locomotives aggregated 18,100 short tons during the first nine months of 1903, of which 6,100 tons went to the British East Indies, 4,850 tons to Spain, 1,250 tons to Italy, 1,100 tons to Holland and 750 tons to Denmark.

The Ambridge Plant of the American Bridge Company.

Part IX.—Eye-Bar Shop.

The 220x225-foot eye-bar shop is near the south end of the plant, between the foundry and the power-house, and is served by the longitudinal surface tracks parallel and adjacent to it at one end and by yard cranes parallel to the two sides. It will have, when the equipment is completely installed, a maximum capacity of about 50,000 tons a year of eye-bars up to 18 inches wide and 3 inches thick, which will be forged in two separate departments adjacent to each other under the same roof. One of them is adapted for the manufacture of heads up to 18 inches wide, and the other for larger sizes, up to 36 inches wide, for which the heavy machinery is already installed. The building conforms, in most respects, to the standards of framework and construction details adopted for the Ambridge plant and described in previous articles. There are, however, special features of the framing which are notable, as, for example, the arrangement by which the roof is supported over so large and wide an area. The wall columns are supplemented by only two interior columns placed on the transverse axis of the building, 30 feet each side of the longitudinal axis, and thus 80 feet distant from the side walls and 112½ feet from the end walls. This arrangement leaves the floor practically unobstructed for swinging the longest bars in any direction.

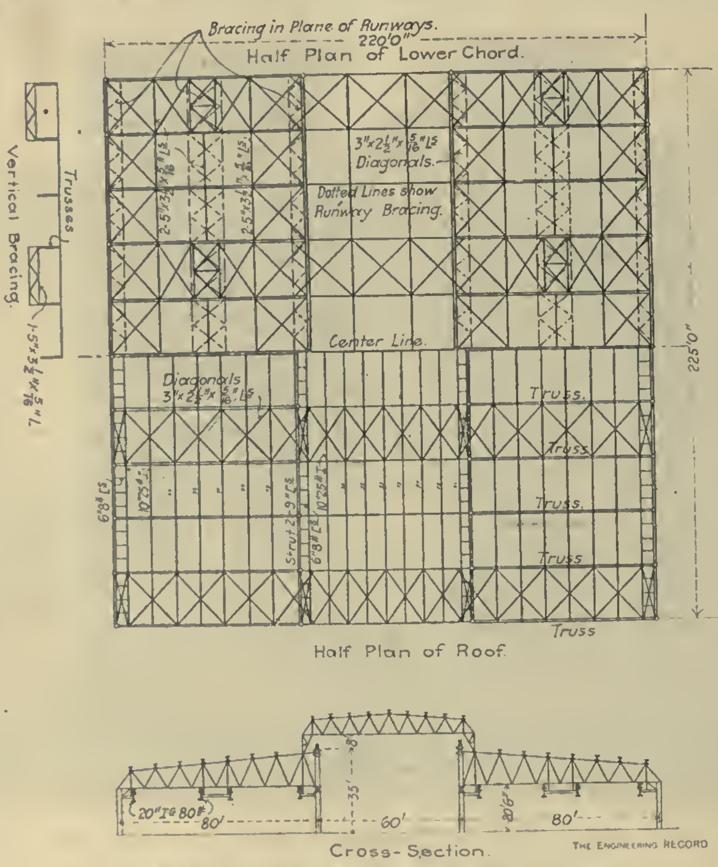
The interior columns and corresponding ones in the end walls support two lines of main longitudinal girders. The side wall columns are spaced 45 feet apart, except in the end panels where they are 22½ feet apart. Their tops are connected by lighter longitudinal trusses which, with the center trusses, support the eleven lines of transverse roof trusses 22½ feet apart, each line containing three spans. The 80-foot side spans have their top chords seated on those of the main longitudinal trusses and have a clearance of about 20 feet from the floor to their horizontal bottom chords. Although it is only 60 feet between the inner ends of the side trusses, the center trusses, which span the space between them, have a length of 71 feet, and are supported by vertical posts at the first panel points of the top chords of the side trusses. This allows clearance for the main cranes which travel on rails carried on the top chords of the main longitudinal trusses. The lower chords of the center trusses are 43 feet above the floor line with an 8-foot clere-story between the center and side roof trusses. The transverse roof trusses are connected by twenty-five lines of 10-inch I-beam purlins and two lines of longitudinal struts, above the hips of the side trusses, and by eight lines of longitudinal struts in the planes of the bottom chords. Eight lines of longitudinal runway girders are suspended from the bottom chords and rigidly braced to them. The trusses in the end and two intermediate panels are X-braced by single angles in the planes of both top and bottom chords. The remaining panels have bracing in the plane of the bottom chords of the side trusses. The upper parts of the side walls are braced with zigzag angles which, with the eaves struts and the lower girts, are substantially equivalent to lattice-girders.

The framework is proportioned for a total roof load of 50 pounds per square foot, for a wind pressure of 20 pounds per square foot of the vertical projection of the walls, and for the maximum crane loads. It is assumed that the 20-ton cranes will each expose a maximum load of 38,000 pounds on each of two wheels 9 feet apart, and that a pair of eye-bar hoists will impose a maximum load of 9,000 and a minimum load of 3,000 pounds on each of four wheels spaced 66 inches, 15 inches and 66 inches apart. The framework is built entirely of medium steel proportioned for a maximum tensile stress of 16,000 pounds net per square inch, for 9,000 pounds shear and for a compression of 16,000 pounds reduced by the formula $P = 16{,}000 \div [1 + (l^2 \div 12{,}500\, r^2)]$. Rivets are stressed to 11,000 pounds per square inch in shear and to 22,000 pounds in bearing. The interior column-bases are proportioned for maximum loads of 604,000 pounds each, those of the side columns from 100,000 pounds to 234,000 pounds each, and those of the main end columns for 391,000 pounds each.

The shop is divided by the longitudinal trusses into two 80-foot side aisles and one 60-foot center aisle which, at floor level, are separated only by a single column in the center of each side of the center aisle. At a height of about 18 feet they are separated by the longitudinal trusses. Each side aisle is equipped with two parallel crane runways of 27½-foot span. Each runway will have two or more cranes of 5 tons capacity, part of which will be fitted with assembling hoists, as described in the issue of Dec. 12. There will be in the center of each aisle a clear space of over 12 feet between the adjacent runways. The assembling hoists have the beams longer than the crane girders so as to project cantileverwise part way across this space and nearly meet there, thus enabling bars to be shifted transversely from one runway to another by means of the trolley hoists, if necessary. In one of the side aisles a third runway consisting of a single longitudinal I-beam is provided near the center of the space between main runways. A four-wheeled trolley runs on the lower flanges of the beam and carries a 5-ton differential hoist operated by sprocket wheel and hand chain for handling small bars and other light weights. In the main aisle there is one 20-ton crane of 60-foot span carried on the top chords of the main longitudinal trusses.

Eye-bar blanks are received at the shop on a surface track running through it transversely at one end, and the finished bars are delivered on a similar track at the opposite end. There are no other surface tracks in the shop. The walls are of the standard Ambridge type of concrete with steel skeletons up to a height of about 9½ feet, above which there is on all sides a continuous line of windows about 10 feet high with fixed sash, designed to be pivoted on the center line later, if necessary. The clerestory of the center aisle is completely filled with windows having sliding sash, except at three places on each side, where long purlins project about half way across the roof of the side aisles. They have double pitched skylight roofs and end windows. There is a monitor 15 feet wide which extends the full length of the middle aisle on the center line. It has three full width skylights with an aggregate length of 90 feet. The main and side aisle roofs are hipped and the steep parts are covered with slate. The flat portions are covered with slag roofing on 2½-inch planks sloped 1:12. In the ends of the building there are rows of windows corresponding with those in the middle aisle clere-story. Most of the doors are about 9 feet high and slide horizontally. The lower edge of each door has bearing on double flanged wheels engaging sunken rails, and the upper edge is fitted with light horizontal rails, the heads of which engage narrow channel bars which permit longitudinal motion and lock them transversely. The doors are made with No. 32 galvanized corrugated steel on channel and angle-iron frames. All of the upper part of the wall not occupied by windows is sheathed with No. 32 galvanized corrugated steel. Four 60-inch ventilators with dampers are set in the center line of the monitor roof.

The main longitudinal trusses are made with built members and riveted connections throughout, and are designed to carry roof loads of 78,300 pounds at each panel point. The top chord is supported at the centers of the panels by sub-verticals from the intersections of the diagonals. It is made with two 20x½-inch web plates, four 6x4-inch flange angles, two 4x½-inch reinforcement plates and one 22x½-inch cover plate, and has a maximum stress of 598,000 pounds. The lower chord maximum section has two 18x½-inch web plates and four 6x4x13/16-inch angles. Part of the web members have I-shaped cross-sections made with a web plate and four flange-angles, and the others have rectangular cross-sections made with two channels latticed. The side longitudinal trusses are 12 feet deep over all and 45 feet long on centers of columns, and are made with zigzag diagonals in the four panels. The U-shaped top chord has a maximum stress of 126,000 pounds and is made with a 12-inch top cover-plate, two 12-inch web plates and two 3x3-inch flange-angles. The bottom chord is made with two 12-inch web plates and two 3x3-inch flange angles riveted to the inside on the lower edge and latticed. The web members are made with single and double pairs of angles latticed.



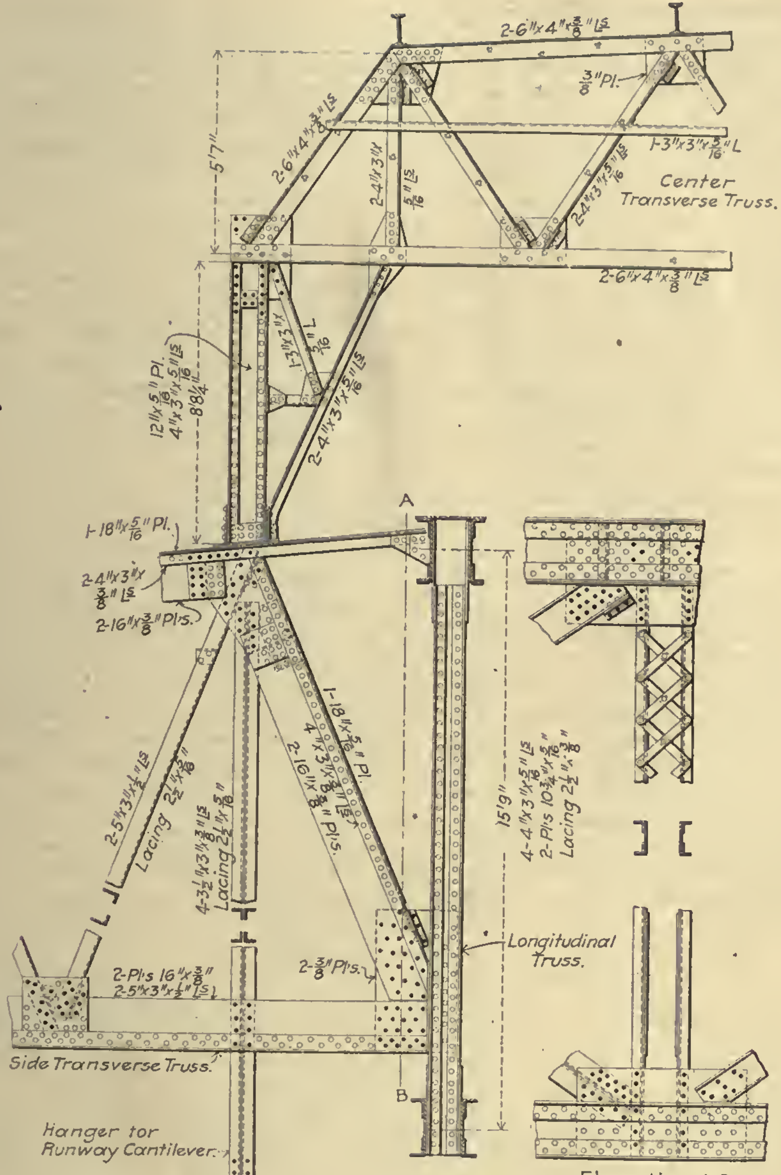
Diagrams of Eye-Bar Shop Framing, Ambridge.

In the sides of the building the truss in the short panel between the last two columns is replaced by a plate-girder 4 feet deep, which connects the tops of the columns and gives clearance for Kinnear rolling doors 16 feet high and 12 feet wide, in order to pass cars on the surface track through each end of the building. The center aisle roof trusses have a maximum stress of 90,000 pounds in the top chord and 88,000 pounds in the bottom chord. They are made with pairs of angles back to back riveted to connection plates between them at panel points. The trusses are field-spliced in the center panel and field-riveted at the ends to the vertical posts and kneebraces which support them from the top chords of the side trusses. The side trusses carry crane girder loads as well as dead weight and roof load and develop maximum stresses of 247,000 pounds and 253,000 pounds in the top and bottom chords respectively. They are seated at the outer ends on the caps of the wall columns, to which they are kneebraced with pairs of 45-degree channel bars riveted across the column flanges. The bottom chords are field-riveted to jaw-plates on the vertical posts of the longitudinal trusses which carry the weight of the roof trusses. The top chords terminate at the first panel from the ends on the center lines of the vertical posts for the center trusses, but their flange angles and cover-plates are continued to form struts bracing them to the top chords of the longitudinal trusses where they are connected to the web plates. At the first and fourth panel points from each end of the top chord the vertical suspenders project beyond the bottom chords to carry the cantilever girders which support the crane runways, as indicated by the cross-section diagram. These cantilevers in the center of the truss are two 15-inch channels 12 feet 2¾ inches long, web-connected at the ends to the 20-inch I-beams which form the runway girders. At the ends of the truss the cantilevers are pairs of 12-inch channels about 6 feet long which carry the runway girders in the same manner at a distance of 15½ inches beyond the suspenders and are connected at the opposite ends to the columns. The 10-inch I-beam purlins are seated on the cover-plates of the top chord and abut on its center line; 3-inch spiking pieces are bolted to their top flanges, and to them the tongued and grooved roof planks are nailed.

The main longitudinal trusses transmit their loads to the columns through both the top and bottom chord connections. The latter are field-riveted to wide jaw-plates which are shop-riveted to both webs of the columns. The top chords of the adjacent spans abut on the caps of the center columns, to which they are connected by field-rivets to jaw-plates projecting above and beyond the column webs, thus securing great rigidity. The columns at the ends of the center longitudinal trusses are similar to those in the middle, except that they are lighter and have 20-inch web plates and one 22-inch cover plate on the outer flanges. The truss connections are, of course, made to one side of the column. This building required 1,800,000 pounds of structural steel, and has been in service since January, 1903.

(To be continued.)

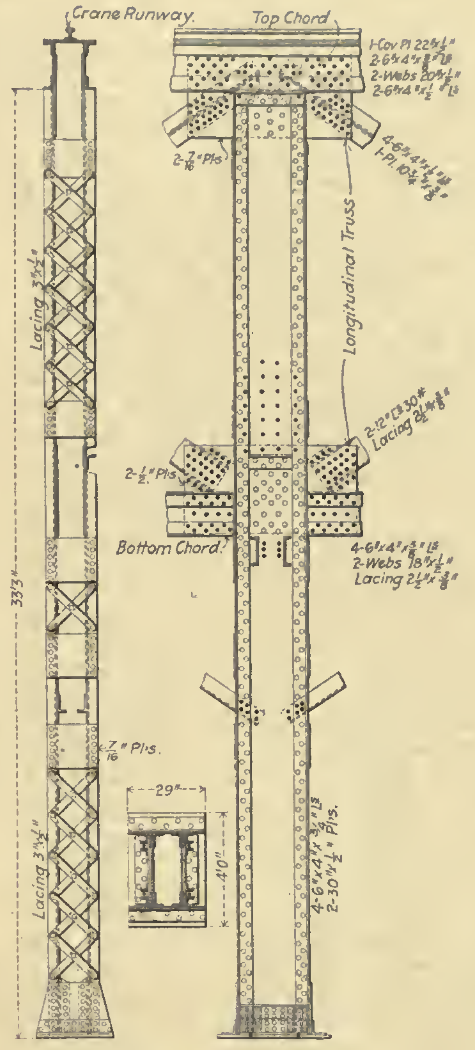
Mechanical Stokers seem to have been a general failure in India, if the status of the conditions is to be accepted from a report recently made to the Indian Government by Mr. Frederick Grover, on the smoke nuisance of Calcutta. The difficulties appear to be largely the inability of the stokers to deal with Indian coal, which yields frequently over 25 per cent. of ash, and the prejudices of the native fireman. He is accused of stoking through emergency fire doors instead of throwing the fuel into the elevated feed hoppers, which are not, as a rule, provided with conveniently located platforms.



Elevation A-B.

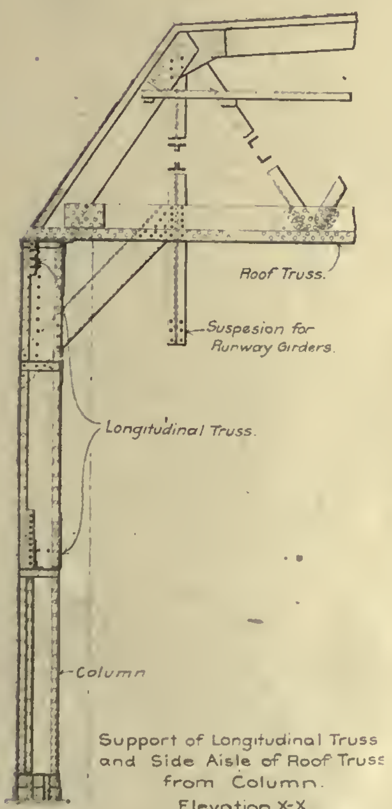
Support of Roof Trusses from Longitudinal Truss.

THE ENGINEERING RECORD.

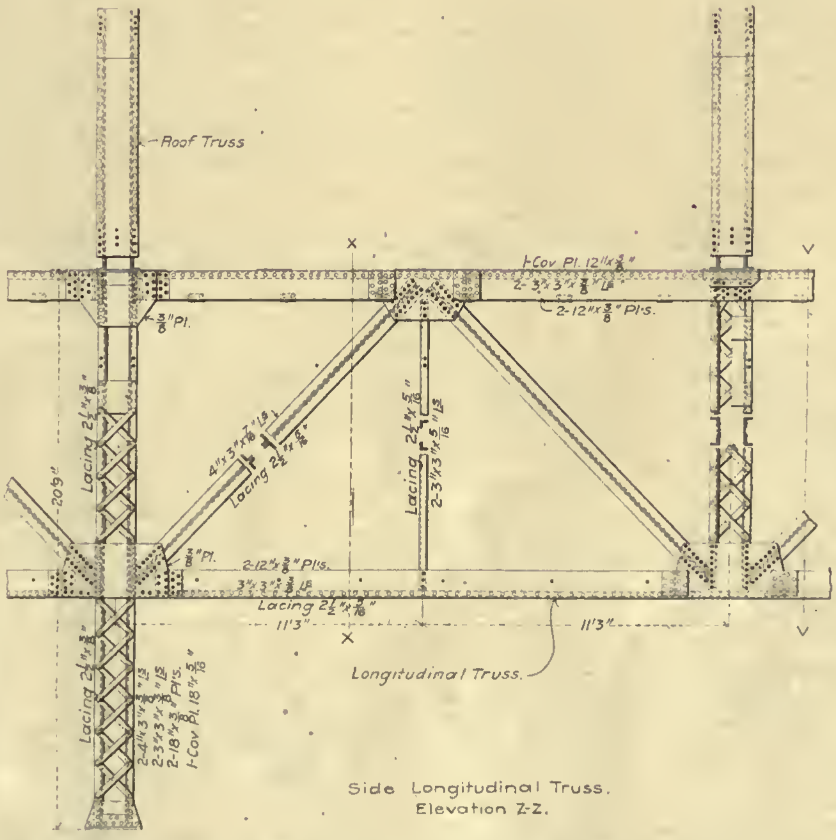


Interior Column in Eyebar Shop.

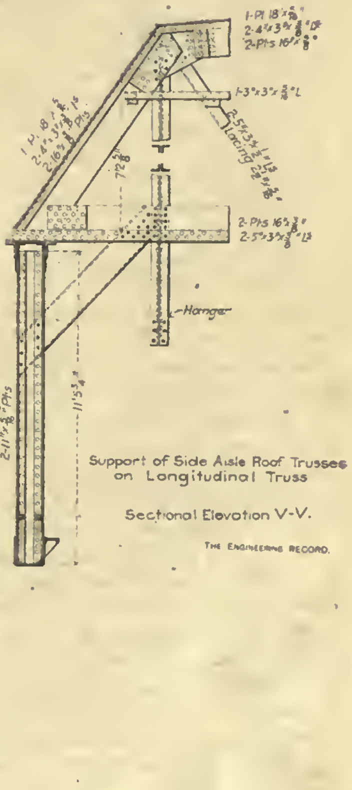
THE ENGINEERING RECORD



Support of Longitudinal Truss and Side Aisle of Roof Truss from Column. Elevation X-X



Side Longitudinal Truss. Elevation Z-Z.



Support of Side Aisle Roof Trusses on Longitudinal Truss

Sectional Elevation V-V.

THE ENGINEERING RECORD.

TRUSS AND COLUMN DETAILS IN THE EYE-BAR SHOP, AMBRIDGE PLANT OF THE AMERICAN BRIDGE COMPANY.

The Marietta Long-Span Highway Bridge.

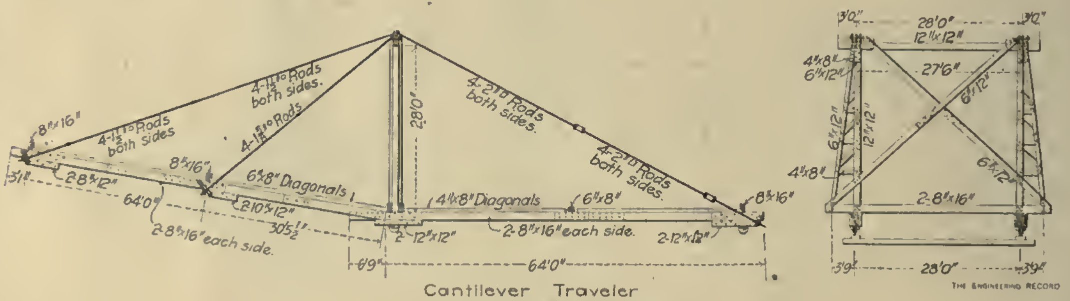
Part III.—Falsework, Travelers and Erection.

The 130-foot and the 600-foot anchorage spans and the two 220-foot spans were erected on false works of the ordinary construction, with a vertical bent under each panel point. For all except the first 220-foot span the lower story of each bent was formed by driving 35-foot piles to a depth of about 10 feet. The parts of the piles extending above the ground were braced with 4x12-inch timbers and capped with a 12x12-inch transverse beam. Under the first 220-foot span the piles were not driven into the ground, but were seated on 12x12-inch mud sills, each long enough to receive two piles. Nine piles were used under each bent for the 600-foot span, and five for each bent under the other spans. Above the piling the falsework bents were each composed of from one to three vertical panels, each braced transversely by four diagonal timbers and seated on a 12x12-inch horizontal tie or cap. The cap on top of the upper panel was also a 12x12-inch timber. There were in each bent five 12x12-inch vertical timbers, two under each truss and one in the middle, besides two outside posts battered 1:6, which took bearing on the top cap directly under the traveler track. Under the 600-foot span there were, above the piles, three vertical panels or stories of falsework, each 21 feet high, except the first one at the lower end, which was 17 feet high. Fifteen lines of 8x12-inch horizontal longitudinal timbers, five lines at each story, extended the entire length of the span. On top of the top caps were five lines of 12x12-inch longitudinal timbers. At intervals, leaving two or three open spaces, the bents were braced together longitudinally with diagonal timbers, forming towers. Under the 600-foot span were five towers each 60 feet or two panels long.

All the 12x12-inch and 8x12-inch timbers were white oak and were afterwards sawed up and used in the bridge for flooring, raising blocks or ties. The timbers which were afterwards used for the 14-inch roadway joists were first used without cutting for all diagonal bracing in the falsework. The connections for the vertical posts and cross ties or caps were made with 3x½-inch steel scabs about 2½ feet long, placed on opposite sides of the posts, and had holes for three ⅞-inch bolts to connect them. All holes, except one in each scab, were slotted 15/16x1¾ inches to allow for slight inaccuracies in boring the timbers. The 14-inch diagonal timbers were connected by ⅞-inch bolts, without scabs, and were bored only on the center line so that their strength as joists was not impaired. The 220-foot spans were erected first and the main part of the falsework used under them was removed and used under the 600-foot span or the 130-foot span without refitting. The traveler runs were set 36 feet apart on the falsework and supported on 20-inch and 24-inch I-beams borrowed from the permanent stringers of the roadway, and from the contractor's stock. Two I-beams under each run carried 6x6-inch cross ties about 3 feet long for the traveler rails. The 650-foot span was erected without falsework by simultaneously building out, as cantilevers, the arms from piers No. 2 and 3 until they met at the center of the 270-foot span. A track for bringing material forward on the bridge was provided from the material for the street railway track.

The plate girder approach was erected without false works by an overhead platform traveler with two 60-foot 10-ton booms. The 220-foot spans were erected by a three-bent outside traveler of the ordinary type, which was 36 feet long and about 55 feet high. It had an inside clearance 40 feet high and 35 feet wide, was built entirely of timber, rolled on six double-flange wheels, and with engine and tackle complete did not weigh more than 60,000 pounds. The travelers used for erecting the 130-foot span and the 600-foot span were similar in design, but larger, in proportion to the work they handled. The one used for the 600-foot span was 60 feet long and more than 100 feet high, with an inside clearance sufficient to cover the truss at the highest point.

The 300-foot cantilever arm was erected by an overhead traveler 128 feet in extreme length and about 30 feet high at the center post. It rolled on four double-flanged wheels on two rails 28 feet apart, laid on the top chords of the trusses. This traveler had two fixed booms 64 feet long with a capacity of about 85,000 pounds each, and was used also for the erection of the adjacent half of the suspended span. It was of simple construction, all wood except the adjustable steel guy rods from the top of the center posts to the booms and to the anchorage. At the tops of the vertical center posts the steel rods were pin-connected to riveted shoes which took bearing on the ends of the timbers. At the lower ends the rods had nuts bearing on angle seats connected to the lower chords. The lower chords were made double and spliced with inside packing blocks. The two trusses of the traveler were connected by five transverse struts bolted across the tops of the lower chords and by a diagonal cross bracing of 4x8-inch timbers in each of the four panels thus formed. The two vertical posts were braced together with a 12x12-inch top strut and two 6x12-inch diagonal timbers. The traveler while moving was counterweighted with a 12-ton dead load, and while lifting was anchored to the top chord of the bridge for an upward reaction of 26 tons on each truss. The estimated weight of the traveler was about 59,000 pounds, and its rigging did not exceed 10,000 pounds. The hoisting engine was not carried on the traveler, but was permanently seated on the pier. Where the top chord of the bridge was composed of eyebars 10x10-inch cross timbers about 3 feet apart were usually laid on them and on top of these a solid beam 16 inches wide and 2 feet deep was built of three 8x16-inch timbers bolted together to receive the rails of the traveler track. In some panels two 24-inch I-beams supported on the bars only at the ends about 2 feet from the pier center, were used instead of the wooden beams.



Traveler for Erecting the Marietta Highway Bridge.

The traveler used to erect the 80-foot cantilever arm and adjacent half of the suspended span was similar to the one just described, but somewhat smaller, being only 100 feet long over all and about 27 feet high. It was proportioned for correspondingly smaller live loads and weighed about 52,000 pounds.

The erection of the 650-foot span was very carefully planned in advance, and complete instructions and drawings were furnished to the erector. The erection diagram for the trusses was marked with reference letters corresponding to the successive positions of the traveler, and each member of the truss had a corresponding reference letter indicating at what position of the traveler it was to be assembled. The members were also marked 1 or 2 to indicate whether they were to be assembled at the first or second lift. At the panel points in the diagram the members were P or B to show whether they were connected by pins or bolts.

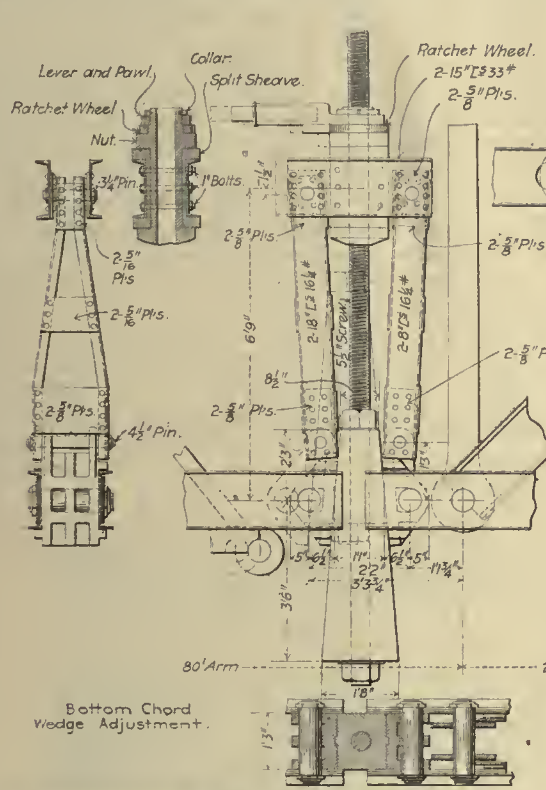
The adjustment necessary for the final connection of the two cantilever portions was made with eight vertical wedges, one in each chord of each truss where the 270-foot span joins the cantilever arm. During erection the wedges were inserted in the top chord in the panel where the slotted eyebars, as previously mentioned, were placed in the permanent structure, thus enabling the top chord to carry continuous tension at that time. The wedges were inserted in the bottom chord between the 270-foot span and the cantilever arm, thus allowing compression to pass through that point. The wedges were of cast-iron 5 feet 9 inches long, 1 foot 2¾ inches wide, about 8½ inches thick at the point and provided for a maximum displacement of about 10 inches. They took bearing on the sides against cast-steel guide blocks which had planed bearing surfaces 2 feet long, the same width as the wedge, and were pin-connected to the trusses. A tongue on the guide block moved in a groove in the wedge to guide it vertically. Each wedge was set entirely driven so that the force required to move it would be only that necessary to withdraw it. The wedges were operated by means of nuts and screws.

In order to operate the wedges it was necessary to have adjustable laterals in the panels where they were located. To take care of the lateral stress, in the bottom chord, from the 270-foot span during erection, the end floor-beam and the bottom laterals from the cantilever arm were omitted, and diagonal rods meeting at the center of the end floor-beams on the 270-foot span were inserted. These rods were 2¾ inches square and had turnbuckle adjustments. Where the floor-beam was omitted a wooden strut was inserted and wire cables used to hold the ends of the bottom chord of the cantilever in place laterally. Wire cables were also used for top laterals in the adjustment panel during erection. There are no top laterals in this panel in the permanent structure. After final connection was made at the center of the 270-foot span the wedges were taken out and the permanent members inserted, leaving the suspended span free to move longitudinally, but anchored laterally as described.

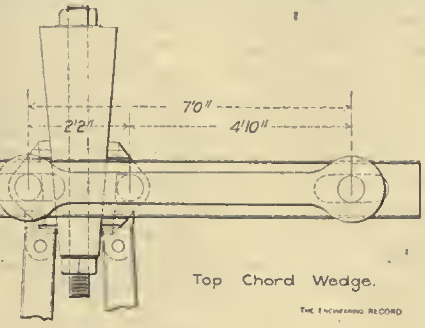
In the 300-foot cantilever arm temporary diagonal erection struts of 12x12-inch timber were placed in the third, fifth, and seventh panels from the pier. In the upper half of the first panel, at either end of the 270-foot span, two temporary tie rods 1¾ inches in diameter were used during erection to support the overhead traveler at that point.

The erector was instructed to set the wedges so that the wide ends were flush with the ends of the shoe plates and to set the bridge shoes at the main piers with corrections for normal temperature of 60 degrees; he was also instructed when making the final adjustments to first bring the ends of adjacent halves of the suspended span opposite each other horizontally, then to make the bottom chord connections and finally to release the wedges until top chord and diagonal connections were made and the span swung free. He was furnished with a table of computations for the operation of the wedges which showed the distances which certain chords moved horizontally and vertically when the wedges were drawn to given positions; it showed the corresponding relative positions of the center pins and their distances apart; it showed how much the top and bottom chords were lengthened or shortened, raised or lowered, and also gave the variations in position due to the changes in temperature.

The erection of the 220-foot spans was commenced in the latter part of July, 1902. The 600-foot span was erected next, but, owing to delay caused by the abandonment of the work by the sub-contractor for the erection, the last pin of this span was not driven until December 28, 1902. Prior to this, high water in the river had proved very troublesome, and the false works were at times in considerable danger from drift and ice. As a precaution against an emergency of this kind, the 600-foot span had been proportioned so that it would carry itself as a disconnected span without the relieving stresses from the cantilever arm, and as soon as the last pin was driven in this span the

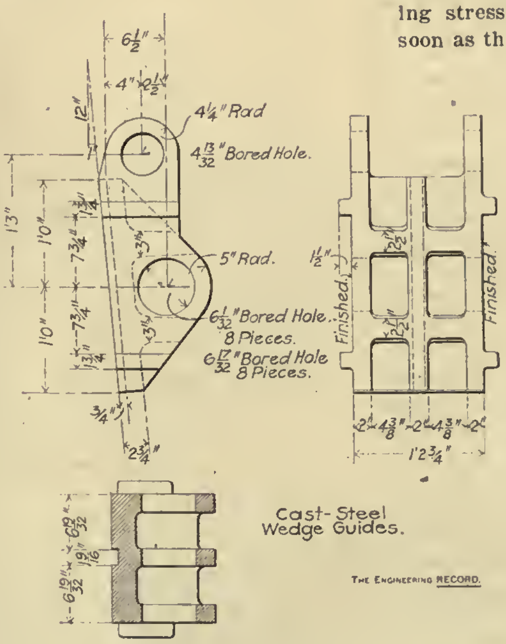


Bottom Chord Wedge Adjustment.



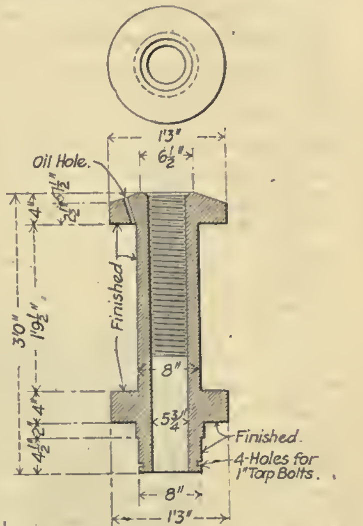
Top Chord Wedge.

The Engineering Record



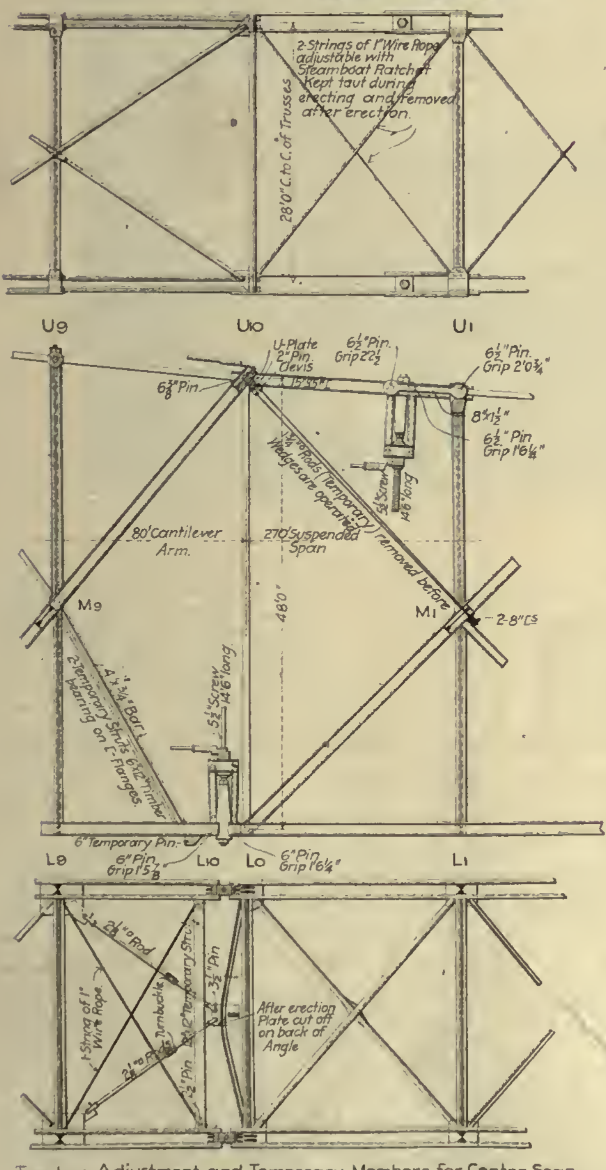
Cast-Steel Wedge Guides.

The Engineering Record



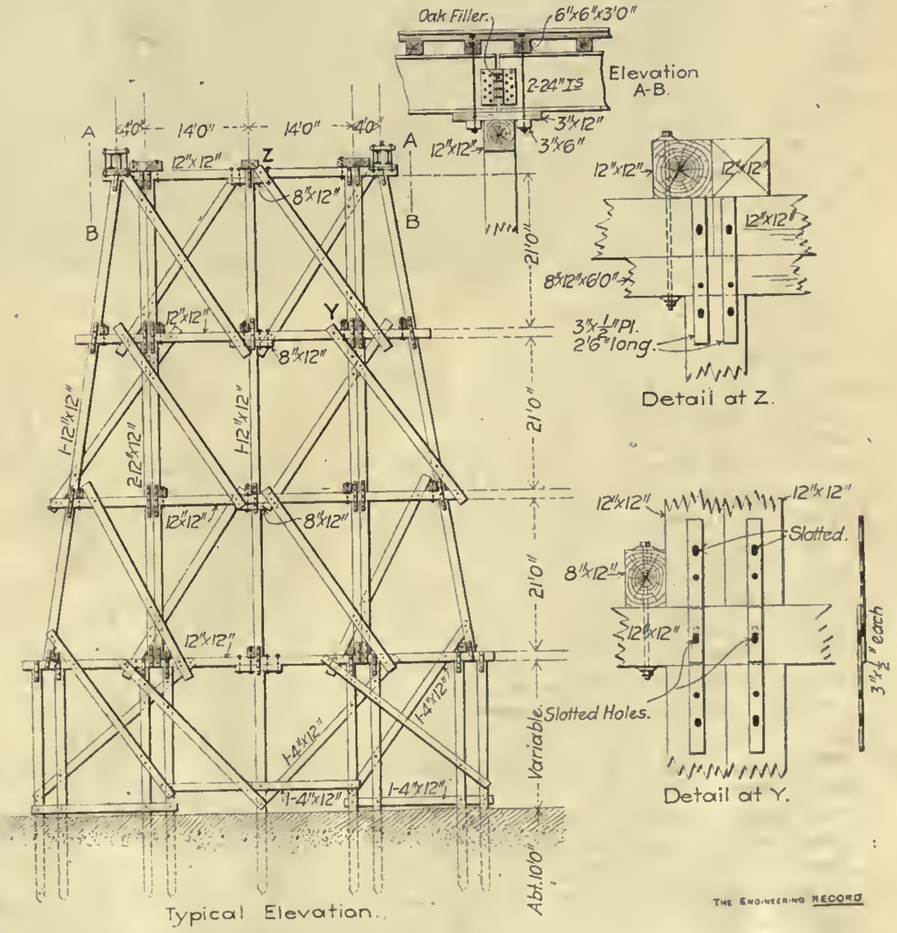
Cast-Iron Nut for Wedge Screw

The Engineering Record



Erection Adjustment and Temporary Members for Center Span.

The Engineering Record



Typical Elevation.

Falsework with Steel Scabs.

The Engineering Record

MARIETTA HIGHWAY BRIDGE: ERECTION PLANT FOR CANTILEVER SPAN AND MAIN FALSEWORK.

removal of the false works was begun. In March and April there was further delay to progress from labor troubles, and the two projecting arms of the 650-foot cantilever span were not connected until June 18, 1903. The bridge was thrown open to traffic on August 21, 1903, and the first electric railway car crossed on the following day.

Mr. C. L. Strobel, M. Am. Soc. C. E., was the consulting engineer and designer of the bridge; and the contractor for the steel superstructure was the American Bridge Company of New York, Mr. Paul L. Woelfel, M. Am. Soc. C. E., chief engineer of design; Mr. S. P. Mitchell, chief engineer of erection; Mr. H. A. Greene, Assoc. M. Am. Soc. C. E., erecting manager in charge of the work. The false work and the wood work of the floor were put in place by day labor.

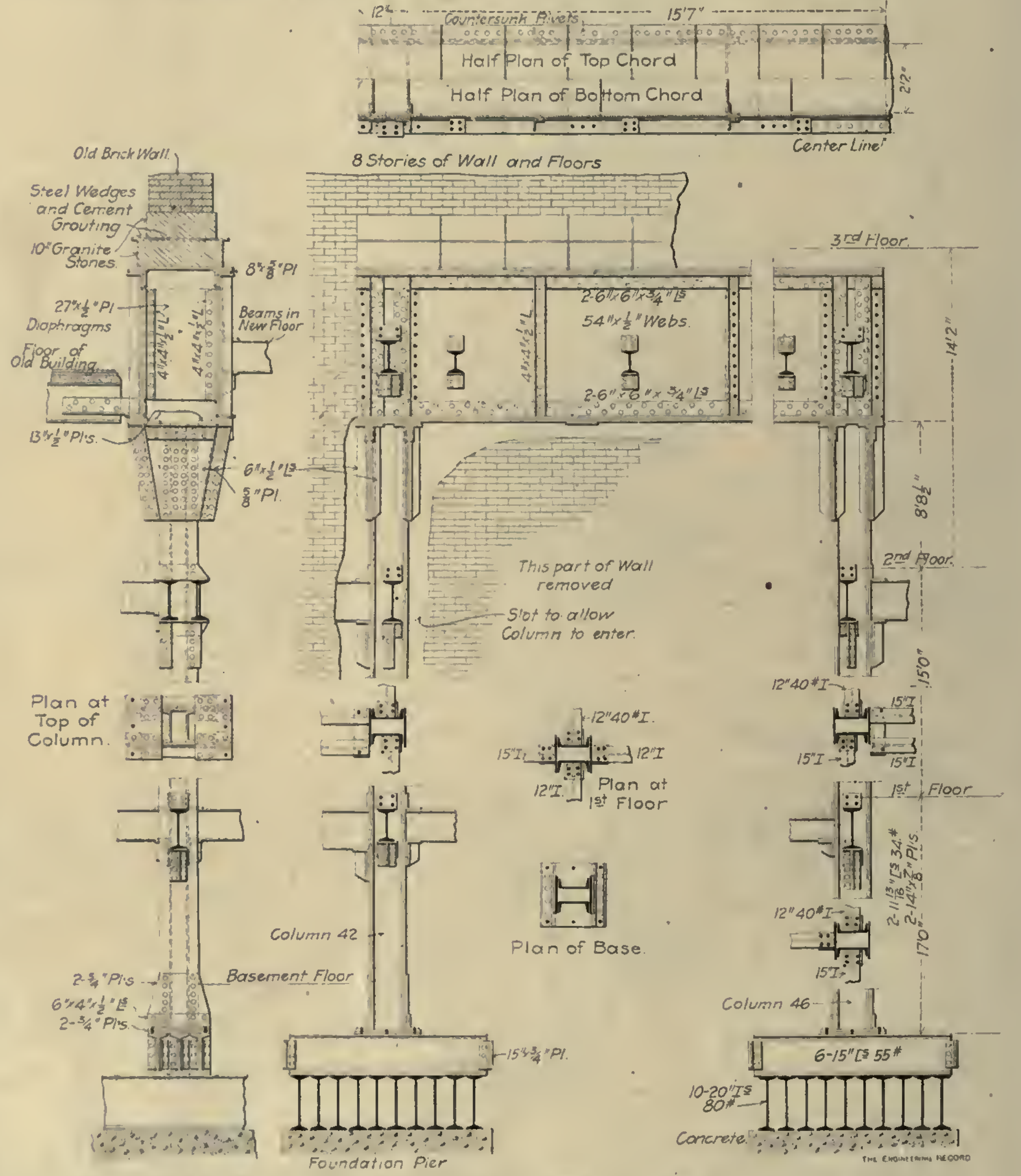
Supporting an Old Wall from a New Building.

The Imperial Hotel, on Broadway between Thirty-first and Thirty-second streets, New York, consists of two portions, one of which is ten stories high and was built several years ago. The other part is seventeen stories high above the basement and is built on a 90x80-foot lot recently acquired adjacent to the old part of the building. In the old building the brick exterior walls carried the ends of the floor-beams. The new building is of steel-cage construction and the walls are thin curtains supported by the columns at every story. It was desired to retain the wall between the old and new parts of the building, but to provide unobstructed communication and to make rooms continuous through both parts in the lower stories, it was determined to remove a portion of the wall about 30 feet long from the basement to the third floor. In order to do this, special provision was made for carrying the upper stories of this part of the wall and their portion of the floor loads on a deep box girder supported on the tops of two wall columns forming part of the regular framework of the new structure. Placing these columns and girder in position and transferring the load of the old building to them was a difficult and delicate piece of work successfully accomplished by the careful and ingenious operations here described.

Two vertical slots about 30 inches wide were cut entirely through the wall from the basement to a point about half-way between the second and third floors on the center lines of columns No. 42 and 46, which were to carry the upper part of the wall. These columns were seated on sets of distributing and cantilever girders with I-beam grillages and concrete piers carried down to the solid rock. The columns are about 46 feet long, shop-riveted in single sections with reinforced angle brackets on the face and one side of each to receive the floor and wall beams of the new building. At the top of each column wide gusset plates were riveted across both flanges and their projecting edges were stiffened with pairs of flange angles to provide reinforcement for the girder seats on the cap plates. These seats were about 28 inches apart on centers and were just clear of the wall on opposite sides. On them were seated the two separate halves of the main girder, each of them having a 54x½-inch web plate 33 feet 2 inches long.

Each flange consisted of two 6x6x¾-inch angles and one 8x⅝-inch cover plate. The angles were both riveted to the web plate with their horizontal flanges in the same direction, so that one angle had the back and the other the front of its vertical flange riveted to the web plate, and their horizontal flanges were in contact. This arrangement provided a normal flange area and left no projection on the back of the web except the thickness of one angle. The girder webs were thus enabled to be set close to the wall and were temporarily fastened together by horizontal connection bolts in holes drilled through the brick work. They were flange-bolted to the seats on the column caps and the construction of the framework of the new part of the building was continued in the ordinary way. The third floor beams of the new part were supported on seats riveted to the face of the box-girder. The old third floor beams were temporarily supported on shores, and short pieces were cut off from their ends so that they would clear that half of the box-girder which was seated in the old part of the building. Permanent bearings for the cut ends of the old floor-beams were then secured by riveting to their web pairs of 6x6-inch horizontal cantilever angles which projected far enough for their lower flanges to take bearing on the tops of the lower flange angles of the wall girder, as indicated in the cross-section.

Meantime holes 2 feet wide, about 21 inches high and 2 feet apart in the clear were cut entirely through the brickwork just above the top flanges of the girders. In each of these holes a pair of cut granite stones 10 inches thick were set with thin steel wedges between them. The upper stones were about 1 inch wider than the 2-foot wall and the lower stones were about 34 inches wide and rested on transverse ½-inch steel plates 2 feet long which were laid across the top flanges of the half girders, and riveted fast to the chord angles. The wedges were driven until they took up a large part of the weight of the wall and then the brickwork intervening between the 2-foot holes was cut out and the spaces were filled with corresponding pairs of blocks which, with the first ones, covered the full length of the girder. The wedges were adjusted until the bearing was substantially equal on all the stones and the support of the wall was completed. The wall under and between the girders and between the columns was then removed and the brickwork carefully filled in between the other sides of the columns and the wall. The webs of the girders were then connected by transverse vertical diaphragms field-riveted in place. The girders carry eight stories of wall and floor load having a calculated weight of 315 tons.



Imperial Hotel, New York: Columns and Girders in New Building for Supporting Old Wall.

Messrs. Warren & Wetmore were the architects of the building and Mr. F. A. Burdett consulting engineer. Mr. H. H. Forsyth was in charge of the shop detailing and designing of the steel work for which the J. B. & J. M. Cornell Company were sub-contractors, Messrs. M. Reid & Company being the general contractors.

THE NEW ENGLAND WATER WORKS ASSOCIATION held its annual meeting at Boston on Wednesday with an attendance of ninety-five. The secretary reported the membership to be 586, one less than a year ago. The editor reported that a card index of all articles published in the "Journal" up to the end of 1902 had been prepared and would probably be printed during the year.

Types and Details of Bridge Construction—XVIII.

By Frank W. Skinner, C. E.

Plate Girder Arches (Concluded.)

A foot bridge which was built across the Seine at Paris, to afford access to the exposition of 1900, is about 394 feet in total length by 26 feet in clear width, and about 27 feet in clear height. It was described in The Engineering Record of July 14, 1900. It has a center span of 246 feet and two side spans of nearly 74 feet each, and combines arch and cantilever principles in a very curious and unusual manner. The main span consists of a two-hinge steel arch whose two ribs are box girders at the ends, and lattice girders in the middle, built up of plates and angles, having a uniform width of 27½ inches and a depth varying from 3 to 6½ feet. Both intrados and extrados are concentric parabolic curves, the former having a rise of 46 feet. Between the haunches the lattice girder floor-beams are pin-connected to the lower ends of stiff vertical suspenders from the arch ribs. The ten middle pairs of verticals are braced together at the top by curved portal frames. Beyond the haunches the floor is a deck supported on vertical columns seated on the arch ribs, and braced together transversely by horizontal struts and X-bracing. All connections are riveted, and the ends of the ribs are flange bolted to cast-steel shoes which have rocker bearings on the 10-inch pedestal pins.

The side spans resemble segmental semi-arches corresponding to the center arch, hinged to the main skewback pins and supported at the opposite ends on the tops of vertical rocker posts. In reality, under dead load alone, the rocker posts are in tension, and the thrust at the shore end of one side span, balances the thrust of the other side span, and the two are tied together by the floor stringers acting in tension from end to end of the bridge, making with the semi-arches a separate system in equilibrium. The bridge was proportioned for a live load of 548 pounds per linear foot. Its end spans were erected on falsework, and the center span was erected from both ends simultaneously by the cantilever method.

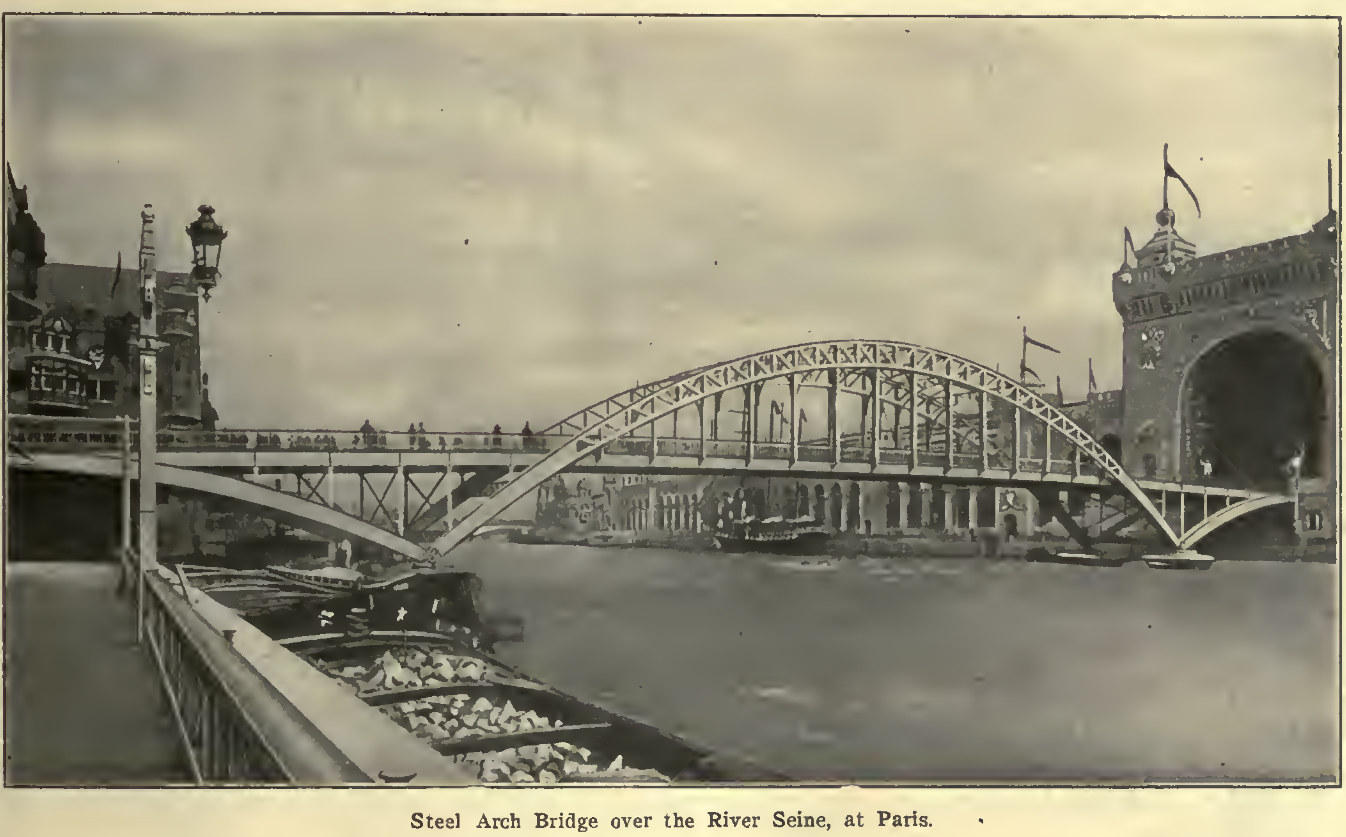
The Alexander III. highway bridge across the Seine, at the exposition grounds, Paris, is the largest and most important cast-steel arch span in the world. It is interesting on account of its magnitude, for the very flat curve of the arch, for the adjustments of the crown segments, for the great amount of ornamental work and the architectural beauty of the structure, for the methods of manufacture of the cast-steel segments and for the very elaborate and unusual method of erection. The bridge is skewed 6 degrees and 22 minutes and has a width of 131 feet. It carries the full width of the street and sidewalks without obstructing the vista, and having the standard pavement and heavy parapets with ornamental lamp posts at every panel appears from the street like a special promenade rather than a bridge. The 67-foot roadway has a 2 per cent. grade to the center, about 32 feet above water level, and is slightly crowned transversely; the two 32-foot sidewalks are pitched sharply to the center gutters.

Each end is flanked by a pair of masonry towers rising about 75 feet above the pavement and ornamented with sculpture and statuary. The roadway is carried across the wide low abutment piers on plate girder approaches, enclosed in ornamental masonry with curtain walls in which there are archways for the low-level intersecting streets and passages. The embankments are retained by long and handsome wing walls parallel with the river on the shore edges of terraces, from which there are entrance stairways to the ends of the span. The skewbacks are about at lower street grade and the face walls of the abutments above them are pierced with ornamental arches of about 9 feet span. The faces of the arch ribs and the roadway platform are masked with cast-iron plates enriched with mouldings, sculpture and elaborate ornamentation.

The rise of the arch is only about 1/17 of the span, so that the thrust developed causes a maximum reaction of about 850 tons, making a very small angle with the horizontal at each skewback pedestal. To resist this the concrete and masonry abutment piers were built on the largest (110x144-foot) steel pneumatic caissons ever made. They were assembled in position on the river banks with their outer edges supported on piles, and were sunk to a sandy stratum about 26 feet below ordinary water level. They were filled with concrete having transverse grooves in the upper surface to bond with the upper part of the piers and afford resistance to the horizontal thrust.

There are fifteen cast-steel plate girder ribs, 5.56 feet apart on centers, which are segments of a circle of 802 feet radius. Each rib is a three-hinge arch of 353 feet span, and 20½ feet rise of intrados. The skewback pins are set in pedestals which project from the face of the abutments so as to increase the span to 358 feet. Each rib has a minimum depth of about 34 inches at the crown and a maximum depth of about 60 inches at the haunches and is cast in 32 segments of an average length of about 12 feet and a weight of from three to four tons. The outside ribs have a channel-shaped cross-section with the web convex outwards. The other ribs have I-shaped cross-sections; all the webs are vertical and each section has, on both sides and both ends, a flange about 2 feet wide, which is strengthened by transverse webs. All metal is 2 inches or more in thickness. The hinge pins are about 8 inches in diameter, and have semi-cylindrical bearings in the crown and end segments, which have tapered flanges converging towards their centers and are reinforced by center ribs.

The faces of the radial flanges at the ends of the arch segments were countersunk so as to have bearings only on the webs and around the edges, and they were drilled for twelve 1¼-inch connection bolts. Inclined seats were cast on the top flanges and have four holes drilled in each to receive the connection bolts through the bases of the vertical spandrel posts. The seats on the top flanges of the pedestals are horizontal and have spherical sockets without bolt holes to receive the convex centers of the end post bases. All the segment joints have full bearings, except those between the crown segments and the adjacent ones, which have bearing only in the plane of the web and have the end flanges beveled on both sides of the center vertical lines so as to give horizontal clearances of about 0.6 inch for transverse movement of the crown pins.



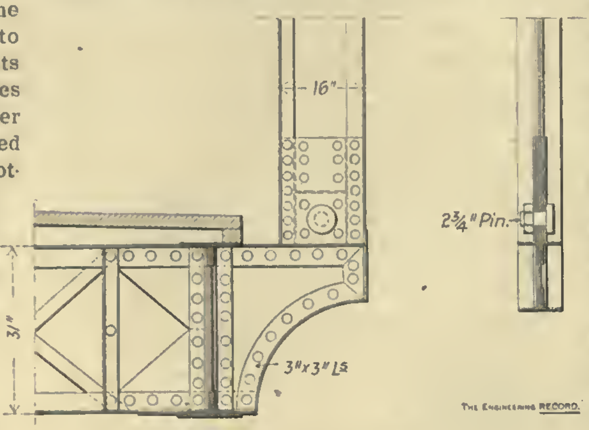
Steel Arch Bridge over the River Seine, at Paris.

The pedestals for the outer ribs are in two pieces, bolted together through longitudinal vertical webs. All have horizontal and nearly vertical masonry seats on the lower edge and base respectively and carry the skewback pins out nearly 3 feet clear of the abutment copings. The arch ribs have no direct lateral or sway bracing except for the center half of the span, where the floor system is connected to them. Over the haunches the spandrel posts have a transverse web and four flange angles with their flanges turned in, except on the outer ribs, where they are of cast-iron with moulded faces. The spandrel posts have top and bottom horizontal transverse struts made with pairs of channels latticed, between which there are X-braces made of pairs of angles riveted together back to back and having their flanges turned in opposite directions to clear at intersections.

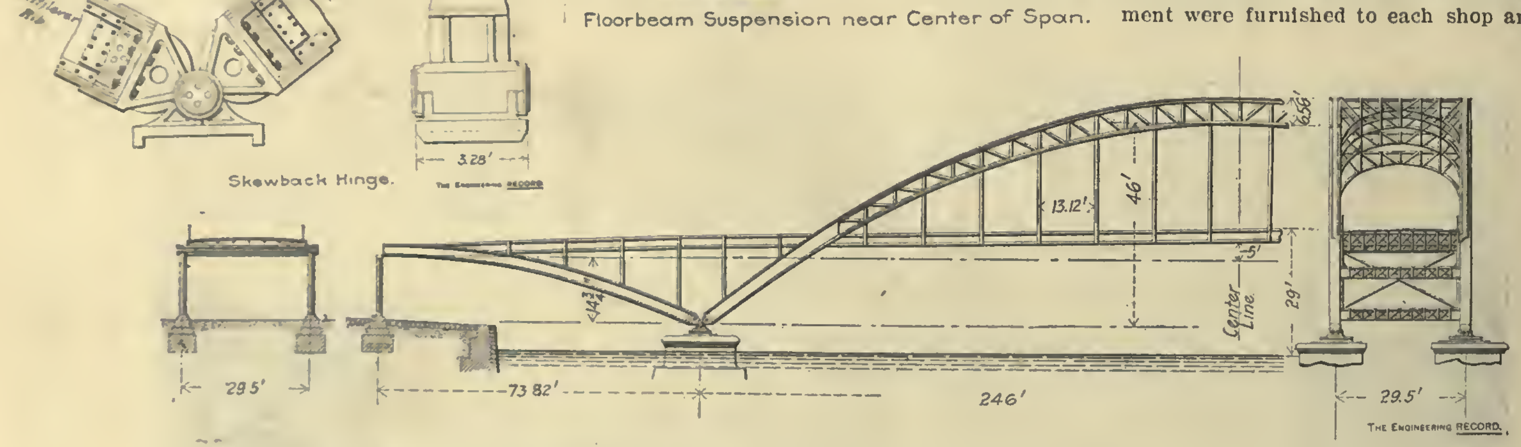
The roadway pavement is laid on flat steel plates, stiffened with channel bars riveted to the under side, supported on transverse plate girder floor-beams 5½ feet long, web-connected to longitudinal girders supported by vertical spandrel posts seated on the top flanges of the arch ribs, about 12 feet apart, from the haunches to the skewbacks. In the center of the span the lower edges of the girders are beveled to fit the top flanges of the ribs on which they are seated.

The bridge is proportioned for a dead load of 332,859 pounds for each semi-arch rib, and for a live load of 82 pounds per square foot. The arch ribs have been proportioned for maximum tension stresses of 12,800 pounds and 14,200 pounds per square inch, for dead and live loads respectively. The maximum compression in the top flanges under ordinary loads is 13,640 pounds, and for dead load only is 9,280 pounds per square inch. Under the most unfavorable loads the maximum stresses are 22,670 pounds and 21,230 pounds, and in the bottom and top flanges respectively of the thirteenth segment from the skewback, and under the most favorable conditions the corresponding minimum stresses are 2,582 pounds and 4,000 pounds. For a temperature variation of 26 degrees centigrade, the arch thrust is increased or diminished about 2.2 per cent. and the crown rises or falls 0.2 inch for each degree. Under full live load the skewback pressures are 2,004,060 pounds for each pedestal, which gives pressures of 7,850 pounds per square inch on the pin, and 98,300 pounds and 25,600 pounds per square foot on the granite seats and on the pier masonry respectively. The deflection at the crown under dead load is 5½ inches and under full live load is 8.1 inches. Tension tests of the steel in the arch ribs showed a maximum elastic limit and ultimate strength per square inch of about 51,000 and 93,000 pounds respectively.

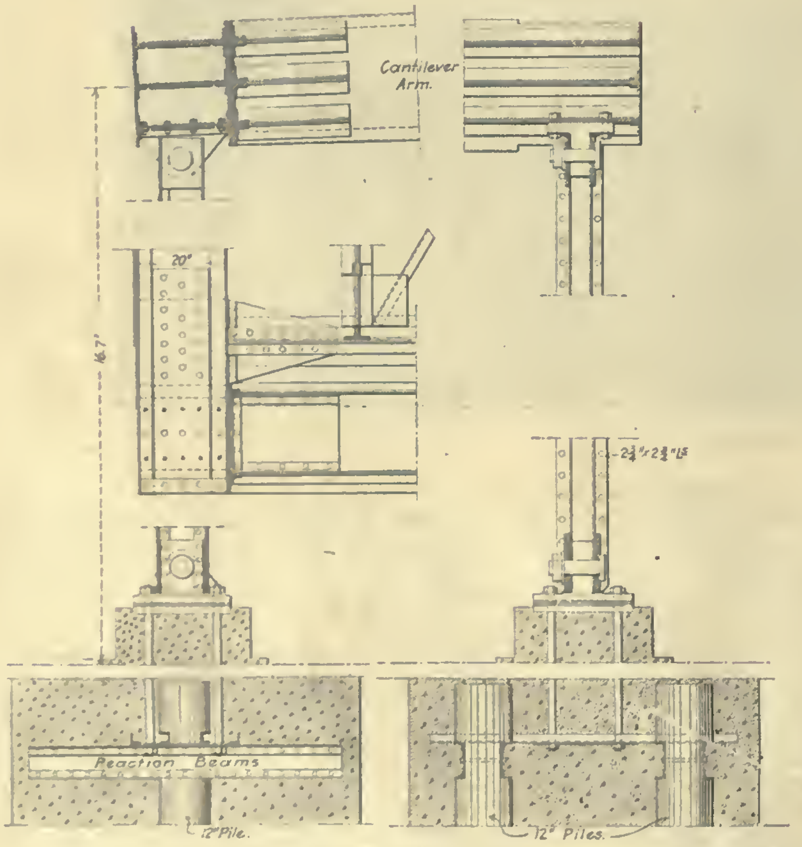
The contracts for casting the arches were awarded to five different firms, each of whom made from two to five ribs, all performing the work by different methods, under the same general supervision. Full size drawings of each segment were furnished to each shop and wooden patterns were made of each segment in the intermediate semi-arch ribs, and of all the segments in the outside arch ribs. They were moulded with the webs horizontal and the cores were made of coke with a coating of sand and an iron skeleton. The moulds were baked for 36 hours at a temperature of about 300 degrees centigrade, and were surfaced with clay and graphite. The moulds were inclined somewhat



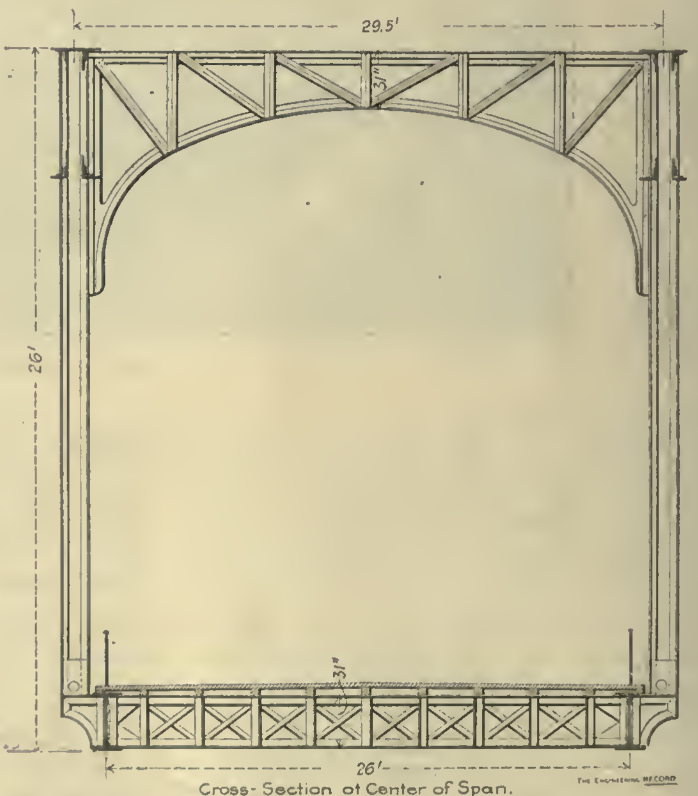
Floorbeam Suspension near Center of Span.



Skewback Hinge.



Rocker Bent and Anchorage.



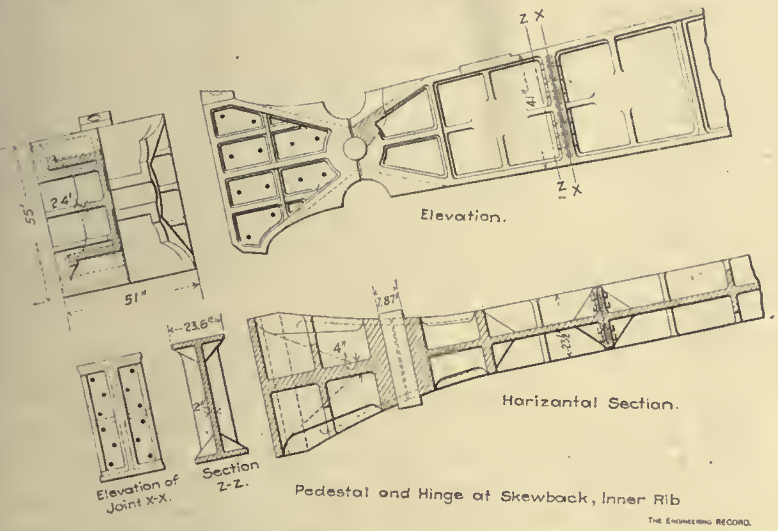
Cross-Section at Center of Span.

Some Details of the Steel Arch Bridge over the River Seine, at Paris.

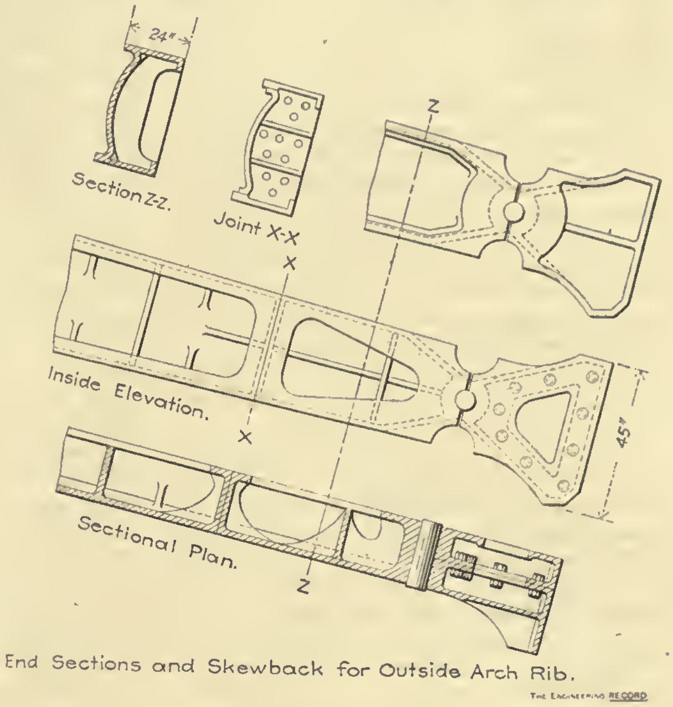
from the horizontal when poured and various devices were resorted to to secure free shrinkage, for which 1.8 per cent. was allowed, and to avoid cracks.

In one shop the metal was poured fast at first and then slowly. In another shop the flasks were loosened in 15 minutes after they were poured. In the other shops the castings remained in the moulds from one to five days. In one shop the castings were annealed by heating to 1,000 degrees centigrade in 30 hours, maintaining that temperature for 6 hours and then cooling them for 62 hours. In another shop the heating was about the same, but the cooling to 600 degrees was made in 12 hours in a hermetically sealed furnace and from 600 degrees to normal in 12 hours in an open furnace. In another shop the temperature was raised to 900 degrees in 40 hours and then suddenly lowered to 600 degrees by opening the furnace. The furnace was then sealed and the casting allowed to cool gradually for about 45 hours. At another works after a preliminary annealing the temperature was raised in 12 hours to 1,000 degrees and maintained there for 2 hours, then quickly reduced to 700 degrees, the furnace sealed and cooling slowly continued for 12 or 14 hours.

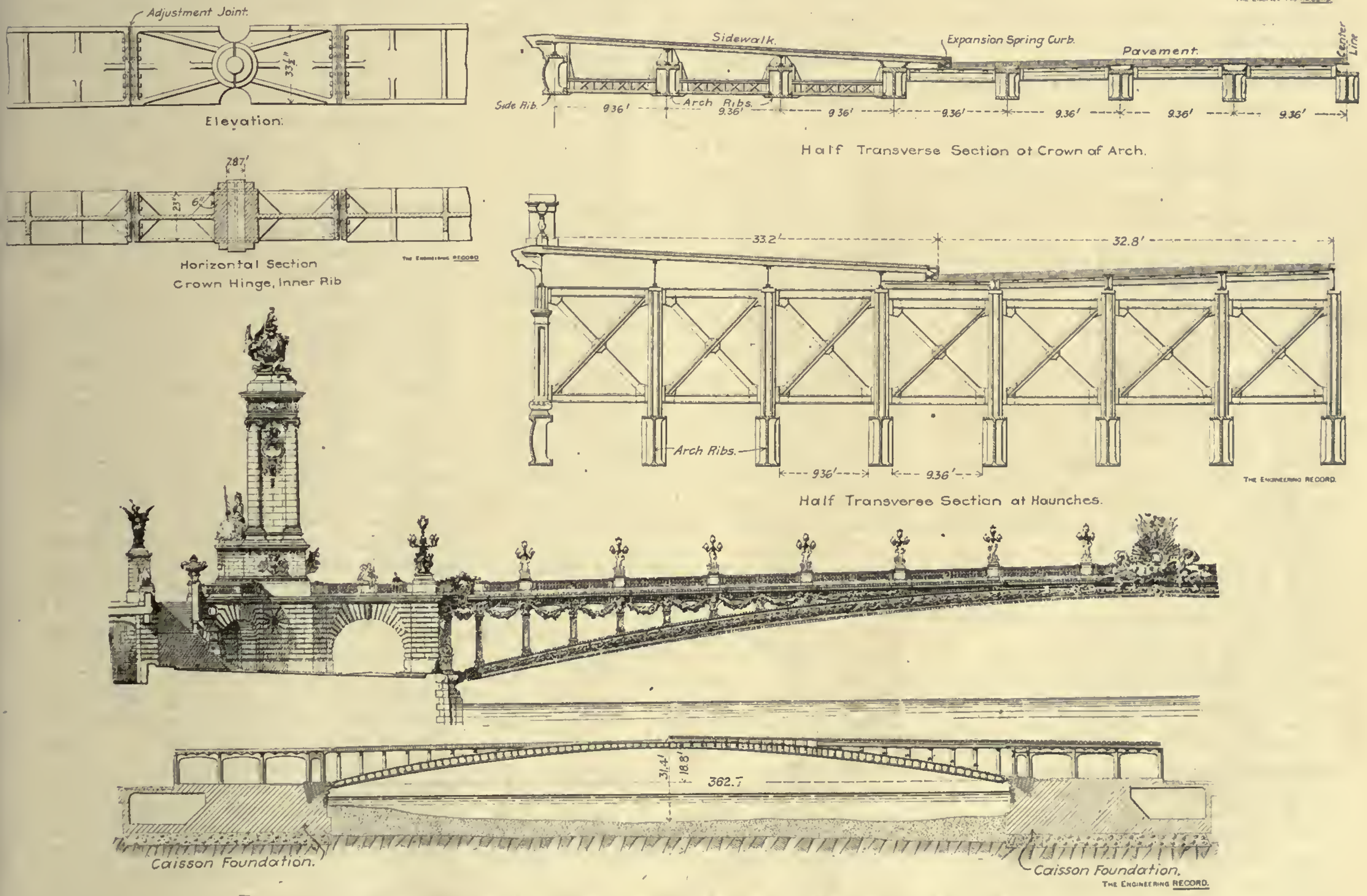
The castings were roughly dressed after annealing, marked by templates and gauges, the bearing surfaces planed and sometimes ground and then they were assembled on special platforms and the splice bolt holes accurately bored. As it required about two months to replace a segment and as the erection had to be done as rapidly as possible special precautions were taken at the shops to have the pieces perfect and the joints accurately fitted so as to avoid danger of delay in the field. In one of the shops the segments were assembled on a concrete floor covered with iron plates, on which the outlines of the semi-arch were accurately marked. At another shop a heavy timber deck was built with iron plates at connection points and iron channels set in its surface at the lines of the neutral axis of its chord and of the top and bottom flanges, and on them the diagram of the rib was marked. At another shop the segments were supported at the joints



Pedestal and Hinge at Skewback, Inner Rib



End Sections and Skewback for Outside Arch Rib.



Alexander III. Bridge at Paris: Longitudinal Section, Half Elevation and Details.

on marble pedestals shimmed up level on planed rails, thus raising the segments so that the under sides of the outside ribs were accessible.

In erection the arch ribs were assembled in pairs on a curved platform suspended from a movable falsework bridge in the center of the channel and supported on towers and trestle bents at the sides. The movable falsework bridge had two lattice girder steel trusses 364 feet long, 24.6 feet deep and 18.7 feet apart on centers, which projected about 21 feet beyond each end of the arch span and were supported on steel towers about 25 feet high which rolled on transverse tracks on the river banks. The bridge was erected on shore in short sections which were successively connected and launched across the channel by protrusion, with a 50-foot pilot. The falsework trusses were intermediately supported at two points 174 feet apart, by pile piers in the middle of the channel.

The bridge carried between the trusses two trolley tracks, 9.36 feet apart. On each track two trolleys traveled from end to end of the trusses and received the arch segments from transverse surface tracks on the banks and delivered them to the required position on the falsework platform. The trolleys were traversed by endless chains, which, with their hoisting tackles, were operated by steam engines seated on cantilever platforms at the ends of the trusses. After erecting two arch ribs the movable bridge was moved 18.7 feet and erected the next pair of ribs, and so on. The arch segments were lifted by two pairs of hook-bolt clamps engaging the top flanges. The clamps were attached to the ends of a yoke, about 4 feet long, which had a pivoted connection to the hoisting tackle. This connection was movable along the yoke and its position was adjusted by a screw rod and ratchet, by which it could be varied to secure the exact inclination required for the different segments.

One day was required to place the four skewback pedestals and two days to assemble the remaining segments of one pair of ribs. The radial segment joints were very carefully cleaned and greased and the segments were tilted by the screw adjustment on the suspension yoke until they were exactly parallel to their required position and gradually lowered to place with the shore end sliding smoothly down in contact with the end of the last segment placed. When the flange holes matched two drift pins were inserted, the splice bolts put in place and pairs of camber wedges driven gently under the bottom flange near the ends of the segment.

After all the segments were assembled and aligned the end segments were blocked away from the pier masonry so as to relieve the skewback pedestals of nearly all pressure, and the joint between the bases of the pedestals and the granite seats were grouted. Measurements were made, temperature noted and the corrections were calculated for the open joints between the key segments and the adjacent ones and steel wedges previously prepared, were combined to correspond within about 1/50 inch and were driven to adjust the crown segments. Notwithstanding every care it was generally found that the bearings for the center pin diverged about 1/100 inch, and this was rectified by grinding the face of one of the adjustment wedges.

After the bearings were satisfactorily adjusted the arch ribs were temporarily braced by horizontal transverse struts and pairs of screw rods at the segment joints with horizontal and vertical X-bracing of wooden struts in the panels thus formed. Twenty-four 16-ton jack screws with 4-inch stroke were put under the joints of each arch rib so that each would support the ends of two segments. Twenty of these screws, those over the suspended platform, were dynamometers, made by placing the screws in sleeves which engaged cylinders and took bearing on carefully rated spiral springs. The outsides of the sliding sleeves were graduated so as to indicate the amount of compression on the springs at any position. The jacks were screwed up to a pressure of 5 or 6 tons each at the crown and 7 or 8 tons at the haunches so as to receive as nearly as possible the calculated weight of the segments they supported and to prevent the development of arch stresses. The camber wedges were thus released and removed. All the jackscrews were uniformly operated to raise the arch slightly and the crown and skewback wedges were adjusted. Finally the jacks were slacked off in groups, the first being slacked from 5 to 4 tons, the second from 5 to 3 tons; then the first from 4 to 2 tons, the second from 3 tons to 1 ton, and so on, the whole operation taking only about two hours. Twenty working days were required for the actual erection of one pair of arch ribs, but several days more were really occupied by holidays and delays.

The foundations, superstructure and erection were described in The Engineering Record of February 26, 1898; September 4, 1897, and March 11, 1899. They were also fully illustrated in several foreign journals, including the "Annales de la Construction," of July, October and November, 1899; the "Genie Civil," of June 26, 1897, and February 4, July 8 and 15, 1898; the "Revue Industrielle," of July 9, 1898, and "Engineering," of August 20, 1897.

Letters to the Editor.

Chert Roads in Atlanta.

Sir:—For several years past the city council of Atlanta has appropriated $14,000 annually for chert and macadam pavement. We find that we get better results from this expenditure than any other we make, the amount considered. Fulton County outside of the city limits, spends on this pavement each year not less than $30,000.

For resident streets and county roads there is no better pavement than a properly made chert and macadam pavement. Our soil is especially adapted to road-making, being stiff red clay, possessing a good deal of iron, with the country rolling and easily drained. Our method of making such a road is as follows:

First the roadbed is graded and properly shaped; for a 40-foot roadbed the center is 10 inches higher than the gutters. It is then rolled with a 15-ton steam roller, and low places filled up and rerolled. Gutters of 4 feet width and 6 inches depth are made with old Belgian blocks, or well-shaped rubble. Between these gutters we spread 4 inches of broken stone, which is thoroughly rolled with the 15-ton steam roller. Then 3 inches of a harder stone, broken smaller than the first layer, is spread and a small amount of the dark red clay, well pulverized, is forked in among the stones, which are thoroughly wet by a wheel sprinkler and then well rolled. On top of this we place 3 inches of chert, from Spark's Gap, near Birmingham, Ala., taking care to break up and scatter uniformly the cement rock therein. This is then thoroughly wet and rolled, as are the two former layers, care being taken to keep the roadbed in proper shape through each successive step.

Such a pavement costs us about 60 cents per square yard. If once in 3 years the surface of the roadbed is scarified by a "porcupine," or by spikes in the steam rollers and reshaped and rolled, and then 2 inches of new chert put on and rolled, this pavement will withstand ordinarily heavy traffic. This resurfacing will cost about 12½ cents per square yard. The surface is hard and can be cleaned by light sweeping.

The chert we use is dark reddish brown in color. There is a light gray limestone chert in Southern Tennessee and North Georgia which is objectionable on account of its dust, for it is easily pulverized.

My idea of a perfectly modern paved city would be to use kreodine wood-block pavement of 3x6x4-inch long leaf Georgia pine blocks, laid as now being done in Indianapolis, for all business and heavy traffic streets, and chert and macadam pavement with proper gutters for streets of lighter traffic. Sewer, gas, water and electric conduits should be placed in the street before the chert and macadam pavement is put down; this should be done with all kinds of pavement.

Yours truly, H. L. Collier,
Com. Pub. Wks.

Atlanta, Jan. 7.

Current Meter Rating Stations.

Sir:—I have read with interest the article appearing on page 768, Vol. 48, of The Engineering Record, describing a new current meter rating station at Denver. The mechanical features of the rating station have been very ingeniously worked out, the design being a marked improvement over existing stations of the kind. But I have always preferred a station that can be operated without a car running on rails. There is always more or less vertical vibration where the meter is carried by such a car, and it is a question as to whether this does not seriously affect the revolutions of the wheel. A meter is never subject to a motion of this kind when operated in the field, and it would seem that if a station could be contrived whereby the instrument could be moved through still water under practically the conditions met with while in use, the rating would be more reliable. There is another feature of the new station which might be commented upon. The car is designed to be pushed by hand and it is a difficult task to maintain a uniform velocity throughout a run. If it be known that the relation between the revolutions of the meter wheel per second and the velocity of the car in feet per second can be expressed by an equation of the first degree, a varying speed might not threaten the accuracy of the work.

The most satisfactory station I have yet seen is located on the city reservoir at Cheyenne. It was installed by the Irrigation Investigations of the Department of Agriculture and has been in use for several years. The design of the mechanical parts was changed somewhat this last season. The station as originally constructed has been already described in the bulletins of the Department. As it now stands, a steel boat has been substituted for the wooden float, and the operator is located therein instead of at the driving wheel. The boat is propelled through the water by means of a wire belt passing over wheels 10 feet in circumference at diagonally opposite corners of the reservoir. These wheels are 286 feet apart, permitting a run of 200 feet after a uniform speed has been attained. The meter is held by a clamp sufficiently far below the surface of the water to be beyond the effect of currents set up by the boat. The person in the boat starts a stop watch when the beginning of the 200 feet run is reached and counts the revolutions of the meter wheel until the terminal signal is approached. Two meters, one on each side of the boat, can be rated simultaneously with the assistance of another observer. The assistant at the driving wheel is enabled to give a uniform velocity to the boat by using a stop watch and timing the revolutions of the crank or, if moving at slow velocities, he may regulate the speed by observing graduations painted on the circumference of the wheel. The cost of a station similar to the one just described should not exceed $100, including the boat and all necessary apparatus for rating a meter.

Sincerely yours, Clarence T. Johnston,
State Engineer.
Cheyenne, Wyo., December 28, 1903.

Steel-Core Dams of the Southern California Mountain Water Co.

Sir:—I want to thank you for the editorial article in your issue of November 21, 1903, on the construction of dams owned by the Southern California Mountain Water Company, but while it does not say so, it implies that the conception of Lower Otay dam was not original. I notice you say, further, such a dam was "suggested, among others, by Mr. A. G. Menocal for the proposed San Carlos dam across the San Juan river in Nicaragua," etc. Do you mean he suggested a steel-core dam like the Lower Otay dam? The idea was original with me, except to this extent: A Mr. Brown, now an engineer at Chicago, planned a steel face dam, to be erected below the Bear River dam in Southern California. In fact, I think Mr. Brown built the Bear River dam. That plan, however, was condemned on account of the fact that an explosion of dynamite could break any part of the steel structure and then the whole dam would go.

The Lower Otay dam was originally contemplated as a standard masonry dam. When searching for bedrock, supposed to exist within a few feet of the surface, rotten porphyry was found. We had to excavate 90 feet before reaching porphyry of sufficient hardness. These circumstances made the dam necessarily double the size originally contemplated. A steel-core dam was the idea that then came to me, forced practically by necessity, and, so far, it is the tightest dam I have any knowledge of, though on account of scarcity of rain during the past five years, we have not had more than a 90-foot head on it.

Before the Lower Otay dam was constructed, I wrote to four or five prominent engineers in the United States with whom I had a speaking acquaintance, submitted my ideas and asked their advice. Not one of these engineers would give his unqualified approval, yet not one could find anything in it to condemn. It was simply a bold breaking away from the recognized rules and I had to go it alone. Since that time, engineers have come here to inspect the dam from Vienna, Berlin, Paris, St. Petersburg, Sweden and all parts of the United States. During the past month, the chief engineer of Australia was met here by the former chief engineer of Australia, now a prominent engineer of London, for the sole purpose of inspecting the dam and applying the principle in damming a river in Australia. My advice to them, however, when they submitted the condition of affairs in Australia, was not to try it on account of the great floods they have there at all seasons of the year along the river in question.

The Lower Otay dam was made so that it practically would not settle, by allowing all the loose rock, which contained a large amount of fine rock and dust, to fall about 70 feet. It is now five years since the dam was completed, and there are no signs of a settlement of even an inch.

The Upper Otay dam was built by me without consultation, but it has been reinforced very strongly at the ends where it butts into the rocks on either side. Mr. Hiram N. Savage, who was my consulting engineer, fearing he might be held responsible in case of its failure, when it neared completion, called my attention to the fact that I had not discussed the construction with him at all, and he did not want to be held responsible. I told him I had not discussed the matter with him because I was afraid he would condemn it. When the dam was near completion, he began to have more confidence in it, and I believe now thinks it would stay. The dam has not had more than a 50-foot head yet. It can do no harm if it does go out, as it holds about one-fifteenth as much water as the dam below, and it will empty into the Lower Otay reservoir. The water of the lower reservoir will back up against the Upper Otay dam when the lower is filled.

Very respectfully, E. S. Babcock, President.
Coronado, Jan. 2.

[The editorial statement to which Mr. Babcock refers in the beginning of his letter, relates to the use of rock-fill dams without a steel core. The steel core is original with him so far as The Engineering Record knows.]

Heating Costs of Various Systems.

Sir:—Referring to the article by Mr. J. B. Holbrook, on "Heating Costs of Various Systems," published in your issue of December 26, we note that he gives a great deal of data relative to cost of various systems per cubic foot of contents heated. He has gone into much detail in the case of buildings heated by the fan or mechanical system, but has practically left the other systems out, except to give his final results. The data given on cost of fan system heating clearly show how this item may vary, depending upon such variable conditions as class of building, guaranteed temperature, etc. Even in the regular factories of different sizes the cost appears to vary greatly, being less per cubic foot of contents as the volume increases. The amount of galvanized duct work is an item which will be found most variable. In some instances the cost of this material will fully equal that of the rest of the apparatus, including fan, engine and heater; this being, probably, an extreme case, while at times the cost of galvanized work will be only a small percentage of the cost of these parts. The type of fan and method of driving, are other factors which govern the cost. The fan may be built of the full steel plate housing type, and carried on the floor without special foundations, or it may be of the three-quarter-housing type with lower part of the scroll or invert made in the foundation.

Referring to the method of driving it will be found that the motive power used will materially affect the cost. Alternating motors cost more than direct-current motors, and the latter cost more than steam engines. In some instances fans may be driven from line shafting, which still further reduces first cost; and sometimes fans are driven from line shafting in the daytime and are driven from a belted engine at night, as it is often necessary to keep the fan running continuously in severe weather. This combination, of course, increases the first cost.

The relative amount of heater and the relative air change used to accomplish a given result are matters which still further enter into Mr. Holbrook's calculation. Glancing over the table, it is observed that the size of heater used in the twenty-two installations illustrated varies from 1 linear foot to 69 cubic feet to 1 foot to 228 cubic feet of contents heated. This brings to mind a comparison of the bids recently made on a foundry containing 1,800,000 cubic feet of space. There were four bidders, three of whom were fan manufacturers, the fourth being an exponent of hot-water heating. The figures were about as follows:

Bidder.	System.	Heater coils, lin. ft.	Price per cu. ft.	Relative price.
1	Two 11-ft. fans	35,000	$0.0064	100
2	One 11-ft. fan	11,000	0.0034	55
3	One 12-ft. fan	18,000	0.0030	47
4	Hot water	....	0.0063	98

In the two foundries mentioned in Mr. Holbrook's table the guaranteed temperature is 50 degrees, and the heater ratios are respectively 1:140 and 1:153, the change of air being once every thirty minutes in the former and once every thirty-five minutes in the latter. In the ship-building plant cited the guaranteed temperature is 60 degrees, while the heater ratio is 1:228 cubic feet heated and the air is changed every twenty-five minutes. From this comparison it would appear that in determining the size of heaters for the foundries, sufficient allowance had not been made for the heat given off by the cooling iron.

In general, our practice has been to use a fan giving a slightly quicker air change than that shown in the majority of those given in the table, and a heater which would be, on the average, a trifle smaller. The result of this change is that larger volumes of air at slightly lower temperatures are handled, the tendency being to avoid unevenness in temperature occasioned by very warm air being discharged from the outlets. It is, of course, appreciated that the use of a relatively small fan and a larger heater is more economical in first cost and operation, providing the distribution of heat is properly made, but the heating will be more uniform where larger volumes of air at lower temperatures are handled.

Taking, for example, a factory containing approximately 1,000,000 cubic feet of air, using an engine-driven fan of the three-quarter type and a heater for low-pressure steam, and estimating an average galvanized iron pipe layout, our practice would show that the cost, exclusive of boiler, steam fitting and foundations would be in the aggregate, delivered and erected, ready for steam connections about as follows: Fan and engine, $0.00094; heater, $0.00103; galvanized iron pipe, $0.00128; total cost per cubic foot, $0.00325.

This apparatus would carry a guarantee of 60 degrees in zero weather, using re-circulated air. From this it would appear that Mr. Holbrook's estimate of cost of fan system of from $0.0036 to $0.007 is, if anything, a trifle high. It is also shown by the illustrations given in his table under the lettered headings.

In conclusion we would say that if a table similar to the one on mechanical heating could be compiled showing, comparatively, the amount of radiation, size of boiler and cost per cubic foot of contents for buildings heated by the various systems mentioned in Mr. Holbrook's article, it would be very interesting, as well as instructive.

Yours very truly, B. F. Sturtevant Co.,
By E. T. Child.
Boston, Jan. 6.

Crusher Dust for Mortar and Concrete.

Sir:—Referring to your editorial on page 795 of The Engineering Record of December 26, 1903, with reference to the opposition to the use of crusher dust, I wish to take sides with you on that question, and heartily second your remarks. I will state that previous to testing this material, I felt as almost all engineers do who have not the time or facilities for testing it, prejudiced against it. I have had facilities for testing and observing its strength in laboratory practice for the past 5 years, in briquettes and concrete beams, using the crusher dust instead of sand. For briquettes I used what would pass a sieve having 100 meshes to the square inch, retaining all the fine dust equal to about 33 per cent., and in concrete using larger stone with the dust. In making briquettes I used a rather wet mixture, 2½ to 1 by volume or 2½ parts crusher dust to 1 part of cement, using 15 per cent. by weight of water. These ingredients were mixed and worked thoroughly into mortar, and tamped somewhat after the fashion of tamping concrete. I have recently had occasion to break some of these briquettes, after they had been kept 3 years in water, breaking them when taken from the water. They were made of 3 different kinds of good Portland cement, and the results were so high, that I preferred to have the breaking witnessed by some first-class engineers, who could substantiate what I said. I found no failures; the crusher dust mortar was easily 50 per cent. stronger than the best sand mortar that could be obtained, and in some cases, strange as it may seem, about equal to the neat cement. As there has been some difference of opinion on this question, and I have been thoroughly convinced of the superiority of crusher dust to sand after about 5 years of study and experience with it, I would advise those who do not believe in it simply because they do not know about it, and have not tested it, to try it before passing judgment on its merits.

Yours very truly, Nelson A. Hallett.

Boston, Jan. 6.

Book Notes.

When the first edition of Prof. Walter Loring Webb's "Railroad Construction" appeared, a review of it was printed in these columns which applies equally well to the new edition. When the publishers brought out this second edition, a copy was sent to the engineer in charge of an important railway survey then about to begin, with a request to give the book a practical test. His reply was received a short time ago, and is as follows: "I have read the chapters on surveys, alignment, curves, earthwork, trestles, tunnels and culverts, all of which are very clear and explicit, the chapters on curves and transition curves especially so. The chapter on earthwork takes in all one desires. I can safely say that the book will be invaluable to a young engineer, and I heartily recommend it to all who may require a fieldbook." This opinion is practically the same as that expressed in the review of the first edition. (New York, John Wiley & Sons; morocco, pocket-book size, 690 pages, $5.)

The Passaic valley has been subject to several floods of late which are of exceptional interest to those engineers engaged in water-power development. Not only is the basin of this stream an unusual one topographically and physically, but it has been subjected in 1902 and 1903 to conditions making the runoff greater than is usually the case. The importance of these floods, which affect a third of the population of the State of New Jersey, and also some of the peculiar features of its drainage have been described in this journal lately. A much more complete article on the subject has been issued by the U. S. Geological Survey under the title "The Passaic Flood of 1902." This monograph is by Messrs. G. B. Hollister and M. O. Leighton, and is issued in the series of Water Supply and Irrigation Papers.

A number of months ago mention was made of the appearance of a third edition of the first volume of Prof. Forrest R. Jones' "Machine Design." That volume is concerned with the kinematics of machinery. The second volume, of which the revised edition has just appeared, is a discussion of the principles underlying the form, strength and proportions of the parts of machines, and the methods of applying those principles in designing work. The character of the book has not been changed in the preparation of the new edition, but it has been improved by the addition of about eighty pages of new information, largely supplied by leading manufacturing companies, and by the addition of many new examples illustrating the application of the principles explained in the text. For those who are unacquainted with this carefully written work, it should be added that it discusses from the standpoint of the designing room such subjects as bearings and lubrication, gearing, belt and rope transmission, screws, keys, shafting, couplings, flywheels and pulleys, riveting and the selection of materials for parts of machines. A book on a subject already so well covered by other authors, which passes through two editions in four years, is shown by that fact alone to have unusual merit. (New York, John Wiley & Sons; cloth, 6x9 ins., 435 pages, $3.)

A Text-Book of Electrical Machinery. Volume I, Electric, Magnetic and Electro-Static Circuits. By Harris J. Ryan, Henry H. Norris and George L. Hoxie. New York, John Wiley & Sons, cloth, 9x6 ins., 260 pages, $2.50.

This book is the result of several years of experience in the use of the text with the classes in electrical engineering at Cornell University. The authors express their obligation for the material in the volume to all contributors to the literature of the profession, and claim credit only for the manner in which the information is presented. How that manner will appeal to the reader depends entirely on his previous reading. If his elementary physics has been learned through the medium of Ganot's famous treatise, he will find nothing but difficulty in this new book. If his knowledge of mathematics is limited by algebra and trigonometry he will be equally at sea. But if he has the training which a young man of eighteen now receives in one of the many scientific schools of the country, the book will be a revelation. There are a large number of engineers who have kept up their interest in subjects outside their specialties, and if they care to understand the elements of electricity as it is to-day taught in the best schools they will find this book an excellent source of the desired information. It is extremely concise and precise in statement and is not so easily read as the more diffuse popular works with which the country is unfortunately flooded.

Vectors and Rotors. By O. Henrici and G. C. Turner. New York, Longmans, Green & Co.; cloth, 5x7½ ins., 219 pages, $1.30.

Vector analysis has assumed such an important place in certain branches of engineering that it is essential to have a working knowledge of it in order to be acquainted with the easiest methods of solving certain classes of problems. In its elementary outlines it is a very simple subject, familiar to all through the polygon of forces although that is not commonly taught as an example of vectors. One of the leading authorities concerning it is Professor Henrici, and engineers will doubtless be glad to know that his lectures on the subject have been arranged in book form by Professor Turner, under the above title.

This work explains the use of vectors and rotors in solving problems in geometry, concurrent forces, centers of gravity and the stresses in beams and trusses. It does not enter into the use of vectors in electrical problems. Many readers whose opportunities for study are limited have been compelled to pass over parts of the mathematical sections of recent electrical treatises through inability to put the time on these sections which a steady passage through the difficulties of vector analysis involves. A few evenings spent in reading this little work will afford just the introduction to the subject they require, and will also indicate numerous applications of this new mathematical method which are foreign to the field of electricity.

Graphic Statics. By Jerome Sondericker. New York, John Wiley & Sons; cloth, 9x6 ins., 145 pages, 3 plates, $2.00.

Professor Sondericker's book on graphic statics is essentially a text-book and not a treatise, like the Culmann-Ritter volumes. It is the outgrowth of the author's long experience in teaching the subject at the Massachusetts Institute of Technology, and the reader is assumed to have a knowledge of statics and the strength of materials. The purpose of the book is not only to explain the general principles involved, but also to point out the procedure in the construction of the drawings, which is an important feature of instruction.

In an elementary work on a subject already so well covered, particularly in the German language, the merits of a new book must be sought in the manner in which the principles are presented. Professor Sondericker has developed his subject with clearness and conciseness, so that no one qualified by previous study to take up work in graphic statics should find any serious difficulty in understanding the book and applying in practice the principles it states. Trusses, beams and masonry arches are well covered, so far as the scope of the book extends.

Annuaire Statistique et Descriptif des Distributions d'Eau de France, Algerie, Tunisie, Belgique, Suisse et Grandduche de Luxembourg. By Dr. Imbeaus, Captain Hoc, and Messrs. Van Lint and Peter. Paris, Vve. Ch. Dunod; 1,675 pages, 25 francs.

This volume contains a full, concise and satisfactory description of water works in more than 1,300 cities in France and French-speaking countries. Of these supplies, 626 are in cities of more than 5,000 inhabitants, and the total population supplied by them is about 17,000,000. The combined average daily use of water is about 802 million gallons per day, or 47 gallons per capita for the whole population supplied. The cost of construction of the works has amounted to approximately $250,000,000, or nearly $15 for each inhabitant of the cities supplied. Forty-five of the cities have double supplies; that is to say, two pipe systems are provided, one supplying water for drinking and domestic purposes, and the other water of inferior quality for public and industrial uses.

About three-fourths of the cities are supplied by ground water and only one-fourth with surface water, and of the surface waters, a large majority are purified by sand filtration before use. Nevertheless about fifty cities are still supplied with untreated river water. The large number of cities supplied from springs in the chalk and other calcareous formations which underlie many of the most populous districts, and from springs in the glacial moraines in the north of Switzerland, is a very striking feature of the summary. The descriptions of the smaller supplies are often brief, while the works of the larger cities are treated at much length, the water works of Paris and its suburbs, for instance, requiring 80 pages for their description.

The work is arranged upon a well chosen system, and contains a large amount of most useful information to students of the art of water supply.

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Unsolved Problems in Engineering.

The fields of engineering have been growing broader with every advance in each particular branch of physical science, so that every step in those special fields of research either give new phases to engineering problems or create new problems themselves. In other words, questions of power and of construction have become more refined as well as more extended. It was but a comparatively few years ago that the design and construction of many even of the larger engineering works, whether in the application of power or in structures, required chiefly the exercise of good judgment consisting largely of those rather obscure mental operations, trained by experience, through which desired results were obtained without quantitative considerations or the use of refined or theoretical principles. Indeed, there are many, and perhaps hundreds, of civil engineers living at the present time who may remember the feeling of almost contempt entertained by many engineering practitioners for the mathematical treatment of engineering problems connected with actual work to be done. The application of mathematical formulae derived from the theory of internal stress or of elasticity in solid bodies, or from the thermodynamics of the steam engine; or the tempering of structural design by refined molecular theories or the results obtained by microscopic analyses of materials used in engineering operations, would have been considered almost preposterous not many years ago. Yet, at the present time, all these refinements of mathematical theory and purely physical analysis are tempering in a most substantial manner, many if not all of the branches of engineering work including the manufacture and application of power and the design of structures.

This view of engineering work is illustrated in a most interesting and marked manner by the eleventh James Forrest lecture before the Institution of Civil Engineers, printed in the "Minutes" of the Proceedings of the Institution for November, 1903. This lecture was delivered by Mr. William H. Maw, M. Inst. C. E., who indicated in a general way what he considers some of the unsolved problems in engineering, both as to the production and use of power and the application of engineering materials in structures and tools. It would be useless for any lecturer to attempt to cover in a comprehensive manner a statement of even some of these problems, but Mr. Maw has set forth enough of the principal features of a few of them to show how vast is the field of unsolved problems in engineering.

Without referring to developments in steam and electrical engineering, in such an everyday matter as the design of plate girders or of rolled beams, there arise problems in the treatment of material which are yet essentially untouched. As Mr. Maw indicated, we have practically no information as to the effect of combined stresses on the materials in either the web or the flanges of these simple structures. The tests of materials subjected to any single stress are exceedingly simple, but tests under concurrent stresses would be more complicated and difficult, and it is for that reason that we have practically no data on the failure of material under the more complex conditions of stress. All portions of the web of a built or rolled girder are subjected to tension, compression and shearing concurrently, the tension and compression acting at right angles to each other. No engineer has any definite quantitative information on which to make his design either of web or flanges on any other assumption than that the material is subjected to a single condition of stress. Even the data obtained by the testing of beams or girders under transverse loading are all treated and interpreted as if any particular portion of the material is subjected to a single stress only, whether that stress be tension, compression or shearing. In other words, we are absolutely without quantitative information regarding the effect of concurrent stresses, although nearly all material used by engineers in structures is subject to such concurrent stresses. Mr. Maw limits his observations in this particular case to the webs of plate girders, but he might have extended his observations to the webs of rolled girders and to the flanges of built girders with equal force.

Again, while wind loads are recognized and treated in connection with bridge and other structural design as if their action is simple and well understood, engineers are without any data of a really reliable character as to the relation between wind velocity and the pressure corresponding to it. The Weather Bureau states without qualification the velocities of wind in miles per hour as observed by the cup and ball or other anenometers, but even this branch of wind observation is not based upon any reliably approximate basis. The usual anenometer observations are assumed to indicate horizontal wind velocities, but the direction of the wind is just as variable and subject to the same extent of sudden material changes as the velocity itself. Anyone who has ever attempted to measure wind pressures upon an exposed surface by adequate appliances will realize that there is no such thing as a constant wind pressure or wind velocity for any sensible length of time. We are also equally in the dark as to actual pressures against exposed surfaces of bridges or other structures. Indeed it may almost be said, and perhaps quite so, that there is no problem in connection with wind pressure or velocity which has yet been solved, although engineers are constantly using both pressures and velocities as if they were matters known with complete definition.

With the advance of scientific knowledge in so many different directions at the present time, it is scarcely possible for the engineer confining himself to his own field of operations to reach the solution of even any one of these innumerable unsolved problems. The engineer's work involves on every hand the niceties of engineering science which are fundamentally based upon almost every branch of physics and upon the ultimate constitution of matter, as is markedly illustrated in the use of the latest steel products. Although much is known about the physical qualities of nickel-steel there is far more remaining to be found out by the engineer aided by the metallurgist. The physical properties possessed by different combinations of nickel and iron and which are required by the civil engineer in many machines and structures still remain largely unknown quantities with scarcely more than a hint of ultimate results in the information already available.

Some remarkable results have lately been obtained in the investigations not only of the alloys of iron with such large proportions of nickel as 30 to 35 per cent., but also by the combination of iron and carbon with tungsten, chromium and other elements which affect such practical operations as the manufacture of tools for the cutting or planing of iron or steel in the manufacture of the heaviest structural members. It has been found that the combination of the proper proportions of some of these simple metals will produce complex metals some of which have only one-thirteenth the coefficient of expansion or contraction belonging to either of their elements and others of which appropriate for cutting tools actually harden their cutting edge, under service, probably by the intense pressure and the heat resulting from such use.

These and other features of a similar character of Mr. Maw's lecture disclose the marvelous progress which has been made in engineering problems, solved and unsolved, and engineering science, within the past forty or fifty years. They indicate, further, the many directions in which the engineer practitioner at the present time must be elaborately fitted in his educational training and by the study of his subsequent experience. These refined demands made upon the members of the engineering profession have a pointed significance both as to his professional training in the engineering school and as to the imperative necessity of his constant interpretation, from the most advanced point of view, of all the physical phenomena which have any bearing upon his practical work.

Iron Alloys.

Of recent years our knowledge of the constitution of iron and steel has increased with great rapidity. This increase is mainly due to two lines of research, the one being pyrometry and the other, miscroscopic work. The relation between the physical properties, the heat-treatment and the microstructure of steel is receiving the attention of all those who are in any way interested in the manufacture or use of steel. As there are many engineers who are large users of steel and iron who have not had the opportunity of keeping in touch with the work of the numerous investigators of the properties of iron alloys, it may be of interest to point out here a few of the leading deductions from this important experimental work.

The study of metals by the aid of the microscope, termed metallography, was originated with Dr. Sorby as far back as 1864. For a while he was the only worker, but some fourteen years later Professors Martens and Arnold took up the subject independently and gave the science such an interest that to-day it is of the utmost importance. In 1901 the Iron and Steel Institute formed a committee to straighten out the nomenclature of the subject and issued a glossary of terms with their German and French equivalents and in this way greatly strengthened this branch of investigation.

The importance of the use of the microscope has been shown in the results of numerous researches recently. Dr. Stansfield, of McGill University, in a paper before the September meeting of the Iron and Steel Institute, 1903, showed that there were several stages in the burning and overheating of steel. First there was overheating, which took place below the point of incipient fusion. Then there was partial melting or burning, (a) merely producing segregation of carbon in the joints of the grains, (b) accompanied with liquation and oxidation in the flaws, (c) further liquation and oxidation in the flaws. He further showed that steel which had been merely overheated could be completely restored by heating just above its highest recalescence point and allowing to cool; that steel in the stage (a) could be restored by suitable annealing; that forging was necessary for steel in the stage (b) whilst steel in the stage (c) could be restored with difficulty, if at all.

The work of Stead and others has shown that heating to high temperatures produces a coarsely crystalline structure and that good steel can be easily spoilt by heating to a temperature a little above that usually employed for rolling or forging. To restore such steel to its original or even better condition, it is only necessary to reheat to about 900 degrees centigrade for a short time.

During the last five years the work for the sixth report to the Alloys Research Committee of the Institution of Mechanical Engineers, London, has been upon the influence of thermal treatment on different steels containing from 0.13 to 1.30 per cent. carbon. In contrasting the microstructure with the physical properties, a great advance has been made upon the fifth report and the whole work of the committee shows the importance of this line of research.

It is now generally recognized that iron, low-carbon, medium carbon and high-carbon steel, and white and gray cast-iron form one continuous series of alloys. The freezing-point curve for the alloys of iron and carbon consists of two inclined branches meeting at 4.3 per cent. carbon and about 1150 degrees centigrade. The one branch, starting from the solidification point of pure iron, 1,600 degrees centigrade, denotes the freezing out of crystals of iron; the other branch denotes the solidification of graphite, which usually floats to the surface as kish. There is a third or horizontal branch passing through the intersection of the other two and this extends from 2 per cent. carbon onwards. This branch denotes the solidification of the mother liquor or entectic of alternate laminas of iron and graphite in the case of gray cast-iron and the entectic of alternate laminas of iron and the carbide of iron or cementite in the case of white irons. Now, steel proper is found outside the region of this horizontal branch, i.e., in the region 0 to 2 per cent. carbon, and solidifies as a solid solution which at a lower temperature rearranges itself with the evolution of heat. In fact it behaves like a liquid solution and has two constituents, ferrite or pure iron and cementite or iron carbide (Fe_3C), whose entectic point is 0.8 per cent. carbon. In other words, steel with less than 0.8 per cent. carbon consists of ferrite in a groundmass of alternate laminas of ferrite and cementite (which groundmass is called pearlite); steels with 0.8 per cent. carbon consist of pearlite alone; steels with more than 0.8 per cent. carbon consist of cementite in a groundmass of pearlite.

The iron which crystallizes out of pure gray or white iron contains say 2 per cent. of carbon in solution and is therefore practically a high carbon steel and so rearranges itself at a lower temperature into cementite and pearlite.

The above holds good for steel which has cooled comparatively slowly past the points of rearrangement or the recalescence points. If, however, we quench our specimens from above this temperature at which the changes take place we tend to prevent these changes; our steels are hard, because they are in the form of martensite, which is hard. That is to say our iron and carbon remain in the form of a solid solution, in which state they exist above the critical temperatures. Finally, steels which lie between the hard and soft states are those which have been rapidly cooled past the recalescence points, but not so rapidly as to prevent all change. Hence we have a transition form called sorbite. Such in brief is the general view of iron and steel now held by those who have given the subject the most careful study. Nobody acquainted with the recent literature of metallurgy can fail to appreciate the importance of these views, and the necessity of a general understanding of them.

New Engineering Text-Books.

It would be an interesting and instructive undertaking for an engineer who graduated from a technical school fifteen years ago, say, to spend a few evenings in a careful study of the best text-books now employed in such institutions. The enormous growth of laboratory facilities within this period is well known. It is generally appreciated that students to-day are able to experiment with actual engines and locomotives, with hydraulic power plants of commercial size, and with the same testing machinery which is employed in the offices of inspectors of material. It is even held by some engineers that too much attention is paid to such laboratory work. They believe that the time devoted to it precludes thorough grounding in the fundamental scientific principles which are the basis of sound engineering practice. A little reflection will show that the weight of such a criticism depends mainly on the character of the course any particular student is taking. The electrical course must be taught very largely by the laboratory method, while the railway, structural and municipal engineering courses really need only a slight amount of practical instruction, just enough to fix in the mind the methods of handling field instruments for different purposes and of using drafting instruments in a careful manner. It is a waste of time to attempt to turn out rapid instrument-men or expert draftsmen. The laboratory work of the mechanical engineering course is between that of the electrical and so-called civil courses. It is probably safe to say that those schools which aim most definitely to produce engineers ready to accept positions of some responsibility immediately on graduation are those in which the careful scientific training is least developed. They approach more closely to the trade or industrial school type than is desirable, for the technical school of the most useful sort does not attempt to turn out an engineer, but rather a young man possessing such knowledge that after a little of the experience which comes only by practical work he will be fitted to assume fairly important responsibilities.

The changed methods of instruction which the prevalence of large laboratories has rendered necessary is marked by the abandonment of certain text-books without which no engineering school of former days would have dared to attempt to conduct classes. The mysterious books of Rankine and the ponderous volumes of Weisbach are fortunately obsolete as class-room manuals. While they were produced by master minds their character is wholly out of keeping with the modern principle of clearness, conciseness and directness. Probably Professor Mansfield Merriman has done more than any other one man in this country to prove the possibility of presenting an engineering subject in a clear manner and without any sacrifice of scientific precision. He was apparently the first to recognize that a text-book must be written for young men with only a limited scientific training and yet be as thorough and accurate as a paper presented before a professional society. The example he set has been followed by many others, until to-day nobody has to worry over the ambiguities and diffuseness of the old-time books. In fact it would not be possible to give really thorough instruction in all the courses taught to-day in four years in the technical school of the highest class without such improved books for the students.

The graduate in civil engineering of fifteen years ago who considers himself acquainted with the elements of electricity, for example, but has not kept up his acquaintance with the subject through a careful reading of electrical journals, will have a surprise in store for him in such a book as Ryan, Norris and Hoxie's "Electrical Machinery." This is an elementary work, to be covered in fifty recitations by undergraduates. Everything in it must be understood as thoroughly as the alphabet by an engineer who undertakes to employ electric apparatus in an intelligent manner. Yet the manner in which the information is imparted, the clearness with which the phenomena of electric currents are presented by methods the direct reverse of those of former days, make the book to old-time graduates almost equivalent to a work on some new subject.

Moreover, this work, typical of the best books now brought out in electrical branches, does not show those changes which have characterized the progress in school literature in other subjects. The prolixity or obscurity of the mathematical works of twenty years ago gave way first to superficiality. Text-books were printed for the apparent purpose of giving only a smattering of a subject. They were easily mastered, but their lack of scientific value gave them but a short life. Professor John Perry and others who assisted him in his crusade for sane teaching in mathematical subjects punctured the pedantry of such toy treatises. He showed that the mathematics of engineering and the mathematics of advanced mathematicians must be taught in different ways; that both grades of students suffered by an attempt to combine the two courses. He and his followers have proved by the success of their own classes that rigorous demonstrations and methods should not be debased into rule-of-thumb processes of computation. Both have their uses and should not be taught as equivalents. Such a book as Maurer's "Technical Mechanics," devoid of mathematical fireworks but clear and thorough, will repay careful examination by any one who believes analytical mechanics was as well taught a generation ago as it is to-day. In short the advance in the character of elementary text-books has been no less marked than the progress in engineering practice.

The Meeting of the American Society of Civil Engineers.

The annual meeting of the American Society of Civil Engineers this week was marked by an unusually large attendance of the older members. The presence of these engineers, the men whose work was largely responsible for the position the engineering profession holds today, was particularly gratifying to the younger members. The latter have naturally undertaken the responsibility of the management of the society's affairs, but at a meeting of the importance of that of this week the counsel of the men who made the American Society of Civil Engineers was highly desirable. The attendance was representative of the society, both geographically and when measured by the age of those present, so that the votes taken may be safely considered an indication of the opinions of the majority of the organization.

The annual report was a satisfactory one. The net increase in membership during the year has been 212, the largest in the society's history. On the first of the year there were 718 resident members and 2,206 non-residents, a total of 2,924. Notwithstanding the payment of $10,000 on the mortgage indebtedness and an appropriation of $3,000 for purposes connected with the Louisiana Purchase Exposition, the balance on hand, nearly $27,000, is larger than that of last year. The Board of Direction has felt itself fully justified, therefore, after the other national engineering societies had declined to co-operate in the project, in assuming responsibility for the expense of an international engineering congress in connection with the Exposition. In fact it would be hardly possible for the society to do otherwise, in view of the character of the request it received from the president of the Exposition company. This recognized the high position of the American Society of Civil Engineers, and the Institution of Civil Engineers, its guests next October, by requesting it to undertake the management of a general engineering congress. The plans contemplate the formation of a large number of sections, each devoted to some specialty and having at its head an engineer eminent in that branch. One or more papers in each specialty will be prepared and distributed in advance of the meetings, so that the sessions can be devoted wholly to discussion.

The library of the society has grown finely during the year, and now contains 12,582 bound volumes, 25,907 unbound volumes, 5,863 specifications and 3,312 drawings and photographs. The second volume of the library catalogue has been published, and a number of searches have been made for members who could not consult the library in person. The expenses of administration, exclusive of salaries, were $943.73. The publications for the year amount to 3,329 octavo pages with 136 plates and 420 cuts in the text. Their cost has been $15,424.76. The salaries of officers, clerks and caretakers amounted to $19,418.19.

But two important votes were taken. One of these was on a technical subject, the appointment of a committee to co-operate with similar committees of other societies in an investigation of concrete-steel construction. The meeting ordered the appointment of such a committee to be settled by letter ballot, in the usual manner. There was no discussion of this step, for the members of the society are fully awake to the dangers of much of the reinforced concrete works now built. The appointment of such a joint committee has long been urged by The Engineering Record, and it seems probable that the American Society of Civil Engineers will see its way toward such action. It is essential for the society to be represented on a joint body of this nature, if the work is to have the greatest possible influence for good. The article by Mr. Kahn elsewhere in this issue, while expressing some views not held by The Engineering Record, points out clearly the need of a better comprehension of the possibilities and limitations of concrete-steel.

The second vote advanced one step farther the society's action on the project for a joint union building for the four national engineering societies. The Board of Direction had prepared a report on the subject, the important feature of which is a summary of arguments for and against the society's participation in the project; this summary is printed elsewhere in this issue, and it is needless to say that its preparation received a great amount of careful attention. Every attempt was made to give the arguments on both sides as clearly and forcibly as possible, so that each member of the society will have complete information concerning the project before he votes. The Board of Direction has maintained an absolutely impartial attitude in the matter. In its last report it stated definitely that a building with suitable accommodations for all the constituent societies can be planned on the land selected and already secured. The Board made no recommendation in this matter, believing that the society at large should decide what is probably the most important question which it has yet been called upon to determine.

Particular attention is drawn, however, to the statement of President Noble, concerning an interview with Mr. Carnegie on January 18. This was made at the opening of the discussion and is printed in full in the Current News Supplement this week. It is the most important statement yet made concerning the project, for it intimates that unless the American Society of Civil Engineers will co-operate with the other organizations, Mr. Carnegie will not furnish any money. In other words, all the societies must enter the project or the offer will be withdrawn. Heretofore the American Society of Civil Engineers has been given to understand that its co-operation was not essential although desirable. Because the deliberations of the society were continued in the slow, careful manner which Mr. Carnegie himself has approved in so many words, various journals have called the members of the society names not calculated to produce that harmony of feeling which alone will make the joint tenancy of a building desirable. The members of the electrical, mining and mechanical societies have no such opinions, in fact the civil engineers' careful consideration of the union building project has been warmly commended by many of the leading men of the other organizations. But the conversation of many people present at the convention this week shows beyond question, that these unwarranted, unjust criticisms have had their result, and that the American Society of Civil Engineers will not enter the project, even if their action causes Mr. Carnegie to withdraw his offer wholly. The Engineering Record has pointed out from the time the project was started, the peculiar position of the American Society of Civil Engineers in the matter, but instead of recognizing that position some of the advocates of the building followed a course which was calculated completely to alienate the society instead of drawing it into sympathy with the project. Abuse is never a strong argument.

NAVIGATION IN THE CHICAGO RIVER has unquestionably become more troublesome since the opening of the Chicago drainage canal. It would seem, however, that such additional trouble must be borne by vessel owners, for Judge Kohlsaat, of the United States district court, has recently refused to grant any redress in an admiralty suit brought against the Sanitary District by the Corrigan Transportation Company. This company was over twelve hours in towing a 288-foot barge with a beam of 44.6 feet and a draft of 16.5 feet, from an elevator west of Halsted Street to the mouth of the river. Four tugs were needed to tow the barge past some of the bridges on account of the current. Judge Kohlsaat ruled, 125 Fed. Rep. 611, that the connection between the river and the canal was made in strict conformity with the laws. The creation of a mean current in the river of 1¼ miles an hour, which is increased in restricted channels, like those at drawbridges, so as to retard the passage of vessels, is not an unreasonable use of the river, rendering the district liable for additional expenses in handling the boats.

THE CONNECTICUT AVENUE BRIDGE across Rock Creek at Washington has already been described in this journal, and many readers will accordingly be interested to learn that a contract for the superstruction will soon be placed. This masonry bridge is one of the finest designs by the late George S. Morison, materially assisted by Mr. Edward P. Casey, whose work in bridge architecture has been unusually successful. The bridge has five full-center spans of 150 feet each and two full-center end spans of 82 feet. The piers of the large arches are 20 feet thick and those between the large and small arches 37 feet; these thicknesses were determined partly on the ground of satisfactory construction, for the scheme of work contemplates the simultaneous construction of the large arches and the consecutive building of the short arches. The bridge will be 52 feet in width between the faces. Above the main arches are a number of full-center spandrel arches having spans of 14 feet each and supported by transverse spandrel walls 3 feet thick. These arches are open over the 150-foot spans, but closed by face walls at the piers and over the 82-foot arches. The main arches are to be built of 1:2:4½ Portland cement concrete, the transverse walls, spandrel arches and most other parts of 1:2½:6 Portland cement concrete. Alternative proposals will be received for cut-stone and for molded concrete blocks for parts of the trim and faces.

The New Sebago Lake Reservoir of the Portland Water Company.

By Edmund M. Blake, Assistant Engineer.

The Portland Water Company, furnishing the city of Portland, Maine, with water for domestic and manufacturing uses as well as for fire protection, takes its supply direct by gravity from Sebago Lake, situated about sixteen miles northwest from the city, between the Saco and Androscoggin river basins. This lake, among the most beautiful in New England, together with several small lakes tributary to it, has a water surface of about 100 square miles and a watershed, including this surface, of over 600 square miles, a large part of which lies to the west and north on the foot hills of the White Mountains, near the New Hampshire line. It has been estimated that the average daily flow from Sebago Lake is 400,000,000 gallons. The average elevation of its surface is 267 feet above tide water in Portland harbor. It is fed by many small streams, notably by the famous winding Songo River, which brings into the lake the waters of Long Pond and its tributaries. There is but one outlet, the Presumpscott River, and a dam at its mouth, the height of whose crest is fixed by law, regulates high-water mark in the lake. The water surface fluctuates within a range of about 6 feet in an ordinary year, generally being at low-water mark in October or November and reaching high-water mark in March or April. The protection of the waters from pollution was effected by recent definite legislation.

To this almost inexhaustible supply, the water of which is pure and soft, comparing favorably with that of any other large body of water in the United States, the Portland Water Company, in 1867, one year after its incorporation, received a perpetual right by legislative authority, the act reading, in amendment to the act of incorporation, "to take and hold so much of the waters of Lake Sebago as may be necessary for the adequate supply of water for the city of Portland." In the Spring of 1868 work was begun on a brick conduit from the intake (a short box conduit and gate house), on the shores of the lake through the rocky rim surrounding the same, 5,440 feet to a second or lower gate house. Work was also started on a 20-inch wrought-iron cement-lined main; running from this lower gate house through the towns of Standish, Gorham, Westbrook and Deering, 84,120 feet into the city, and on the distribution piping within the city limits. A year later work was started on a 9,000,000-gallon storage reservoir on Bramhall Hill in the city, its overflow level being 167 feet above tide water in Portland harbor. In 1876 a 26-inch wrought-iron, cement-lined pipe was laid from the lower gate house to Wards Hill, 18,500 feet, and a 24-inch wrought-iron, cement-lined pipe from this point, 63,669 feet to the city. Later, the brick conduit, found to have been left about 3 feet above grade and in an unfinished condition by the original contractor, was partially reconstructed and improved and a second 10,000,000-gallon storage reservoir was built on Munjoy Hill in the city limits. About 500 feet of 48-inch cast-iron pipe was also laid out into the lake from the intake gate house, its inlet end being about 30 feet below high-water surface.

This was the condition in 1890. The rapid growth of the city from 36,425 in 1890 to 50,145 in 1900, a gain of nearly 38 per cent., made it evident that the quantity and pressure of the supply would soon have to be increased. Accordingly about 4½ miles of 30-inch cast-iron pipe were laid in 1901 and one mile of 30-inch cast-iron pipe in 1902. The balance of about 10½ miles is to be laid as fast as the funds are available. In the same year the reservoir on Bramhall Hill in the city was cleaned out, the gate house corner strengthened and the slopes relined with 8-inch granite blocks laid on a bed of 8 inches of No. 2 crushed stone, under the supervision of Mr. Percy M. Blake, of Newton, Mass., as engineer, who was also retained as designing and constructing engineer for the improvements contemplated at the lake. The brick conduit was examined and found to be in fairly good condition, but a large amount of silt containing iron oxides had accumulated on the bottom, and whenever a heavy draft was made on this conduit, as happened periodically, this silt gave color and taste to the water in the city. Mr. Blake's plan to construct a 10,000,000-gallon settling basin and storage reservoir at the outlet of the old brick conduit, with a 36-inch cast-iron waste pipe between the old conduit and the new basin, was accepted by the company, and the plans, specifications and contract were drawn up in June and July, 1902, from preliminary contour surveys of the site.

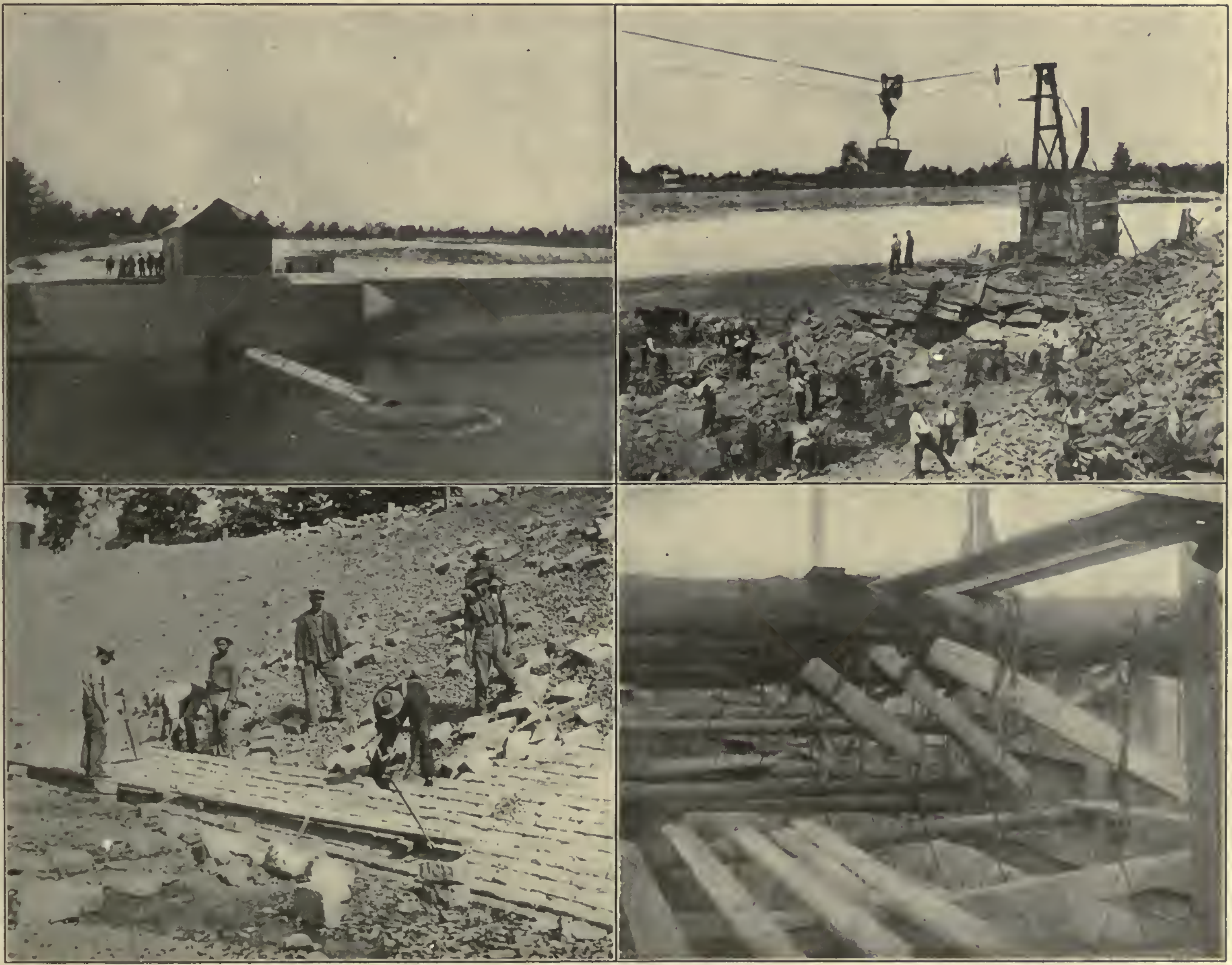
The contract was awarded to Booth & Company, contractors, of Boston, on August 1, 1902. The general work of stripping, earth and rock excavation, building the bank, trimming, ballasting and paving the slopes was let at unit prices and all special work on pipes, gate house, connections, etc., was to be paid for at the actual cost of the same to the contractor, plus 15 per cent. The writer was assistant engineer in charge and the field party under him began its work on August 6. The preliminary plowing of the field was begun by the contractor on August 12, and the work of excavation was pushed rapidly until the entire rock surface was stripped. It covered very nearly the entire field, an area of about 3¾ acres, and cross-sections showed that the amount of rock was much larger than had been anticipated. As the early reconnaissance had shown that the field adopted was the only site available for a storage basin of 10,000,000 gallons capacity in the vicinity of the outlet of the old conduit, the Portland Water Company had decided not to sink test pits. There was no alternative location. Final calculations showed that over 50 per cent. of the entire excavation was solid shale rock, not including soft rock at the surface which could be removed with pick and shovel. It developed a good working face and proved to be of an excellent quality for crushed stone.

The contractor installed a new modern Lidgerwood cableway with a span of 300 feet, including a double-drum hoisting engine, boiler and six heavy buckets. This cableway averaged about forty trips per bucket in nine hours or about 240 bucketsfull per day, requiring less than three minutes to pick up a loaded bucket, carry it across the span to the carts, dump it, return the empty bucket across the span and lower it into the pit. The rock was blown to a face and what went beyond the economical reach of the buckets was thrown up into carts and hauled out to the dumps. The total rock excavation was 33,100 cubic yards, and this was taken out in about 216 working days, or at the approximate average rate of 150 cubic yards per day. For a long period, however, after the installation of the cableway, this rate was nearer 220 cubic yards per day, and so far as the writer has been able to ascertain, a record for the state of Maine was made in May, 1903, when 6,020 cubic yards of rock were removed by cableway and team force combined in 26 working days, or at the average rate of 230 cubic yards per day. Ingersoll-Sergeant and McKiernan drills were used on this work, steam for which was furnished by an 18-horse-power Nagle boiler, carrying about 90 pounds pressure. The force employed by Booth & Company averaged for the entire time about 150 men and 15 double teams, not all of which, of course, was employed on rock excavation. For draining excavations and for similar purposes a 15-horse-power Erie Engine Company's portable engine and boiler and a 4-inch centrifugal pump were used. Work was prosecuted vigorously until December 10, 1902, when the severity of the weather caused operations to be suspended until March 9, 1903, when the work was again taken up and entirely completed on November 21, 1903, covering in all 290 working days.

The completed basin is trapezoidal in shape with the corners rounded and was designed to fit the limitations of the field. The bottom is at an elevation 2 feet lower than the former outlet of the old mains in the old gate house and covers an area of 1¾ acres. The sides are built on a slope of 1¾ to 1 and the top of the bank is 4 feet higher than the highest freshet level recorded for Sebago Lake. This gives a depth of 20 feet from bottom of basin to top of bank. The bank, where it was not formed in cut, was built in 12-inch layers of clay thoroughly wet and rolled with a 3,000-pound ring roller. In all cases the original surface was plowed longitudinally as was also the surface left over the winter. The built section of the clay bank left through the winter was 1,250 feet long with an average depth of 6 feet and a mean width of 38 feet. This bank, eroded somewhat by the winter snows and rains, showed an average shrinkage of 4 inches when new cross-sections were taken before work in the spring. The material was compact, bluish clay. The slopes are covered with 8 inches of crushed stone, and on this ballast are laid heavy granite paving blocks, averaging about 8 inches in depth, cut in the Conway, N. H., Redstone Quarries. A very fine crushed stone was swept over the entire paved surface, filling and packing the joints. This paving is not intended to be watertight, as the clay bank behind it performs that function. The rock appearing on the slopes was also covered and plugged with clay. The paving runs up to within 3 feet of the top of the bank. The top is 10 feet in width, with a pathway in the center and the slopes and corners are grassed and sodded down to the top of the paving blocks. The total distance around the top of the bank is 1,330 feet, or over a quarter of a mile.

The water from the conduit is diverted into the new basin by the erection of a heavy brick and concrete stop wall built across the old gate chamber. From this old gate chamber the water then passes through a short length of new steel-concrete conduit and thence into a 48-inch cast-iron pipe. From the section of new steel-concrete conduit there also leads out a 36-inch cast-iron waste pipe running to a point about 500 feet down the valley, where it empties into the bed of a natural stream. This waste pipe line is provided with a 36-inch gate at its entrance, surrounded by a brick manhole. Where the 48-inch inlet pipe passes through the new gate house it is provided not only with a 48-inch Ludlow spur-geared gate, weighing 12,000 pounds, but also with a 42-inch by-pass connection with the new 42-inch outlet pipe. On this by-pass is a 42-inch gate. The 48-inch inlet pipe then runs through the outer wall of the new gate house and extends about 80 feet out into the basin, where it ends in a masonry inlet well. This well, circular in form, with its walls rising nearly to the top of the 48-inch pipe, has a conical surface of paving carried down from its top to the bottom of the basin and is intended to break the rush of the entering water and distribute it around the basin. Two drainage channels penetrate the walls and slopes of this well at the grade of the bottom of the basin and from the inside of the well runs back a 12-inch cast-iron waste, through which the basin is to be emptied for cleaning or repairs. These drainage channels are not on radial lines, so that the effect is to give a spiral motion to the water in the well when the water in the basin has fallen below the top of the well, from which results an almost perfect scouring action. This 12-inch waste pipe, passing through the new gate house where it is provided with two 12-inch regulating valves and a low level 6-inch branch with a valve for draining the interior of the new chamber, discharges into the 36-inch waste pipe line already mentioned.

Inside the chamber starts the new 42-inch cast-iron outlet or supply pipe which passes down the valley, where it connects with the 30-inch cast-iron supply main laid by the company two years ago and also with both the old 20-inch and 26-inch cement-lined mains. This new supply main has a 42-inch gate at its entrance, 2 feet in front of which are located a duplicate set of heavy fine mesh screens built in two sections each running in heavy grooved frames constructed of well seasoned southern pine. These screens are adjustable and easily raised and lowered by means of a windlass mechanism attached to a pony truss resting on brick pilasters built into the brick superstructure walls of the gate house. The water enters the chamber from the basin through an arched port built into the outer wall and guarded on the outside by a heavy iron grating or rack. The big gates are all operated from the floor of the gate house, 20 feet above. The method of operating these gates may be mentioned in brief. By closing the 42-inch by-pass gate and the 48-inch inlet gate and opening the 36-inch waste pipe gate, the water from the lake may be wasted down the valley, thus scouring out the old brick conduit as often as the condition of the water and the interior of the conduit may make it advisable. By closing the 36-inch waste gate and opening the 48-inch inlet gate, the water from Sebago Lake will then flow into and fill the new basin. By then opening the 42-inch outlet gate, the newly stored water, settled and clarified, will flow down the supply pipes to Portland under an increased head. If, on the other hand, at a later day, it is desired to clean or repair the new basin, and at the same time maintain the flow to Portland, the 48-inch inlet gate and the 42-inch outlet gate are closed and the 42-inch gate on the by-pass from the inlet to the outlet pipe is opened, when the water will flow directly through the pipes to Portland without entering the new reservoir. At such time the two gates on the 12-inch waste pipe line may be opened and the water in the basin drawn off and wasted down the valley. Last of all the 6-inch gate inside the gate house may be opened and every drop of water thus drained out of the gate chamber.



Sebago Lake Reservoir, Portland, Maine: Gate House, Rock Excavation, Slope Paving, and Old Pipe Lines Hung in Wire Rope Slings.

The new gate house, already referred to, is built into the bank, its inner face being plumb with a line running through the toe of the slope. It is rectangular in shape, 33 feet long by 26 feet wide on the outside. The walls, 21 feet in height to the floor line, rest on a solid concrete bottom and consist of 3 feet of water-tight rubble masonry laid in Portland cement mortar and 8 inches of hard-burned brick lining laid in the same. The pipes inside this chamber are protected with a covering of about 6 inches of Portland cement concrete, and all such concrete surfaces are sloped and valleyed to drain into the 6-inch gate on the 12-inch waste pipe line. The exposed flanges and valve chests are protected with a thin coating of Portland cement grout to prevent oxidation and a similar coat is applied to the 48-inch inlet pipe, where it lies exposed on the bottom of the basin, to the iron grating covering the outlet port and also to the brick lining of the chamber up to a point one foot above high-water mark.

The gate house substructure, or chamber is flanked on both sides with heavy masonry wing walls curving back into the slopes, and the entire front face of these wings and of the front wall of the chamber itself is faced with paving blocks similar to those on the slopes, laid in Portland cement mortar, so that the general effect of the interior of the basin is uniform. All the broken stone used in the concrete for this chamber and as ballast under the paving blocks was made from rock taken by careful selection from the excavation and crushed in an American Road Machine Company's portable stone-crusher installed by the contractor for that purpose.

The gate house superstructure, resting on cut water-table stones, consists of 12-inch brick walls laid in Portland cement mortar, about

12 feet high. Two brick pilasters are built into each side wall to serve as columns for pony trusses. The windlass mechanism for raising and lowering the screens is attached to the forward truss. The floor is provided with trap doors above the screens and also with three additional trap doors through which access may be had at any time to the chamber below by means of a ladder always kept in the room. The spindles from the gate stems pass up through the floor and end in upright standards with hand wheels and cranks for manipulating the gates, and dials to record the movement and position of the three big valves. The door is on the south side, above which is a stone lintel bearing the inscription cut into the stone: "Portland Water Co., 1903." Four small windows with stone caps and sills are grouped together on the north side, while there are no openings in the end walls. A hipped roof, simple but effective in design, is covered with shingles stained a dark moss green and such woodwork as appears on the outside is painted a dark bronze green. The windows and doors are black.

The following table shows some of the quantities involved in the work:

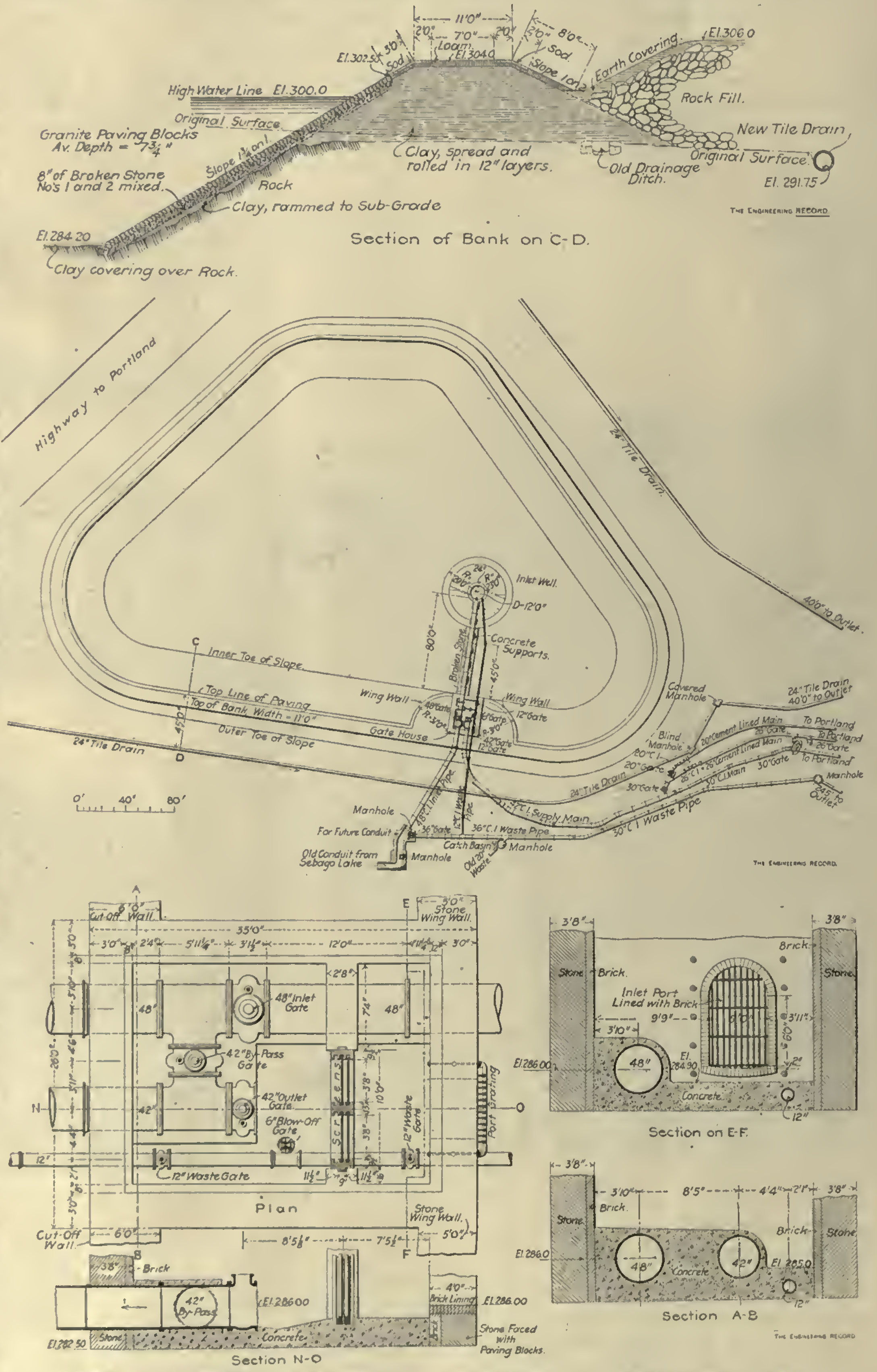
Table of Quantities.

Area of bottom of basin	8,432 square yards
Total capacity of completed basin	11,000,000 gallons
Rock excavation	33,100 cubic yards
Earth excavation	32,150 cubic yards
Total excavation	65,250 cubic yards
Total embankment built in 12-in. layers	15,850 cu. yds.
Paved surface on slopes	4,720 square yards
Paving blocks used	110,000
Crushed stone used as ballast	1,450 tons
Crushed stone used elsewhere	650 tons
Bricks used for all purposes	110,000 approximate
Portland cement used	1,400 barrels
Concrete laid	150 cubic yards
Dynamite used	11½ tons
Cast-iron pipes, specials and gates	210 tons
24-inch drain pipe laid	1,450 linear feet
Average force of men employed	150
Average double-team force	15
Time from start to completion	290 working days

Among the many interesting engineering features of the work was the study for disposal of the 33,100 cubic yards of rock excavation within 600 feet of the basin in such a way as to present a fairly systematic grading when finished. This rock was placed first as a reinforcement to the built section of the bank and then laid out to grade the valley and the low points around the old gate house. The balance was leveled off in terraces and a large part of all these rock dumps was covered with earth excavation and trimming from the slopes.

Another feature was making four crossings with the new cast-iron pipe lines under the old wrought-iron cement-lined mains and connecting with both of these old mains. In each case a wide trench was opened and carried down to the old mains which lay at nearly the same grade, to a point about 15 feet each way beyond the points of crossing. Hemlock logs were then cut in the neighboring woods, averaging about 10 inches in diameter and 35 feet in length. These logs were run across the trench, their ends sunk into the ground and rested on short pieces of 2-inch plank laid transversely. Brackets were spiked to log and plank to prevent sliding. Then a ½-inch steel wire rope was dropped from each log and carried down under the old mains in turn. A jacket of short lengths of ⅞-inch boards was placed around the old mains at the points of suspension to prevent the wire rope from cutting into the shell. A strain was then put on the wire rope and the warp tied to the log. The old mains were slung in this manner at intervals of about 4 feet, and every day the wires were tested and tightened when necessary. In this way the crossings were successfully made with only a few leaks where joints in the old mains opened and this was generally where they went into the sides of the trench. The connections with old mains were made by breaking the latter at a joint and using a cast-iron clamp sleeve with six 1-inch bolts and running the lead joints as usual. Sheet lead was placed between the flanges of the bolted joints and the whole sleeve was later encased in concrete.

The connection with the old gate house developed some interesting problems and was done after the interior of the basin was completed. The new basin would be filled with water during the night and then the inlet gate at the lake would be closed early in the morning. By nine o'clock the old conduit would be empty save for a continual leakage flow, and construction work on the partition walls and on the connection would be pushed until night, when water would again be turned on at the lake. By the device of two sets of stop planks all the work was carried on at the same time. When finished, the stop plank opening to the old 20-inch and 26-inch mains was filled in with brick and the water then turned into its new channels. The method of filling the new basin before this connection was made, was to flow back through the new 42-inch outlet pipe by opening the gate at the point of connection between this new pipe and the old 26-inch main.



Sebago Lake Reservoir: Plan, Section of Embankment and Details of Gate House.

It is of interest to note that the short section of new conduit running from the old gate house to the new 48-inch inlet pipe, was constructed as follows: A 12-inch concrete floor, concrete mixed in the proportion of 1 cement, 2 sand and 4 No. 2 crushed stone; 24-inch concrete side walls, mixed in the proportion of 1 cement, 2 sand and 4 No. 2 crushed stone; 6-

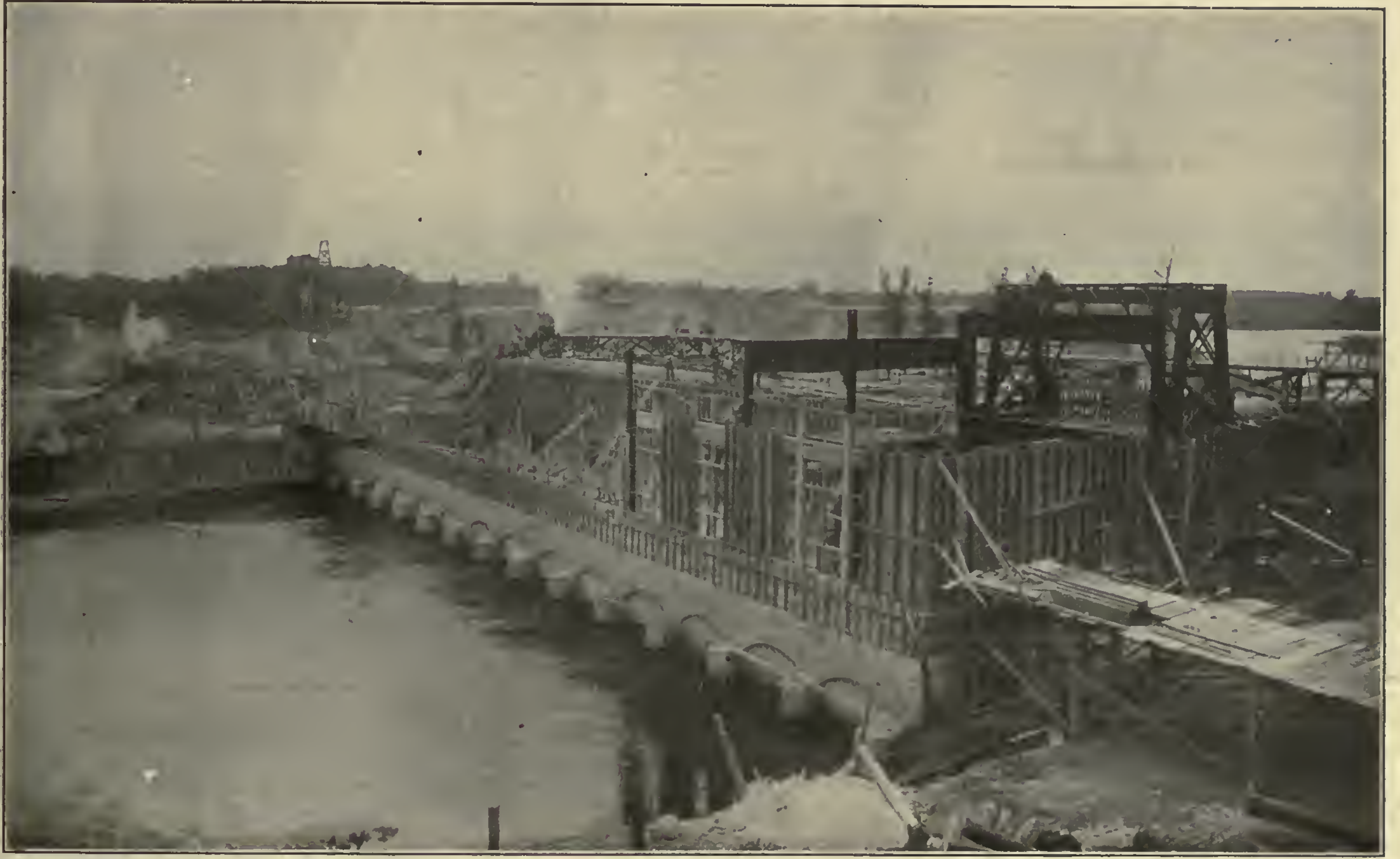
inch steel I-beams laid transversely across the walls, 4-inch North River flagging stones laid on top of I-beams; a top covering of 6 inches of concrete, mixed in the proportion of 1 cement, 1 sand and 4 No. 2 broken stone, in which were embedded one man stones; above this 12 inches of concrete, mixed in the proportion of 1 cement, 1 sand and 5 No. 2 crushed stone; and last, about 10 feet of backfilling, consisting of clay well puddled and mixed with rock of all sizes and rammed down.. From the various tests made, no leakage was discovered through this concrete work.

The completion of this new Sebago Basin, with its added capacity of about 11,000,000 gallons, marks another step in the progressive policy of the Portland Water Company, one of the few remaining private water companies in the State where the movement of municipal ownership of water works is getting a slow but sure foothold. In the field work the writer was assisted by Mr. Charles H. Rice, Mr. Gordon H. Fernald and Mr. George H. Sargent.

The Hackensack Meadows, in New Jersey, only a few miles from New York City, are being reclaimed by filling an area of about 3,000 acres to a level about 8 feet above tidewater, or substantially to the level of the tracks of the Pennsylvania and other trunk lines of railroad passing in that vicinity. It is stated that some 12,000,000 cubic yards of material will be used, which will be dredged from the Bay Ridge channel of New York harbor by the hydraulic process. This tract will have a water front of 7½ miles on the Passaic River and Newark Bay, and it is estimated that its value will be about $5,000 per acre for manufacturing plant sites, railroad yards and similar purposes. Messrs. Hughes Brothers & Bangs have the government contract for dredging the channel. The combining of these two projects has made the former possible at a reasonable expenditure.

Water-Power Electrical Development in Northern Indiana.

The recent starting up of the ultimate 12,000-horse-power Twin Branch power-house, ten miles west of Elkhart, Ind., marks an important development of the hydraulic power available on the St. Joseph River for manufacturing and industrial purposes. It is the first of a number of plants projected by the same parties at various points along the river. While the present station promises to stimulate chiefly the manufacturing interests in South Bend, Mishawaka and Elkhart, the ultimate scheme will provide for all the industrial centers in that region. It is understood that the owners of the Twin Branch plant may soon build another dam and power-house at Bristol, fifteen miles east of the present development. As the population within a ten-mile radius of the new plant is upward of 100,000, engaged largely in manufacturing industries, it is felt that the success of any well built hydraulic electric power development in the neighborhood is assured. Many manufacturers, it is stated, have already been attracted to the cities named by the cheap power now obtainable.



Twin Branch Power Plant during Construction, Tail Race in Foreground and Dam Beyond.

The Twin Branch plant was designed and built throughout by Messrs. Sanderson & Porter, of New York, engineers and contractors, and will soon be turned over to the St. Joseph & Elkhart Power Company for regular operation. This company will supply power to the Elkhart Electric Company, the present operating company in the city of Elkhart, which during the past two years has been extended and modernized under the direction of the same engineers preparatory to operating it as is now being done, independently, or in parallel with, or as a substation of, the new plant of the St. Joseph & Elkhart Power Company. The Elkhart Electric Company has a combined water-power and steam-power plant with a present generating capacity of over 1,000 horse-power and also a step-down transformer substation of 1,000 horse-power. In Mishawaka, three miles west of the Twin Branch plant, 1,000 horse-power of step-down transformers, with a number of large induction motors, is being installed in the plant of the Mishawaka Woolen Manufacturing Company, for operating machinery used in the manufacture of rubber goods. Contracts have been entered into with the Lake Shore & Michigan Southern Railway for lighting the new yards between Elkhart and Mishawaka, and for power in the new railroad shops.

The building of the plant has been actively directed by the resident engineer, Mr. W. H. Lang, in charge of the construction office of Sanderson & Porter, at Mishawaka. The dam is 400 feet long with a combined base and apron 145 feet wide. The dam structure is 30 feet high from bottom of timbering and develops about 20 feet head without flashboards. A line of grooved and splined sheet piling, 6 inches thick and 30 feet long, driven through alternate layers of gravel and sand to hard pan, is used at the upper and also at the lower side of the dam, in addition to six parallel rows of round piles driven to hard pan—three rows on each side. To these rows and to the above mentioned sheeting the dam is secured. It is built of 4-inch rock maple plank, closely fitted, bolted and spiked. The construction is what is known as filled crib work, the planks forming solid-walled compartments, and the spaces being filled with screened and washed gravel, no rock being available. Some 3,000,000 feet of lumber and 125 tons of bolts and spikes were used in the construction of the dam and apron.

The power-house is located at the south end of the dam and constitutes an extension thereof. The building is 180 feet long and 130 feet wide, and is built throughout of steel and concrete. In preparing the foundations 2,000 oak piles were driven through 30 feet of gravel and sand into a firm layer of hard pan. These piles were cut off 15 feet below the water line, covered with oak capping secured to the piles by 2-inch oak pins, and on these caps was laid a flooring of oak 5 inches thick, this being grooved and splined. On this floor the foundation walls were built. There are 15 walls 3 feet thick, 130 feet long and 12 feet high, forming 14 sluices or tail races. The crowns of the arched top of these sluices are 3 feet thick and form the floor of the generator-room and wheel forebays. There are to be eight lines of horizontal turbines, six of the lines for main units and two for exciter sets, with a combined total of 12,000 wheel horse-power. Each unit is set in an independent compartment, controlled by a series of gates operated by electric power. There are five water wheels in each main unit, mounted on a horizontal shaft 11 inches in diameter and about 60 feet long. This shaft passes through the bulkhead wall and is directly connected to an alternating current, 1,000-kilowatt, three-phase, 60-cycle electric generator. The turbines are of special design, with steel plate runners, and were made by the Trump Manufacturing Company, of Springfield, O.; the heavy wheel bases, wall frames, etc., by the Webster Manufacturing Company, of Chicago; the draft tubes by J. M. Matthews, of South Bend, and the generators, switchboard and other electric equipment by the Westinghouse Electric & Manufacturing Company, of Pittsburg.

Steel and concrete are used almost wholly in the construction in order to minimize repairs. Operating expenses, it is thought, will also be low, partly because of the comparatively small amount of débris carried by the river, even at flood periods, and partly because of the facilities furnished for cleansing the racks and forebay channel by the special sluices provided for such work and for controlling the pond. This pond has a length of 10 miles and an area of between 1,000 and 1,100 acres. The large water storage so secured, coupled with the remarkably small variation in the rate of river discharge, as compared with many rivers, renders practicable the installation and operation of a considerably larger amount of electrical equipment per square mile of water-shed than is ordinarily possible. The causes of these uniform flowage characteristics are explained by data contained in the Water Supply and Irrigation Papers of the U. S. Coast and Geodetic Survey. The statement is therein made that the drainage basin of the St. Joseph River contains more than 400 small lakes and lies in a completely glaciated region, overlain with diversified glacial drift deposits. The porous character of the gravel deposits permits the rainfall to percolate quickly below the surface so reducing evaporation losses. The gravel drift furnishes a large underground water storage from which the river is mostly fed and which so equalizes the rate of flow that extreme floods do not show a discharge of over 5 second feet per square mile of water-shed according to the U. S. reports referred to. The geology of the St. Joseph River drainage basin is interesting from the fact that the direction of the flow of the river from Lake Michigan to South Bend was formerly reversed. Such portion of the river formed an outlet for the waters of Lake Michigan, which turned to the southwest at South Bend, through the Kankakee River, and reached the Mississippi through the Illinois River. The old river channel connecting the St. Joseph River with the Kankakee River is still well defined. Subsequent withdrawal of the glacial ice sheet and the consequent lowering of the lake formed by it at the south end of the Lake Michigan basin resulted in a reversal of the direction of the flow then existing through the lower end of the St. Joseph River. The later erosion has slowly lowered the bed of the St. Joseph River some 50 feet below the bed of the old channel at the point where the latter leaves the line of the present river.

The Necessity of Moisture in Heated Houses.

Abridgment of a paper by Prof. R. C. Carpenter. of Cornell University, read before the American Society of Heating and Ventilating Engineers.

It is established, I think, with reasonable certainty, although there seems to be very little scientific data available on the subject, that the inmates of a room are more comfortable when the relative humidity of the inside air does not differ greatly from that to which they are accustomed outside. The amount of moisture required to maintain the relative humidity the same as the outside air may be of considerable amount. Thus, supposing saturated air at 10 degrees Fahrenheit be introduced into a room at the rate of 1,000 cubic feet per hour, we find by consulting tables that in order to maintain the air at the saturated condition we shall need to introduce, if the air be warmed to 70 degrees, about 6.8 grains of water for each cubic foot, or for the 1,000 cubic feet we would need 6,800 grains, or practically one pound per hour. A building containing 10,000 cubic feet of space would, to maintain 50 per cent. humidity, need to have something like 5 pounds of water or say 2½ quarts evaporated per hour in order to maintain the degree of humidity somewhat near that usually found in the outside air. This calculation is interesting as showing that large amounts of water may be needed to preserve the relative humidity the same as that of the outside air during the processes of heating.

It would be an interesting question to know what effect the dry air in our inhabited rooms has upon the health of the occupants. I think we will find much difference of opinion regarding this proposition. It is a well-known fact that dry air is extremely favorable for the cure of certain diseases and I believe, also, that it is quite certain that it is not quite so favorable a medium for the propagation of disease bacteria as moist air, but nevertheless I do not think it as healthy for a normal person; but regarding this I have little data which could be considered as conclusive.

Mr. G. A. Loveland, section director of the United States Weather Bureau, Lincoln, Neb., read a paper on this subject before the Nebraska Academy of Sciences, January 25, 1902, which as presenting some valuable observations I have quoted:

"The previously evident effect of dry air on the furniture in the United States Weather Bureau office in Lincoln, Neb., during the winter months resulted in the taking of a few observations to determine the relative humidity of the air in the rooms in the winter of 1898-99. The relative humidity proved to be so low that it was decided to make a consecutive record for the next winter, that of 1899-1900. Mr. A. B. Smith, a student in the university, working in the office, becoming interested, kept the record. Observations were made usually twice a day, but sometimes as many as four or five times a day, and occasionally but once a day. The observations were made by means of an ordinary sling psychrometer.

"The rooms are heated by steam, using the ordinary pipe radiators. Lack of time prevented Mr. Smith's computing the relative humidity from the mass of observations for the use he intended to make of them. When he graduated in June, 1901, he transferred his data to me in the hope that it might prove useful. During the summer and early fall these observations were computed and tabulated for convenient study by my wife and myself. The result proved that the air in the office was exceedingly dry during the whole winter. The coldest month, February, 1900, with a mean temperature in the shelter of 19.2 degrees above zero, was also the driest in the office, with an average relative humidity of but 15.3 per cent. The variation was not great from day to day, the extreme ranges for February, 1900, being from 7 to 25 per cent.; but the record shows that it was only twice above 20 per cent. and once below 10 per cent. December, 1899, comes next, with a mean exterior air temperature of 22.6 degrees and a relative humidity in the office of 18.6 per cent. January, 1900, was warmest and in the office the most moist, with a mean temperature of 26.8 per cent. outside, a relative humidity of 21.0 degrees inside. The temperature of the office did not vary materially for the three months, and averaged slightly below 70 degrees. The relative humidity, from the readings of the whirled psychrometer in the shelter, was: For December, 77.4; for January, 73.4, and for February, 77.9 per cent. This gives a mean relative humidity of the outside air for the three months of 76.2 per cent., while for the inside air for the same period it was but 18.3 per cent. In an article in the 'Boston Medical and Surgical Journal' of March 1, 1900, Mr. R. DeC. Ward, Instructor in Climatology in Harvard University, gives the relative humidity of the outside air at many of the driest places where observations have been kept, including places near the deserts in both Asia and Africa, but he quotes no place as dry as the Weather Bureau office at Lincoln was during the three months mentioned.

"The results obtained as above stated caused me to attempt an experiment this winter. I live in the north half of a double house. The two halves are very much alike, of course being built under exactly the same conditions, and heated by the same sized furnaces of the same make and pattern. The arrangement of rooms is slightly different, but the cubic space of each house is about the same—14,000 cubic feet. Furnaces are almost invariably furnished with a pan in which water may be kept, since, as text-books say, 'heated air requires more moisture than cold air contains to maintain a comfortable degree of saturation.'

"The investigation began by using the water pan in my furnace and not using the one in my neighbor's house, and by making humidity observations to determine the efficiency of the pan as an attachment to a furnace. The water pan holds 20 quarts. The amount of water evaporated from the pan was determined each day by filling it daily and measuring the water required. The observations commenced November 4, and were taken once daily by my wife about 12.00 noon. The result of the first 17 days' observations was as follows:

	Average.	
	Temperature of air, deg. F.	Relative humidity, per cent.
Inside, with water pan........	72.1	36.2
Inside, without water pan......	67.9	38.8
Outside	39.4	68.2

"The amount of water evaporated was two quarts per day. The difference in humidity seems to be due almost entirely to the fact that one house was, on the average, warmer than the other. Reduced to a temperature of 70 degrees, there seemed to be a slight difference—about 1 per cent.—in favor of the house with the water pan, but the difference was so very slight that the value of a water pan as an adjunct to a furnace was not established, but on the contrary it seems probable that such a small pan is of little or no value.

"It was then determined to increase the evaporation sufficiently to affect the humidity, continuing to measure the water. Pans of water were placed in each of four registers. This increased the evaporation to an average of 5.9 quarts per day for the 17 days beginning November 23. The averages for this period were as follows:

	Average.	
	Temperature of air, deg. F.	Relative humidity, per cent.
Inside, with water pan	70.0	35.8
Inside, without water pan	70.0	33.4
Outside	39.3	73.8

"For this period the temperatures in the house averaged the same and the relative humidity was 2.4 per cent. greater in the house using water in the furnace and register pans.

"Two large pans were now attached to the furnace at the point where the cold-air return delivers the air to the furnace to be reheated. These were in operation for the period from January 15 to January 21, and increased the evaporation to 10 quarts per day for the period, with the following results:

	Average.	
	Temperature of air, deg. F.	Relative humidity, per cent.
Inside, with water pan	69.9	29.1
Inside, without water pan	70.0	26.9
Outside	23.3	66.8

"This shows a difference of 2.2 per cent. in favor of the house in which the 10 quarts of water were evaporated daily, from which it would seem that the 4.1 quarts increase in water evaporated did not quite offset the lower temperature (averaging 6 degrees) and lower humidity (averaging 7 per cent.) of the outside air in the second experiment.

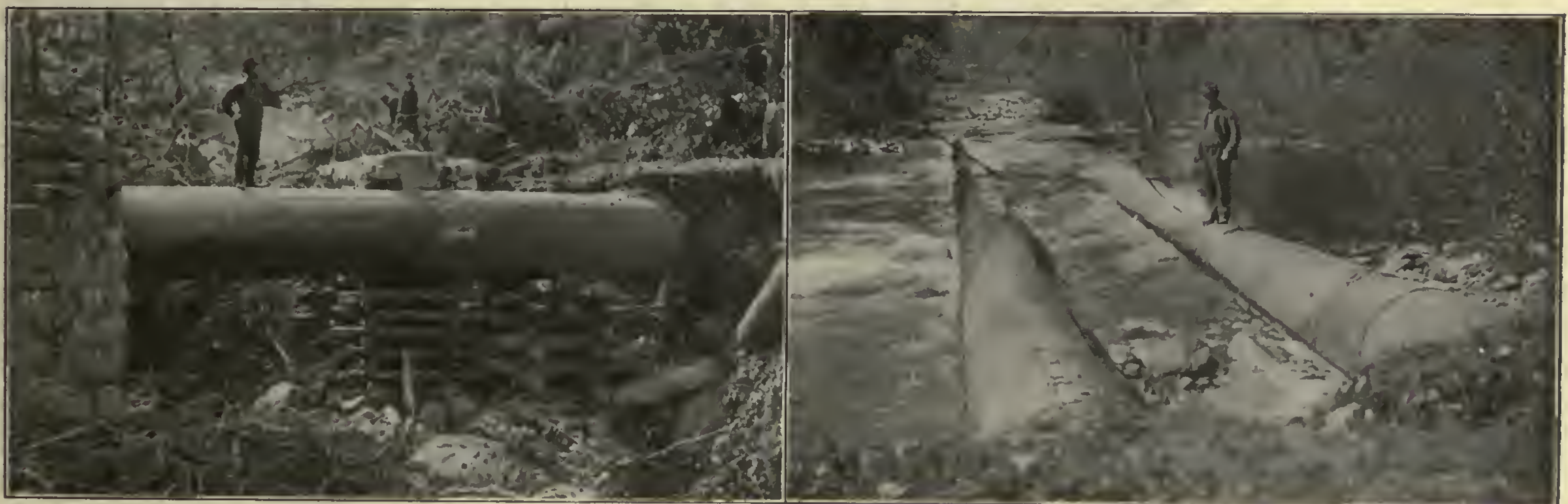
"The only ventilation the houses have is one open fireplace in each. No special effort was made to change the air other than that resulting from the ordinary usage of dwelling-houses. As the two houses were so nearly identical in all conditions affecting ventilation, it was assumed that the change in air was practically the same in both houses. Neither furnace took air directly from outdoors; the cold-air return from the rooms and air from the cellar were the only sources of air for the furnaces. If there was no change in the air, six quarts of water would be sufficient to saturate the air in one house. It seems probable, however, that the air in a house of this kind, with no special effort at ventilation, changes completely once in two hours, and possibly once an hour, or even in less time. With this in mind, it will be seen that in a house of the kind in which these experiments were made (ordinary 8-room) 70 to 150 quarts of water, or possibly more, per day, will be required to maintain the relative humidity as high as it is outside the house, the difference between inside and outside temperatures being from 35 degrees to 50 degrees, as is the case in winter months in Nebraska. This degree of humidity would not be desirable, for the moisture in the house would condense on the windows to such an extent as to be very disagreeable. In fact, later in the winter, with a daily evaporation of 36 quarts and a temperature slightly above zero outside, 70 degrees inside, and an inside relative humidity of 30 per cent. (about 10 per cent. higher than in a house without evaporation), considerable condensation on the windows took place, but not sufficient to be troublesome.

"At present, from a rather short series of observations in a house heated by hot water, but quite extensive observations in furnace and steam heated rooms, there seems to be little or no difference, so far as the relative humidity of the air is concerned.

"I do not know what effect the dry air of living and office rooms has upon health, being unable to find a record of any experiments in this direction. Most physicians maintain that it is injurious, but this seems to be based mainly upon theoretical considerations."

A Flood Test of Two Large Riveted Steel Pipe Lines.

Remarkably heavy rainfall on October 8 and 9, 1903, caused very destructive freshets on the ninth and tenth throughout the northern, central and northeastern sections of New Jersey. The floods did not wholly subside for several days and wrought serious damage to railroad lines, bridges, water works and other public and private property, as many readers of this journal will remember for a long while to come. Among the structures which were severely tested were the two 48-inch riveted steel pipe lines of the Newark water works. Very fortunately for Newark and also for Jersey City, which was compelled to borrow water because the pumping station supplying it was temporarily put partially out of commission by the floods, the pipes withstood the strain brought upon them without so much as developing a leak.



Two Riveted Steel Conduits of the Newark Water Works Undermined by a Flood.

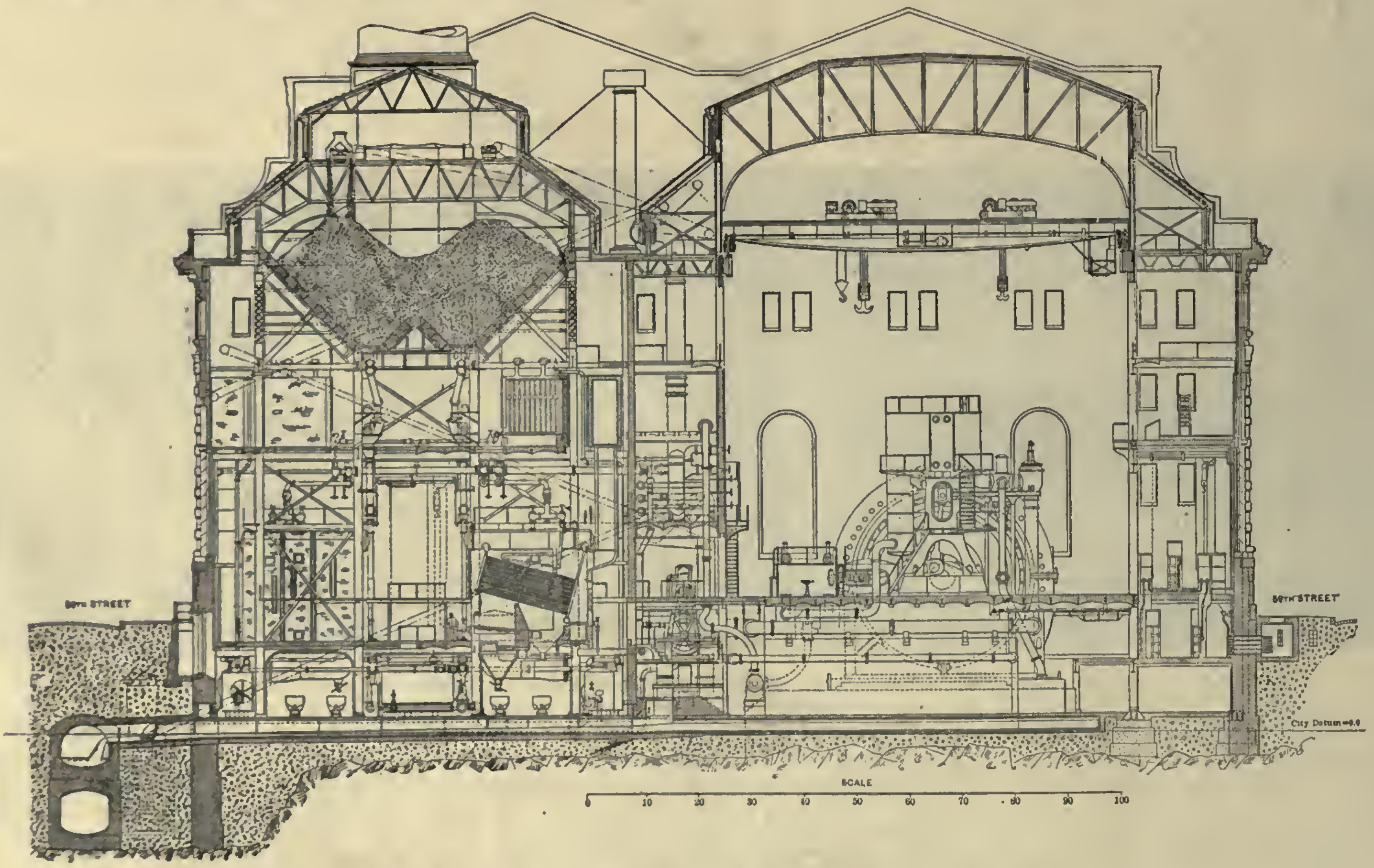
Both pipe lines were laid from the Pequannock watershed for the East Jersey Water Company by the T. A. Gillespie Company, of New York, one in 1891 and the other in 1896, and are of ¼-inch plates. About a mile and a half below the Macopin intake the two lines, which were laid side by side, were undermined by water. In one place, the Pequannock River had been diverted from its channel so as to straighten its course and remove it from the pipe location, a dike being constructed to keep the water out of the old river bed, in which the pipes were subsequently laid. During the flood the river broke through the embankment, and, entering its old channel, washed the 3 feet of earth covering from over the pipes for a distance of about 200 feet and also undermined them. One pipe was unsupported for a distance of at least 50 feet, and the water surged over and under the two lines, as shown in one of the accompanying views. Fortunately the old bed of the river was filled with large boulders at this place, which prevented the entire support from being washed out from under the pipes. At the height of the flood the water was at least 1½ feet deep on top of the pipes. Neither pipe suffered any damage whatever, not a single joint starting even a minute leak. Both pipes were full of water when the accident occurred.

At another place the pipes crossed a mountain brook, spanning the stream bed between masonry abutments 14 feet apart so as to give a waterway about 10 feet high, ordinarily ample for any floods on the brook. But higher up on the stream there was a little dam forming a small reservoir, and the flood caused the failure of this dam, thus adding the water in the reservoir to the already swollen brook. Large trees were uprooted and carried down by the torrent and some thirty of them were jammed in the culvert, against the pipes and on top of them, and one large tree trunk was even forced between the pipes so as to exert a prying action upon them. The waters, thus diverted partly from the culvert, undermined and carried away the lower part of one of the masonry abutments, leaving its upper portion to be supported by the pipes. To the very severe strain thus brought upon them the pipes were subjected for some time, and although left unsupported under the load described for a distance of over 35 feet, they were not forced out of position nor damaged in any way excepting that a few joints in one pipe only showed a slight weeping. As soon after the water subsided as it was feasible, the debris was partially cleared away and some temporary log cribbing built beneath the pipes, as shown in the photograph. At a third place, also, the pipes were subjected to a test very similar to the one just described, at a point about 50 feet distant, on account of the surcharging of another culvert, one of the abutments of which was undermined and the earth back of it washed away.

Judging by other experiences, if these lines had been laid with cast-iron pipes, any one of the three accidents mentioned would probably have been sufficient to cause the complete rupture of the lines with the consequent cutting off of the water supply to Newark and a large part of Jersey City at an unfortunate time, with railroads and highways crippled by the floods so that it would have been difficult to make repairs. The masonry and earth removed by the freshet from around the pipes were replaced and no trouble has since been experienced with the pipes. This is certainly a noteworthy record and shows, as have a number of other occurrences, the remarkable capacity of properly made steel pipes of good materials to withstand unexpected hard usage. The photographs and notes from which this statement has been prepared were courteously furnished by Mr. M. R. Sherrerd, engineer of the Newark water works, and Mr. Gillespie.

The Power House of the Interborough Rapid Transit Company, New York.

On Wednesday afternoon members of the American Society of Civil Engineers, in attendance upon the annual meeting, visited the new power house of the Interborough Rapid Transit Company on Eleventh Avenue, between Fifty-eighth and Fifty-ninth Streets, Manhattan. To add to the interest of the excursion, a brief description of the plant was prepared by the company, and as this is the first official statement which has been issued concerning the station, now nearing completion, it is reprinted below.



Cross-Section of the Power House for the Interborough Rapid Transit Company, New York City.

Substructure.—The substructure of this power house consists of Portland cement concrete, in the following proportions: 1 part cement, 2 parts sand and 5 parts broken stone. This proportion is used for all column bases, engine beds and wall footings, and all these foundations have been taken down to bed-rock, all concrete work being brought to Elevation +1.5 feet above mean high water (city datum). The rock elevations vary from +12 to —33 feet; thus showing a very irregular bottom. There are 397 columns and twelve engine beds, the bases of each being enlarged to meet the deflection in the rock. To carry the column loads, there is a granite cap-stone on the surface of each concrete pier, and these are of various sizes. On these cap-stones are set cast-iron bases into which the steel columns are set. All engine-bed footings are of concrete from bed-rock to Elevation +1.5 feet. At this elevation the forms are put up, and the anchor bolts, washers and nuts (for engines or generators) are set. Corrugated steel bars, placed horizontally and vertically, are also built into these monoliths. Each bed, above Elevation +1.5 feet, contains 1,350 cubic yards of concrete. All wall footings are of similar construction, and are taken from the rock to Elevation +1.5 feet. The walls are of hard red brick to Elevation +17.75, and, from this point to the top of the water table, granite facing is used.

The intake and return-water conduits, for condensing purposes, are of concrete, reinforced on the river end by corrugated steel bars. This is also true of the coal-conveyor tunnel. The bottom of the intake conduit rests on piling, driven to bed-rock, extending out to the city dock line, and cut off at Elevation —19.5 feet. All foundations for feed pumps, air pumps and circulating pumps are of concrete. The basement floor, also, will be of similar construction.

Structural Steel.—The steel in the building is independent of the exterior walls, which are self-supporting; so that the integrity of the structure would remain if the walls were removed. The weight of the steel will approximate 12,000 tons, and, in this respect, it is one of the heaviest structures on record. Some of the columns sustain 750 tons. A feature of the design is the bracing required to withstand the strains caused by the chimneys and by the excessive loads carried high in the structure. Each chimney is supported on six columns, which carry a platform of plate girders 8 feet deep, over which is placed a grillage of 20-inch beams, placed at 2-foot centers, and filled solidly with concrete. The base of the masonry, resting on the grillage, is reinforced by a steel frame 3 feet deep, with steel rods running in both directions through the base of the brickwork.

The Masonry Superstructure.—The base of the exterior walls is finished with cut granite, up to the water table, above which the facework is of light buff pressed brick enriched with terra cotta. The general treatment of the design may be termed Italian Renaissance, and is rather ornate. The structure will be one of the most attractive in New York City. All window sash and framework is of cast-iron, glazed with ribbed glass, and all exposed trimwork on the roof is of copper. The flat portion of the roof is of concrete (expanded-metal construction), and the sloping sides of the roof are of terra cotta covered with green enameled tile of a Spanish roll pattern. The chimneys are faced with brick of the same quality as used in the facework of the structure. The interior of the operating room is faced with brick of a light buff color, and the trim of all doors, sash, etc., is covered with kalamein iron, or sheet copper. This trim is reduced to a minimum, so that the building is fireproof, in the strictest sense.

Plant Equipment.—The power house is 200 feet wide on Eleventh Avenue, and extends westward 694 feet. Its height, from the basement floor to the highest point of the roof, is 125 feet. The structure is divided into two main sections: A boiler house on the south or Fifty-eighth Street side and an operating house on the north or Fifty-ninth Street side, each extending the full depth of the building. On the Eleventh Avenue end is extended a track connected with the main line of the New York Central Railroad, and this is used in bringing machinery and materials into the building. Coal, however, is conveyed into the building with a belt conveyor. This conveyor extends to a pier in the North River, at the foot of West Fifty-eighth Street, 700 feet in length. From the pier, the coal is conveyed underground to a point at the southwest end of the building, where it is raised, by an elevating belt system, to the coal bunkers constructed in the roof. The bunkers have a capacity of 25,000 tons. From the bunkers, the coal is conducted to the points of requirement at the boilers.

A new feature is the use of a distributing coal conveying system under the bunkers, by which coal of a high grade, stored in any one bunker, can be distributed to all boilers without handling, thus permitting the use of two or more grades of coal, when needed at different times of the day. The ashes from the ash hoppers are removed from the building to the front by a system of trackage with storage battery haulage.

Interborough Power House, New York, Eleventh Avenue and Fifty-eighth Street Fronts.

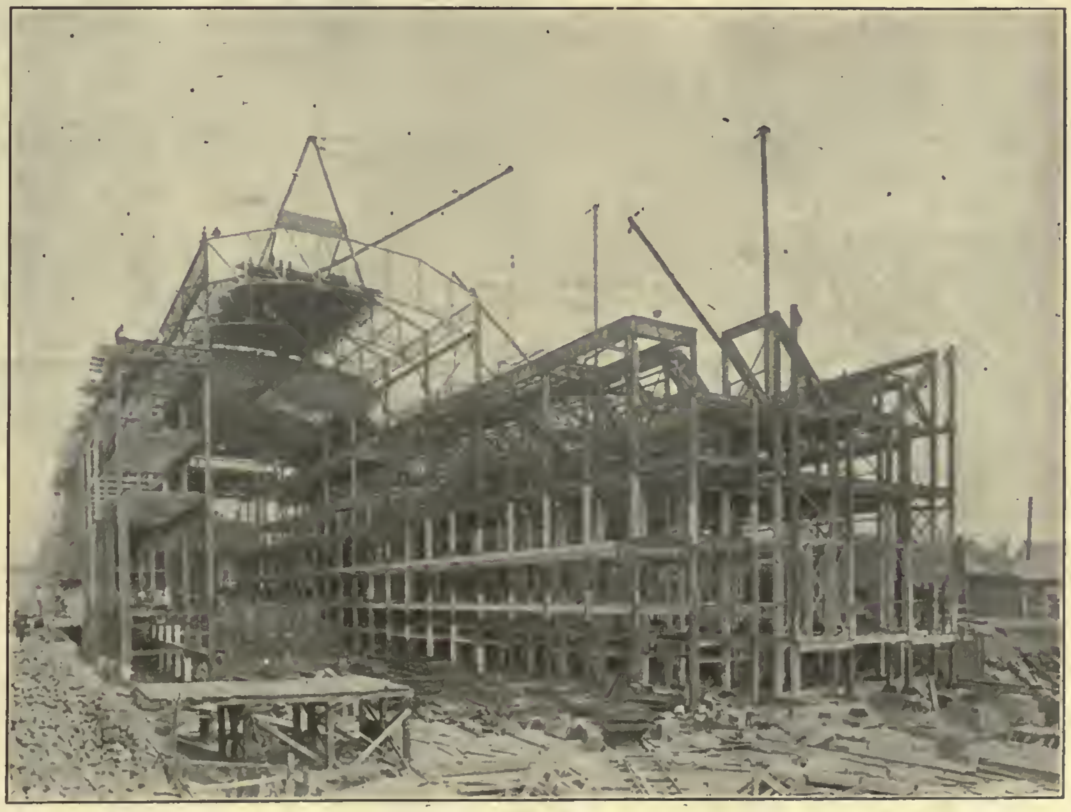
The condensing water is taken through the river wall at the pier, and passes through a masonry conduit to the several suction wells adjacent to the structure. From the wells it is piped to the circulating pumps, and thence back to a second masonry conduit, from which it is delivered at a point about 200 feet outside the river wall. The intake conduit is oval in cross-section, 10 feet wide and 8 feet 6 inches high, the bottom of the opening being at 19.5 feet below mean high water.

For the immediate installation under construction, the boiler plant will consist of sixty safety water-tube boilers, each having 6,000 square feet of effective heating surface, placed in two rows with a firing space between. The grates are 12½ feet wide and 8 feet deep. The boilers are set higher from the floor than in older practice, and a continuous operating platform extends in front of each row of boilers, thus separating the boiler tenders from the firemen. The level of the operating platform is continuous with the floor of the operating room. The boiler backstays form a part of the structural steel of the building, and a steel floor, with railings, is constructed over the tops of the boilers, thus preventing radiation of heat, and avoiding accidents to the men. The gases from the boilers pass upward through round steel smoke uptakes, lined with brick, to steel smoke flues, also lined with brick, arranged so that the gases can pass to the chimney directly, or first through economizers. The immediate installation includes five radial brick chimneys 162 feet high from the base and 15 feet in diameter at the top, which is 236 feet above the street level. Each chimney weighs about 1,200 tons, and its base is carried on girders and columns, the division between the steel substructure and the masonry superstructure being 74 feet above the basement. This construction permits the use of the space under the chimneys for boilers. Each chimney is connected to twelve boilers, arranged symmetrically with respect to its center.

On the north side of the operating room there is an area for the electrical work, and on the south side an area for the steam auxiliary machinery. Extending through the operating room is a row of nine 8,000 to 10,000-horse-power engines, direct-connected to 5,000-kilowatt alternators, the row being broken, at the center of the structure, by an installation of four 2,000-horse-power turbo-generators for lighting purposes. The total capacity of the nine engines, together with the turbo-generating plant, will be 80,000-horse-power, when operating at their best efficiency, but it will be possible to operate this plant at 100,000-horse-power. To this should be added 30,000-horse-power proposed for a future generator equipment in the 108-foot extension at the western end, now in process of construction. Thus the total generating capacity of the completed plant can safely be placed at 130,000 horse-power. The engines are of the twin-compound type, having horizontal high-pressure cylinders and vertical low-pressure cylinders; the high-pressure cylinders being provided with mushroom or puppet valves for superheated steam. Each low-pressure cylinder is placed in direct relation with the condensing chamber of a barometric tube-condenser.

Six boilers are provided for each engine, and the entire plant is designed on a unit or sectional basis, the design of each section being identical with that of the others; that is, each section will consist of one chimney, twelve boilers and two engines, in connection with the respective auxiliary equipment for each engine, consisting of one boiler feed-pump, one feed-water heater and one condensing outfit. Each section can be disconnected from the general system by power-operated valves, thus permitting each section to be thrown out or operated independently. Power-operated valves are also supplied for each boiler and engine.

The steam main for each engine connects with six boilers by bent pipes, then passes straight to a center, back of the engine; thence it divides and connects to the twin-engine cylinders. At the point of division, a manifold system of curved equalizing pipes connects all the several mains when desired. All the pipe fittings are heavier than the socalled extra heavy fittings, all pipe being designed for the strains incident to 200 pounds pressure, with steam superheated to 500 degrees Fahrenheit, as all boilers, ultimately, will be provided with superheaters. All the main features of the piping system are located within the area for the steam auxiliary machinery, and are enclosed above. All manipulations required in operating the piping system can be conducted from an exterior gallery running along the south side of the operating room.



Partially Erected Framework, Boiler House at Right.

The atmospheric exhaust system is unusually ample, as one 48-inch exhaust pipe is provided for each section of two engines, so that the entire plant can be run on atmospheric exhaust. A new feature is the location of the auxiliary pump equipment for each engine. This is placed back of the engine, and is controlled from the point where the engine throttles are located.

All the electrical apparatus, on the north side of the operating room, is designed on the unit basis, and is controlled from a main operating pulpit in the center of the building, from which radiate all the wires, or "nerves," controlling the entire electrical equipment. The nine 5,000-kilowatt alternators generate energy at 11,000 volts, the alternators being of the three-phase, revolving-field type, for 25 cycles. An exciter plant of three motor-driven, and two engine-driven exciters, will be provided.

A Concrete-Steel Lighthouse.

A concrete-steel lighthouse has just been built by the Russian Government at Nicolaieff to light the canal which joins that town to the Black Sea. It has a thin circular shaft about 110 feet high which has a diameter of about 6½ feet at the top and straight sides slightly battered to a point about 40 feet above the base where the batter increases, and the sides are curved so as to widen to a diameter of 20.7 feet at the base. This shaft is set on a circular cup-like foundation 8 feet deep with a horizontal footing 28.2 feet in diameter. The side walls of the foundation are battered and within them there is a circular space 19.7 feet in diameter which is filled with earth and covered by the reinforced concrete floor of the shaft. The shaft is surmounted by a cylindrical chamber 14.8 feet in diameter inside and 9.8 feet high with reinforced concrete brackets carrying the overhanging floor. On top of the chamber there is a domed lantern about 6.8 feet in diameter and 13 feet high.

The shaft is made without interior divisions, floors or bracing and contains only a spiral staircase reaching to the upper chamber. The construction throughout of foundation, shaft, chamber, lantern and stairs is of reinforced concrete made in the proportion of 661 pounds of Portland cement, 14 cubic feet of coarse sand and 28 cubic feet of washed gravel. The reinforcement in the shaft consists of horizontal circular ¾-inch steel rods about 1 foot apart vertically and ⅞-inch vertical rods about 9 inches apart wired together at intersections and spliced by short pieces lapped and wired over the joints. The foundation walls are reinforced by rods in the vertical and battered faces, and horizontal tie pieces. The footing, which is 30 inches deep, is reinforced by ¼-inch horizontal rods at right angles to each other near the upper and lower surfaces. The brackets supporting the floor of the upper chamber are made integral with the walls of the shaft and the floor and have their under sides curved to form mouldings. They are reinforced by horizontal and inclined rods wired to the vertical rods in the shaft and by vertical and diagonal rods wired to those in the upper and lower flanges of the brackets. The walls and roof of the chamber and lantern are reinforced with simple vertical and horizontal rods.

The lighthouse was proportioned for a wind pressure of 55 pounds per square foot of the surface. All the reinforced rods were painted with cement grout before being bedded in the concrete. It is stated that the reinforced construction cost 40 per cent. less than a corresponding one entirely of brick or entirely of metal. The brick lighthouse would have weighed 1,365 tons against 460 tons which this one weighs. This structure was more fully described in a recent issue of the "Génie Civil."

Heat Transmission Data for Calculating the Proportions of Heating Systems.

At the meeting of the American Society of Heating and Ventilating Engineers, Mr. Charles F. Hauss, of Antwerp, Belgium, presented a paper on the calculating of heating systems, including a table, giving in English units the heat-transmission coefficients employed by Mr. Adolf Block, a practicing engineer of Hamburg. This has been reproduced so far as it concerns the coefficient for one degree difference between the temperatures of the air on the two surfaces of the building material, so that the coefficient for any temperature difference, as for 70 degrees difference, is obtained by multiplying the coefficient given by 70. For example, the coefficient of transmission for a 4¾-inch wall brick with air at 20 degrees Fahr. on one side and at 70 degrees on the other would be 24 British thermal units per square foot per hour. The table includes also a tabulation summary of additions to be made for undue exposure and also for unusual heights of ceiling. An addition is made to the calculated number of thermal units also for rooms that are heated daily, but where the heating is interrupted at night, and for rooms that are not heated daily. In the former case the addition is obtained in accordance with the following formula: $[0.0625\ (N-1)W] \div Z$, and in the latter by the formula $[0.1\ W(8+Z)] \div Z$, where W is the number of British thermal units lost per hour by the exposed surfaces; *W*, the number of British thermal units, including that for ventilation or change of air; N, the time in hours of the interruption; and Z the time in hours elapsing after fire is started before required room temperature is reached.

Coefficients of Heat Transmission, being the number of British thermal units transmitted per square foot of surface per hour per degree Fahrenheit difference in temperature.

Solid brick walls:
4¾-inch, 0.48; 20-inch, 0.22; 35-inch, 0.13
10-inch, 0.34; 25-inch, 0.18; 40-inch, 0.12
15-inch, 0.26; 30-inch, 0.16; 45-inch, 0.11
Solid sandstone walls:*
12-inch, 0.45; 28-inch, 0.29; 40-inch, 0.22
16-inch, 0.39; 32-inch, 0.26; 44-inch, 0.20
20-inch, 0.35; 36-inch, 0.24; 48-inch, 0.19
24-inch, 0.32
Solid plaster partitions:
1¾ to 2¼ inches, 0.60; 2½ to 3¼ inches, 0.48
Floors:
Joists with double floors, 0.07
Stone floor on arches, 0.20
Planks on earth, 0.16
Planks on asphalt, 0.20
Arch with air space, 0.09
Stones laid on earth, 0.08
Ceilings:
Joists with double floors, 0.10
Arch with air space, 0.14
Windows:
Single, 1.00; double, 0.46
Skylights:
Single, 1.06; double, 0.48
Doors, 0.40.
Additions:
For rooms with unusual exposure, 5 per cent.
For north, east, northeast, northwest and west exposures, 10 per cent.
Where ceiling is more than 13 ft. high, 3⅓ per cent.
Where ceiling is more than 15 ft. high, 6⅔ per cent.
Where ceiling is more than 18 ft. high, 10 per cent.

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*For limestone walls add 10 per cent.

Looking through Framing over Coal Bunker, Interborough Power House.

To illustrate the application of the coefficients, the author reproduced a table, for which calculations were given for a corner office 15x18 feet in plan and 12 feet high, thus containing 3,240 cubic feet. In single windows there were 112 square feet; with an outside temperature of zero, and a room temperature of 70 degrees, the coefficient from the table is 70, and 7,840 thermal units are lost per hour through them. There were 284 square feet of 20-inch outside, plastered, brick walls, for which the coefficient under the same conditions is 15.4; 364 square feet of 15-inch wall, of which 148 is not subject to a transmission of heat, being a partition wall between two heated rooms, but of which 216 lies between the room in question and an ante-room where a temperature of 50 degrees is maintained, so that the coefficient is 5.2; 270 square feet of floor subjected to a temperature difference of 35 degrees and thus having a coefficient of 2.45; a door of 32 square feet of surface to the ante-room, so that the temperature difference is 20 degrees and the coefficient 8; while the ceiling having a heated room over it is not subject to a transmission of heat. The room having a northwest exposure, the outside walls and windows have their heat transmission amounts augmented by 10 per cent.

It will be found that this room loses 15,473 thermal units, including those applied for the exposure, amounting to 1,220; and if ventilation is to be offered, 4,309 thermal units in addition will have to be supplied for a change of air once in the hour. The latter figure is calculated on the assumption that the outside air finds its way or is allowed into the room, and if sufficient in amount to bring about one change in the hour amounts to 3,240 cubic feet. As 0.019 thermal unit is necessary to heat one cubic foot of air one degree Fahr., to heat 3,240 cubic feet 70 degrees requires $70 \times 0.019 \times 3{,}240 = 4{,}309$. If more than one change of air is required, just so many times 4,309 would have to be added. For one change, the total thermal units per hour would thus be 19,782. A similar calculation was given for the ante-room, but in this the heat losses through the outside walls were in part compensated by the fact that there is a transmission through the partitions of the rooms that are maintained at a higher temperature, and this allowance, regarded as a source of heat, is subtracted from the heat losses, to obtain the resultant amount of heat that must be supplied by the radiation.

In calculating the radiation the author said that it is assumed that in a room heated to 70 degrees, one square foot of direct single-column radiation gives off 300 thermal units per square foot; two-column radiation gives off 275 thermal units; three-column radiation, 250 thermal units; and four-column radiation, 225 thermal units, with a pressure of 1½ pounds at the gauge. For the room losing 19,782 heat units in an hour, there would thus be required, say of two-column 38-inch radiation, 72 square feet.

The amount of boiler surface, the author stated, is also derived from the number of heat units necessary in the building. Thus, a round, one-piece fire-pot boiler, having principally direct fire surface, if fired with anthracite coal or coke will supply 4,400 to 5,000 heat units per square foot of fire surface per hour, and if fired with soft coal, from 3,700 to 4,000 heat units per square foot. A sectional boiler built especially as regards grate, etc., for coke, with principally direct fire surface, supply from 4,000 to 4,200 heat units per square foot; and other sectional boilers fired with bituminous or anthracite coal, from 2,600 to 4,000 heat units per square foot per hour. For hot water heating, the number of heat units necessary will of course remain the same, as will the fire surface of the boiler; only the radiation will be increased 60 per cent.

A hot air furnace with considerable extended surface, run at a comparatively low temperature, with easy firing will give off 450 to 550 heat units per square foot of fire surface, whereas one with smooth surface, and not too much flue travel, will give off 750 to 850 heat units per square foot per hour, and the air as it enters the room should be between 100 degrees and 125 degrees Fahrenheit.

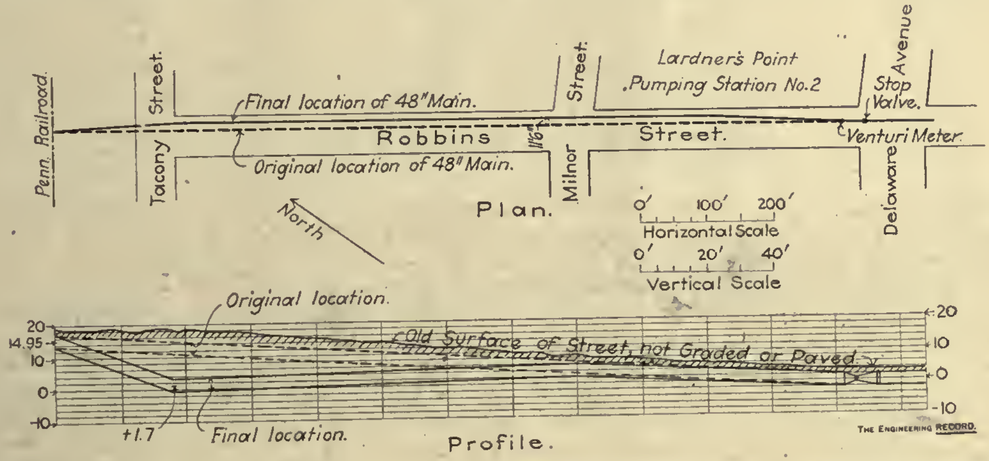
Relocating a Large Pumping Main under Pressure, at Philadelphia.

By Seth M. Van Loan, Bureau of Filtration, Assistant Engineer in Charge.

Before proceeding with the main feature herein described, it may be well to outline briefly the reasons why the undertaking was necessary and also show the conditions existing during the progress of the work. Since the year 1893 a portion of the water supply of the City of Philadelphia has been pumped at Lardner's Point on the Delaware River, through a 48-inch pipe to the Wentz Farm distributing reservoir, distant 4½ miles. This main supplies practically 29,000,000 gallons daily, the pressure of 70 pounds being maintained by the partial working of four pumps with a total capacity of 51,000,000 gallons. Under the improvement, filtration and extension of the water supply of Philadelphia, the capacity of the Lardner's Point pumping station is being increased to practically 300,000,000 gallons, necessitating a relative change for distribution purposes. This change involved the laying of four 60-inch mains, these being located between the boundaries of the street already occupied by the above mentioned 48-inch main, a condition requiring the removal and relocation of the latter.

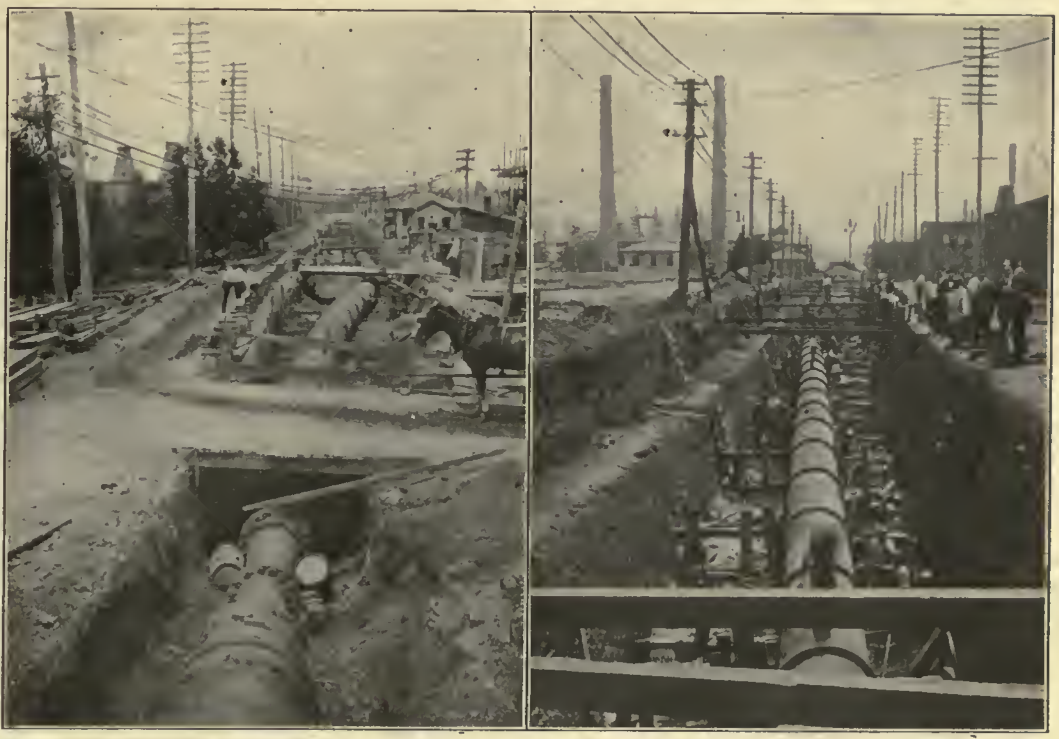
As the greater portion of the supply to the reservoir and distribution system is furnished, at the present time, through the existing 48-inch main, it may be readily understood that the city authorities would not allow a suspension of its service. Moving the main under pressure was the only alternative and it was the pleasure of the writer to be present during the relocation of same.

The original laying length of pipe was 1,194.45 feet, the limits being a Venturi-meter and stop valve on the easterly end, and the Pennsylvania Railroad on the westerly end. The ends showed a difference in elevation of practically 15 feet, the course being generally rising. The new location called for a deflection in alignment of 11 feet 6 inches, and at each end of the portion of pipe moved, a section 200 feet in length was allowed for this change. In order to effect certain connections with the new 60-inch mains a depression of 13 feet 2 inches was necessary, the same limit of 200 feet holding in this case. The plan and profile indicate the relative positions of the original and final alignment.



Using the deflection 11 feet 6 inches, and the depression 13 feet 2 inches, as sides of a rectangle, the diagonal would show as 17 feet 6 inches, being the deflection, if the pipe is assumed as revolving to a horizontal plane.

To place the pipe in its new position, the actual laying length was found to be practically 14 inches longer than in its original location, which indicated the necessity of drawing the points to that extent. It might appear that 14 inches distributed over 100 joints would offer no difficulties providing each joint would perform its respective duty, but the additional length was, in a measure, required at one end limited as is mentioned above to a distance of 200 feet. This increased length taken with the decided opening of the joints to break down on the established grade proved that the utmost care should be exercised.



Views Showing Lateral Deflection and Depth of Lowering.

The method of procedure was to prepare the trench for the final location of main, uncovering the pipe in question at the same operation. Excavation beneath the pipe followed, earth being removed about 2 feet below the barrel, leaving that section of earth which supported the blocking. Having prepared about 200 feet in this manner, the work of lowering was started and conducted uniformly by digging directly under the blocking. The greatest depression was the last to be placed in position, thus allowing any gain in pipe to work up to where it was most needed.

When a grade slightly above the final elevation was reached, skids were inserted beneath each length of pipe; on these skids were placed greased iron straps for a sliding surface and the work of moving laterally was started. Screw-jacks were used for this purpose, one on each pipe, placed about 18 inches from the bell end. The main was then worked over, following the same plan as in lowering. As a precaution to prevent buckling of the pipe, braces were placed on the side opposite the screws and these braces were shortened by sawing sections next to the pipe as moving advanced, thus insuring a tight grip and relieving the strain on the joints. The character of excavation greatly assisted the work, very little shoring of the sides of the trench being necessary, as may be seen in the photographs.

To guard against excessive pull in any joint, punch marks were placed on top and on each side of every pipe 3 inches from the bell of its neighbor. Small gauges were used continually at these marks and should a joint pull more than the adjacent ones, care was taken to relieve it by a manipulation of the screws. During the lateral moving the pipe revolved on its horizontal axis to a decided extent, in some cases as much as 100 degrees, due undoubtedly to the forcing of the pipe along the inclined skids. The lead in many joints was forced out ½ inch and in one case 1 inch, this latter joint being at the top of the sharp grade towards the railroad. A peculiar circumstance about this joint was that at no time during the work did it leak. Joints from which the lead had been forced were in no way disturbed unless water spurted from them, at which time just enough tapping with a chisel was applied to stop the leak. Several men were kept busy calking leaks and frequently extra lead had to be inserted and driven to stop the jets. Too much pounding of the joint was not allowed, it taking the life out of the lead.

The work of moving was accomplished in one month and only once was the pressure taken off the main, this resulting from the discovery of a cracked pipe, undoubtedly existing when the main was first laid. Bands were placed about this piece, which gave no more trouble. A careful measurement was taken after the pipe had been placed in position, and on account of a deviation from original lines and grades the actual increase in laying length showed 11 inches, a loss of 3 inches from the 14 inches, as was first laid off.

A rigid inspection was maintained both day and night during the relocation. Men were placed in sight of one another so as, in case of an emergency, to signal the engineers at the pumping station and those stationed at the nearest stop valves, the former to shut off pumps and the latter to relieve the pipe from back pressure. Had a break occurred enormous damage and probable loss of life would have followed.

The same contract included moving a 30-inch pumping main in the same street as the 48-inch, but as its service could be dispensed with the pipes were moved to their new position separately or in several-length sections.

The work under construction is in charge of Mr. John W. Hill, chief engineer of the Bureau of Filtration, and is being performed by contractors Harmer & Quinn, Philadelphia.

Condensing Water taken from an arm of San Francisco Bay for a plant at Alto, Cal., for an electric railway from San Francisco to San Rafael, is impounded at high tides by means of a flood gate in a reservoir. The difference in elevation in tides is 5 to 6 feet and the occurrence of high tide every 11 to 13 hours.

The Ambridge Plant of the American Bridge Company.

Part X.—Machine Shop and Foundry; Summary.

Structural Design.—The 116x252-foot machine shop and foundry of same dimensions are similar buildings located on the east and west sides of the pattern shop and tempering shop at the south end of the plant. They are served on opposite sides by the main lines of the yard surface tracks and by the narrow-gauge belt line which makes a loop around the machine shop. They are also served by a transverse yard crane across the north ends of both shops. Provision is made for doubling the length of each shop by an extension on the south end which will reach to another transverse yard crane. Both shops have four longitudinal rows of columns which divide them each into one 60-foot center aisle and two 28-foot side aisles. The wall columns are 12 feet apart on centers and carry directly the outer ends of the side aisle roof trusses. The columns in the inner rows are 36 feet apart on centers and are connected by longitudinal trusses which support the center aisle roof trusses and the inner ends of the side aisle roof trusses. The roof trusses are connected by the purlins, by the traveling crane runway girders, and by transverse X-bracing in the end and four intermediate panels. This bracing is continued to the ground through the wall panels and the walls are additionally braced by the channel studs and girts used for the concrete filling and for the window and door framing. The roofs are steeply pitched, have five 60-inch tubular ventilators on the center line of each, and are covered with slate on 2½-inch planks.

The trusses are proportioned for dead load, crane loads and for a roof load of 55 pounds per square foot of roof surface. The sides of the buildings are proportioned for stresses from a wind pressure of 30 pounds per square foot of vertical surface. Provision is also made for 25 per cent. of the crane loads for impact and 20 per cent. for traction. Working stresses of 18,000 pounds per square inch in tension and $P = 18{,}000 \div [1 + (b^2 \div 12{,}500r^2)]$ in compression are used except in the office floor and foundry charging floor, where, for tension, $P = 16{,}000$ pounds, and for compression $P = 16{,}000 \div [1 + (b^2 \div 12{,}500r^2)]$. The above values apply to the stresses from the roof and dead loads plus the crane stresses and their impact allowance. For stresses due to wind load and crane traction unit, values of 24,000 pounds per square inch are allowed. Shop-driven rivets have values of 12,300 pounds shearing and 24,600 pounds bearing, where 18,000 pounds is used in the numerator of the formula, and 11,000 pounds shearing and 22,000 pounds bearing where 16,000 pounds is used in the formula. The value of field rivets is assumed to be 80 per cent. that of shop rivets. All material is open hearth steel with an ultimate strength of 55,000 to 65,000 pounds per square inch. The maximum bearing on masonry is 300 pounds per square inch. All field connections of trusses, trusses to columns, crane bracing and beam connections in floors are riveted. All field connections for purlins, wall framing and bracing, except for crane bracing, are bolted.

The walls are made with concrete 8 inches thick up to the lower chords of the trusses and with 2-inch concrete on metal lath above that level. There are a number of Kinnear doors 12 feet wide and 16 feet high in the ends and sides of the building, and in the ends are four tiers of windows which occupy more than half of the wall space. In the sides of the building there is one tier of windows in the main walls and another in the clere-story walls. The lower sash of the lower tier has clear glass, the others have ribbed glass.

Crane Service.—The foundry and machine shop differ chiefly in the special provision in the former for the charging floor and the cupolas and in different arrangements of traveling cranes. Both buildings are served in the center aisle by two 25-ton cranes of 60-foot span and by parallel sets of 10-ton cranes which run clear of them overhead. Each set contains two 10-ton cranes of about 27½-foot span with their runway girders carried at one end on the wall columns and at the other on cantilever girders suspended from the roof trusses. The runways for the 60-foot cranes are carried on the tops of the main columns, the latter being offset to carry the roof trusses clear of the runways. In the foundry there are on each side of the main aisle two or more walking jib-cranes of 20-foot radius and 5-ton capacity. These are supported at the bottom by double-flanged wheels on rails at floor level. At the top they have flangeless horizontal wheels engaging reaction girders carried by brackets web-connected to the sides of the runway girders for the 25-ton cranes. The side aisles are each served by two 2-ton cranes of 27½-foot span with I-beam runway girders carried on column brackets.

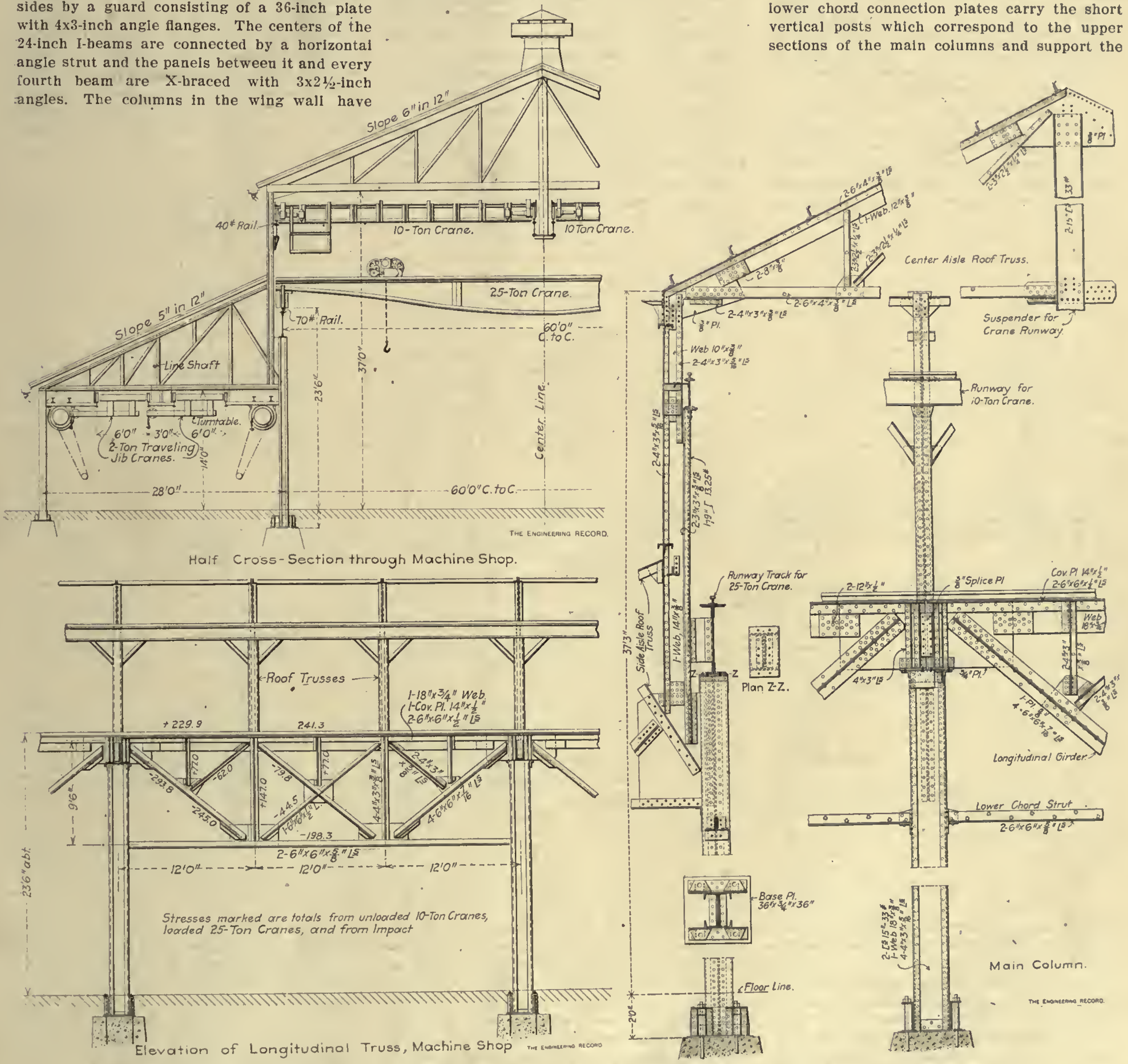
In the machine shop there are no walking jib-cranes, and the side aisles are served by two sets of traveling jib-cranes. These cranes have 6-foot-gauge tracks 3 feet apart suspended from the roof trusses of the leantos. They are of a type designed to serve the small machine tools in the galleries of the Pencoyd machine shop, where they have been found very convenient and satisfactory. Each crane has a trolley with two axles 7 feet apart having double-flanged wheels and two pulleys. The front axle is geared to a 2½-horse-power motor and drives the rear axle by belts at each end. The truck frame carries a cast-steel turntable 5 feet in diameter, which has an L-shaped cross-section supporting an L-shaped ring on one hundred and seventy-five 1-inch hardened steel balls between grooves in their horizontal lower flanges. To the ring is bolted a frame which projects about 2 feet clear of the lower side and carries a 6-horse-power motor and a horizontal jib with an effective radius of 6 feet. The motor operates a right and left handed grooved drum for the hoist ropes, which pass over two fixed sheaves at the point of the boom. The traverse and the hoist of the crane are thus operated by power and it is revolved by hand. The two sets of cranes together command all the space for a width of 18 feet and overlap 2 feet in the center of the aisle. The extreme positions of their jibs just clear the pulleys on the counter shafts suspended from the columns and roof trusses on the sides of the aisles. The countershafts are driven from a line shaft in the center of the aisle attached to the middle vertical post in the roof truss and operated by electric motors of from 7½ to 20-horse-power, which are located on platforms on the lower chords of the roof trusses and drive groups of lathes and other small machine tools.

Steel Framework.—In both foundry and machine shop the office is an 18x20-foot wing in the center of the north end, and the foundry alone has a 15x72-foot wing on one side near the end, which serves as a charging floor for the cupolas and has a 12x15-foot receiving platform at each end, where material is delivered from the standard-gauge surface track alongside. Opposite this wing there is a transept or large dormer with double-pitched roof at right angles to the main roof and forming valleys with it, which is framed with special rafters and purlins. Special horizontal X-bracing of single 3x2½-inch angles is introduced in the planes of the lower chords of the trusses in this part of the building. The charging platform forms a second story 19 feet above the main floor, extends across the side aisle of the building and has a floor of 24-inch I-beams about 30 inches apart covered with 12-inch channels laid flat and supported inside the main building on plate-girders 28 feet apart carried by one-story columns. The floor is proportioned for a distributed load of 500 pounds per square foot, and is protected around all sides by a guard consisting of a 36-inch plate with 4x3-inch angle flanges. The centers of the 24-inch I-beams are connected by a horizontal angle strut and the panels between it and every fourth beam are X-braced with 3x2½-inch angles. The columns in the wing wall have special bases to receive additional columns supporting the girders of a future runway for a 60-foot traveling crane of 10 tons capacity, which has a clearance of about 11 feet above the charging floor.

The longitudinal trusses which carry the transverse roof trusses are latticed girders 9½ feet deep and 36 feet long on centers. They are made with 12-foot panels corresponding to the spacing of the roof trusses, and the top chord is supported at center points by sub-verticals. All members are made with pairs or double pairs of angles riveted to connection plates between their webs. The top chord has a T-shaped cross-section made with an 18x¾-inch web-plate, a 14x½-inch cover-plate and two 6x6x½-inch flange angles and carries the rail for the main traveling girder. The trusses are supported by seats at the ends of their top chords which rest on the column caps and are web-spliced together at their center lines. The lower chords are continued through the end panels to connections with the columns to afford additional rigidity.

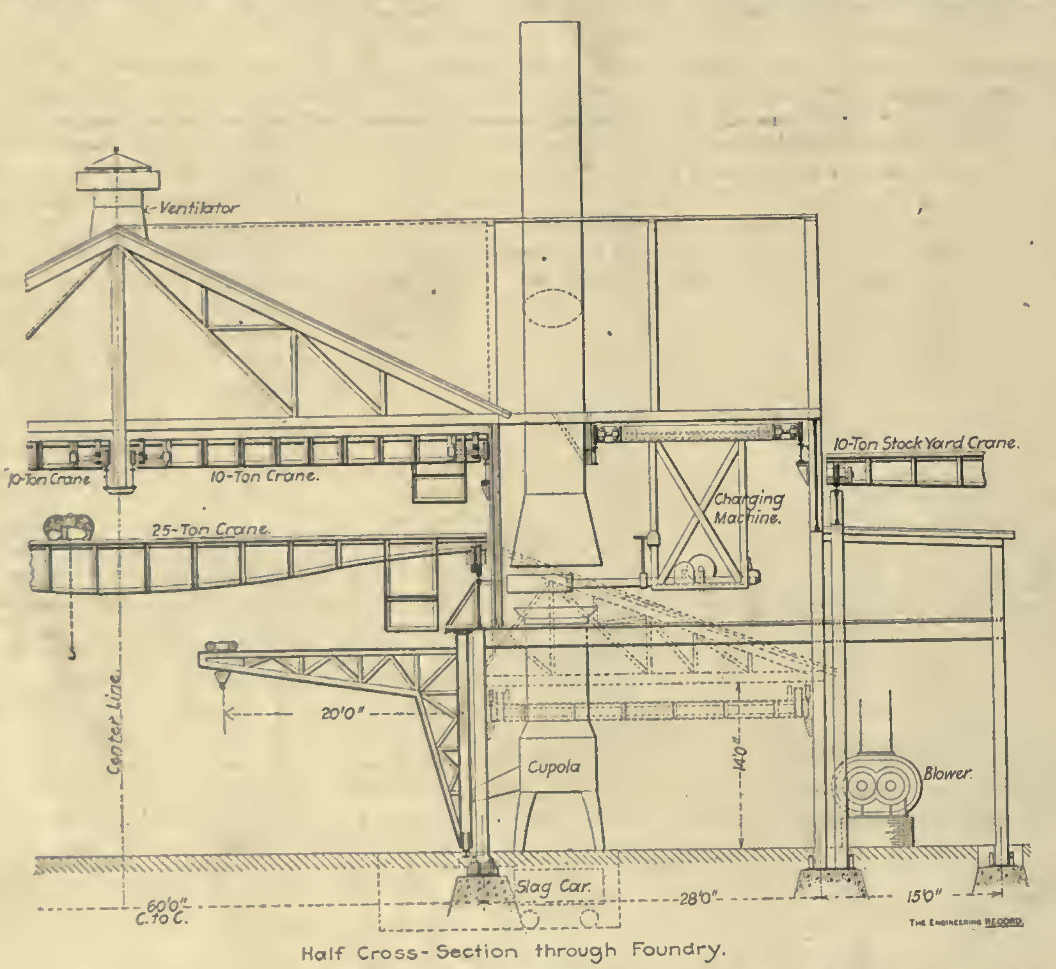
The main columns are substantially vertical plate-girders with their webs parallel to the longitudinal axis of the shop. The lower section is about 22 feet high and carries at the top a heavy diaphragm bracketed to the center of the web-plate on the side toward the main aisle. To this web-plate is shop-riveted the upper section of the column which is 12 feet long to the seat of the upper crane runway, where it is offset and again continued about 5 feet to the connection with the center aisle roof truss. The diaphragm at the top of the lower section receives the field-riveted connection to the lower chord and inclined end post of the side aisle roof truss, and the top chord of the latter is flange-connected to the upper section of the column. The column has a base plate 3 feet square which is stiffened by vertical webs riveted to both flanges of the column and having at the opper edge reinforced bearings for the anchor bolts. The intermediate roof trusses in the side aisles are web-connected to the vertical posts in the longitudinal trusses, as shown by the cross-section of the latter. Their end lower chord connection plates carry the short vertical posts which correspond to the upper sections of the main columns and support the center aisle roof trusses and the runway girders for the upper tiers of traveling cranes.

The walls of both machine shop and foundry conform to the Ambridge standard and have, except at the corners, columns with I-shaped cross-sections partly embedded in the concrete, from which the inner flanges project, as indicated in the detail. The corner columns are similar to the intermediate columns, except that the outside plates project beyond the flanges to receive small corner angles. Where the inner surface of the concrete intersects the

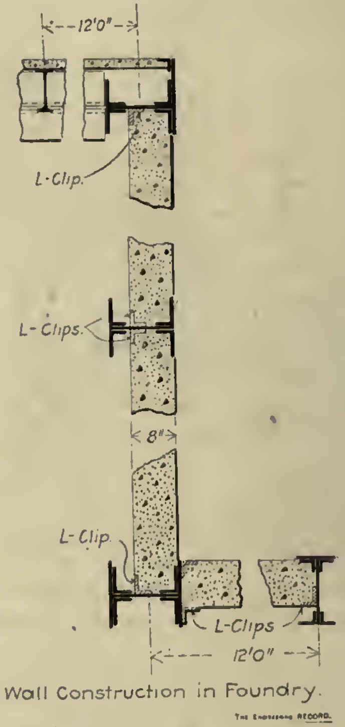


Machine Shop, Ambridge Plant of the American Bridge Company: Main Columns and Connections to Trusses and Girders.

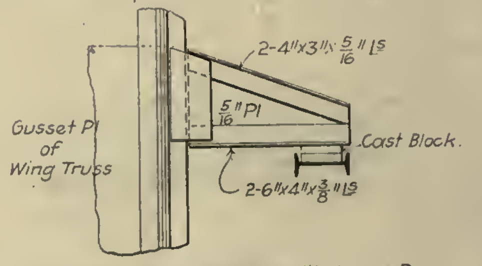
column web, it is bound with a small corner angle, as shown in the detail. The main end columns have special cross-sections to provide for the extra loading. The weight of structural steel is 1,200,000 pounds in the foundry and 1,000,000 pounds in the machine shop.



Half Cross-Section through Foundry.



Wall Construction in Foundry.



Intermediate Bracket for Jib-Crane Runway, in Foundry

A Few Details of the Foundry at the Ambridge Plant of the American Bridge Company.

Equipment.—The foundry will be equipped with two open-top cupolas of 66-inch and 45-inch internal diameters served by an electrical charging machine with a radial arm. The cupola bottom will be dumped directly into a car in the pit and transferred to a rumbler, from which the dust is exhausted and the broken slag and iron discharged into a separator which will save the iron. A Tilghman type sand-blast apparatus will be provided for cleaning castings. All burnt sand will be collected by a special night gang and delivered to a Chileau mill, mixed with the proper proportion of new sand and thence delivered to a Sellers mixer, from which it will be carried to the moulding floor by a bucket hoist and conveyor, so as to provide for a continuous supply and prevent unnecessary waste. The pig-iron stock yard will eventually be covered by a traveling crane of 60-foot span and 10 tons capacity to carry the loaded buggies from all parts and deliver them to the charging platform so as to obviate all necessity for surface tracks in the stock yard, except those for the delivery of material from the railroad.

There will be a longitudinal narrow-gauge surface track extending through each aisle of the machine shop from end to end. These tracks will be crossed by a transverse narrow-gauge track near the middle of the building. There will be no tracks in the center aisle of the building, where the largest machine tools will be arranged close to the columns, the middle space being left clear for large work, which is handled by the traveling crane. The tools will be arranged according to class so as to concentrate the different kinds of work. All lathes will be on one side of the shop, drills in another place, shapers in another, and so on. The smaller machines will be installed on both sides of each side aisle, and in all cases they will be arranged so that the operators will face the centers of their respective aisles. The larger tools will be driven by separate electric motors and the smaller ones will be arranged in groups, each of them driven by a motor located overhead and belted to a jack shaft suspended from the roof truss. Many of the tools will be sent to Ambridge from the other plants belonging to the American Bridge Company, and there will also be many new machines. The equipment will include five planers from 36 to 60 inches wide, eight shapers of 20 to 28-inch stroke, two slotters of 12 and 22-inch stroke, three horizontal boring mills, one radial drill, nine vertical drills of 20 to 42-inch swing, two grinders, one emery wheel, one milling machine, twenty-four lathes of 15-inch swing and 6-foot bed up to 50-inch swing and 24-foot bed, one cut-off machine, four centering machines, a gear cutter and a cold saw. A total force of 150 men will be employed in this shop.

This article concludes the series of ten describing the new Ambridge plant of the American Bridge Company, publication of which was begun November 31, 1903. These $5,000,000 works, occupying 150 acres, with fifteen principal buildings, some of them unusually large, constituting by far the largest bridge and structural steel plant in the world, are designed for an annual output of 576,000,000 pounds, with a total force of about 6,000 men. Principles which have had governing weight in the scheming of the property are: The classification and separation of the various kinds of work to be done, assigning a building to each of the more important divisions, but grouping them so as to realize the most advantageous degree of co-operation; the always-forward movement from the receiving of the raw materials to the shipping of structures; the minimizing of manual labor by the liberal use of power tools, including many special machines of great capacity; maximum convenience and rapidity in handling and transporting materials and product, accomplished by extensive inter-related systems of yard and shop surface tracks, gantries and traveling cranes; minimum obstruction by columns or other supports in shops for the fabrication of long members of bridges or other structures; ample storage spaces at convenient points for partially completed members as well as for raw materials; benefiting by experience gained at other plants and in the construction and erection of a great number and variety of bridges and buildings.

Careful provision has been made for the accommodation of an office corps of about 1,000 men and for the comfort and sanitary welfare of the shop workmen. The construction of the plant is now well advanced, and portions of it are already in operation and yielding a considerable output. The plant has been designed and constructed under the direction of Mr. Paul L. Wolfel, chief engineer, and Mr. James Christie, mechanical engineer of the American Bridge Company, aided by a staff of experts selected from among men of long experience in executive and technical positions in the service of the Company and its many constituent corporations, including a large number of the bridge builders of the country. Acknowledgment is made to the chief engineer and the mechanical engineer, with their staff, for a large amount of data and great pains in its explanation and for the revision of the descriptions, thus making possible the presentation of so much accurate detail in these columns.

The Cost of Boiler-Room Labor, covering coal and ash handling, was given at figures that range from 21 to 57.2 cents per ton of coal used, in a recent question-box discussion, conducted by the Pennsylvania State Street Railway Association.

A Plea for Re-Enforced Concrete.*

By Julius Kahn, Assoc. M. Am. Soc. C. E.

There have been so many failures in re-enforced concrete buildings of late, that it becomes a matter of importance and self-protection for every engineer and architect designing in this type of construction to reflect and study their cause. If this construction is all that has been claimed for it by men of prominence, if large and important works of engineering have been successfully and economically accomplished, then, indeed, re-enforced concrete has come to stay, and the engineer must awaken to its study that he may hold his position in the line of progress of the engineering world. If, on the other hand, this type of construction is unscientific and theoretically unsound, then, indeed, it is his duty to condemn it and exert himself towards its non-adoption.

The writer has given this subject considerable study and feels such perfect confidence in re-enforced concrete that he cannot bear to sit by quietly and allow what he considers a most beautiful field of construction to be ruined by the incompetence of the men who so largely work therein. He feels it his duty, therefore, to place his views regarding some of the failures of re-enforced concrete before the public, and he trusts that architects and engineers may agree with him, and possibly be more cautious in the design of works of this nature, and in entrusting the same to men of competence and conscience.

The failures of concrete are generally due to one of the following causes: First, weak and insufficient centering; second, bad material and mixing; third, insufficient and improper re-enforcement.

It is, of course, of primary importance that the centering for these structures should be sufficiently strong to carry the dead weight of the concrete while it is as yet green and unset. In a number of failures which have been described in engineering journals up to the present, the centering collapsed under the dead weight, allowing the heavy concrete to fall on the floors below, and carrying these with it. Such failures as these are, of course, entirely inexcusable. The writer does not feel it important to lay stress on this matter of centering; common sense alone should dictate the importance of making it sufficiently strong.

Regarding the materials used for re-enforced concrete, it is, of course, essential that these be of the very best grades. Portland cement is manufactured in this country of such excellent quality and at such a low price, tests are so readily made thereon with even the simplest appliances, that the use of poor cement is hardly excusable. As for clean, sharp sand and broken stone or gravel, these are procurable almost everywhere. Regarding the mixing of concrete, there are on the market at the present time a number of makes of very excellent machine concrete mixers; and where conscientious workmanship exists, no reason can be given for the poor handling of materials.

The writer sincerely believes that the majority of contractors who are working in this type of construction are conscientious, and that they make every attempt at good, honest workmanship. Unfortunately, however, only very few possess a scientific knowledge of the materials with which they are dealing, and their work at its best is mere speculation, which, if it stays in position after loads are applied, is considered successful, and if it falls down, is called a failure. Such a time for judgment is late indeed, and the lesson generally costs the reputation gained after a life of hard toil.

Bad materials and workmanship are the generally credited causes for the failure of concrete structures, but the writer is absolutely certain that in the majority of cases where our leading engineering journals have held out in this manner, the causes were of a different nature. Let us consider for a moment some of the types of re-enforcement used for long span floor systems at the present day. Among those most prominent are expanded metal, wire cloth, and plain or deformed rods.

Regarding the first two of these constructions, the writer has come into repeated contact with standard floors about as follows: Spans up to 22 feet; thickness of floors, 5 and 6 inches; material, cinder concrete; area of re-enforcement per foot of linear cross-section of floor, 3/16 to ¼ inch; the floors being in the majority of cases a single slab. If a floor of 22 feet span were constructed of 6-inch I-beams placed side by side as closely as their flanges would allow, and such a floor subjected to the ordinary lightest live loading, together with the plaster and wood floor, the same would deflect from 2/3 to ¾ inch. And yet, these concerns who pretend leadership in re-enforced concrete constructions, have built them repeatedly of concrete, re-enforced as above, using even cinders instead of stone, and producing concrete with only one-half the strength of stone concrete. Are failures of such constructions as these to be made the argument for the abolishment of re-enforced concrete? If, on the other hand, such constructions as these do stand, as proves to be the case with but few exceptions, then indeed we may expect in scientifically constructed works of this nature, wonderful possibilities; and, for the progressive engineer, a new field has opened, wherein he may design with greater economy than he has ever done heretofore, where his structures may have the permanency of masonry and yet the strength of steel, with the fireproof, rustproof and rotproof qualities of concrete, together with that wonderful property of all cement construction, its increasing strength with age.

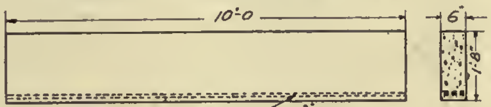


Fig 1

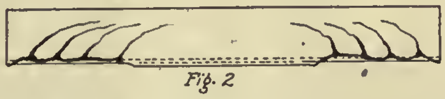


Fig. 2

The writer has seen floors re-enforced with expanded metal, as above described, deflecting as much as 3 inches, immediately on the removal of centering, after the concrete had been allowed to set for a month or more. How it could possibly do otherwise than deflect, was to him more of a problem than that it should fall down. In spans where the writer should deem it necessary to insert at least ¾ square inch of metal per running foot of floor, he has seen expanded metal floors stand up with less than ¼ square inch. Who should be blamed for failures such as these? Is it a fault of concrete, is it poor mixing, or is it the ignorant boldness of a concern dealing in what they do not understand?

The writer knows of concrete floors 6 inches thick and 22 feet span, with nothing more embedded therein than a wire cloth, with occasional cables of similar wire, one-half inch in diameter, the total re-enforcement providing a cross-sectional area of steel per running foot of floor of about one-eighth square inch. As already said above, even common sense engineering should protest at a floor designed in this manner. If a floor were specified to be of such thickness and span, by all the rules in creation the writer could not calculate it strong enough with less than three-fourths of a square inch of metal per running foot, and, although structures designed as above do stand, their factor of safety is probably one and a half, at full loading at rare occasions it may be two, and sometimes, a little less than one, in which case we have the natural collapse. Our patrons of wire cloth will tell us of the high tensile strength of the wire, but only recently the writer had occasion to test a sample of the most largely used brand and found its strength to be only slightly above 60,000 pounds per square inch.

The failures which have occurred by the use of plain or deformed rods, are also becoming quite common, and a little study of the method of failure will at once bring forth the large faults in design. The generally adopted arrangement of re-enforcement with rods has been to embed them along the lower edge of concrete floorbeam for the purpose of supplying the tensional strength in which concrete itself is so largely lacking. The principle of supplying steel in this locality is proper enough, and the generally adopted methods by engineers of the quantity of steel required at the center, possibly true enough providing the beam actually failed there at test to destruction. But the fact of the matter is, a beam re-enforced in this manner and subjected to stress, so that its shearing as well as bending strains are developed, rarely fails in this manner, and our calculations for the beam have therefore been made for the wrong place in the beam. Such a beam will invariably fail by the shearing of the concrete at the ends, diagonally from the point of application of the load, or longitudinally along the re-enforcement bars. Take, for example, a given beam, as shown in Figure 1, wherein the re-enforcement is horizontal only. Assuming such a beam to be 6 inches wide and 20 inches deep, and to have three ¾-inch bars embedded along the bottom edge. Such a beam, if the full safe strength of the metal were developed, should have a carrying capacity of about 25,000 pounds uniformly distributed, and if a factor of safety of four has been assumed, it should carry 100,000 pounds before failure. Now regarding for a moment this beam in shear, its cross-sectional area is 120 square inches, and assuming the safe shearing value of concrete to be 50 pounds per square inch, the beam would only carry a safe load of 6,000 pounds in shear, instead of 25,000, as it should do when bending moment alone is considered. The writer has made a number of tests on concrete in shear, and has rarely obtained results larger than 250 to 300 pounds per square inch. It is evident that a beam thus re-enforced is exceedingly weak in shear.

Vertical shear is, however, not alone to be considered. The matter of longitudinal shear along the steel re-enforcement is of equal importance. In an ordinary steel girder it is generally agreed that the vertical shear is transmitted into the bottom horizontal chord within a distance equal to the depth of the girder. There is no reason to suppose that this principle does not apply with equal truth to re-enforced concrete girders, and according to this the shear of 12,500 pounds should be carried from the concrete into the steel within a distance equal to the depth of the girder; which means that the safe adhesion between three ¾-inch bars and the concrete within a length of 20 inches should be 12,500 pounds. Ordinarily where a large body of concrete surrounds a bar, it is safe to count on an adhesive stress of about 50 pounds per square inch, which would produce a safe loading of about 12,000 pounds, but in this case the bottom of the concrete beam has been so cut up with steel that even if the required adhesion were there, the layer of concrete immediately surrounding the bars would not be capable of transmitting this stress. If the steel is to receive a stress of 12,500 pounds the concrete must transmit the same into it within a length of 20 inches. It is ridiculous to assume that a layer of concrete 6 inches wide, cut up by three bars such as this, is capable of transmitting safely such stress.

The general method of failure above described is, therefore, a common one, and whether the rod be plain, twisted, corrugated or bulbed, adds very little to the strength of the concrete. It is the *layer of concrete* immediately surrounding the bar which is incapable of transmitting the longitudinal shearing stress and which fails; the matter of adhesion is but a small factor in comparison with this. But, neglecting even this inability of the concrete to transmit such shearing stress, the writer has seen re-enforced concrete beams constructed by some of the leading re-enforced concrete concerns in this country, where the bottom of the beam was so cut up with twisted and otherwise deformed rods, that a portion of it fell off without any load whatever being on the beam, and leaving the rods entirely exposed thereby.

To take up the vertical shear, it is generally recognized that some form of vertical re-enforcement is necessary, and Hennebique and other contractors in concrete have supplied stirrups set up loosely about the rods. To the writer such stirrups seem unable to accomplish the necessary results. In the first place, shear cracks generally occur as shown in Figure 2, being inclined to the vertical at an angle of about 45 degrees. If vertical re-enforcement is necessary at all, it should cross these lines of rupture at right angles to hold together the concrete at places where the natural tendency is to open up. In the second place, if this vertical re-enforcement is to carry stresses at all, it should carry the same into the bottom chord member, and should therefore be rigidly connected with the same. These two principles seem to the writer just as important of observance as the placing of steel in the bottom. Hennebique supplies the stirrups, but, in the first place, he sets them in a wrong direction, and secondly, he makes absolutely no connection between them and the main steel bars.

To review the matter of vertical re-enforcement, therefore, it seems to the writer that designs wherein vertical re-enforcement is entirely omitted are very dangerous, and where this re-enforcement is in the form of vertical stirrups, they are decidedly faulty although perhaps not equally dangerous. In the calculation of a steel structure, the engineer is very careful about the design and detail of every joint. Neglect to take into account a single connection may cause failure. Why, then, expect a re-enforced concrete construction to take its full loading when only half way re-enforced? It is true many accidents have occurred, but it is also true that the field of re-enforced concrete is remarkably new and difficult; it requires great care and accuracy, and should be handled by men of understanding only.

Would a construction engineer, under ordinary circumstances, submit the safety of his structures to the design of an ordinary layman unacquainted with the materials at hand? If be insists upon experience here, how much more so should experience and careful thought be insisted upon in the design of re-enforced concrete, where the structure is of a composite nature and everything about it is absolutely new! But the fact of the matter is, that nine-tenths of the concerns now erecting buildings in this material neither employ an engineer nor have the slightest theoretical knowledge themselves in the calculation of the structures with which they are dealing.

Constructions in re-enforced concrete designed by engineers have failed but rarely, because as a rule these men have used their technical knowledge and an inborn conservative caution in design. But where men have lacked such technical knowledge, they have invariably entrusted the work to concerns who specialize in concrete, and who have been paving or sidewalk contractors before. Such contractors are not so much to blame. They have faith in a material which, if well made, has wonderful properties indeed, and they are willing to risk their all for it. But anyone who entrusts this construction with them is certainly guilty of gross negligence; for the problem requires fully the same scientific study as the steel skeleton frame, and demands the most skilful engineering knowledge.

Another matter wherein engineers are possibly at fault is the careless manner in which formulas are sent about by some parties with the assurance that structures will be safe if they are designed in accordance with them. On a recent occasion the writer visited the engineering office of one of the leading railway companies, where, in order to satisfy themselves regarding the uses of re-enforced concrete for culverts and the accuracy of the formula advanced by some well known concerns, a number of experiments had been made, using one of the generally accepted types of deformed rods. Beams were designed for safe loads of 20,000 pounds. It had been assumed in their calculation, that the steel was to carry the entire tension of the beam and naturally fail at test to ultimate destruction. The beams failed with loads in the neighborhood of 21,500 pounds, showing a factor of safety, therefore, of a little above one, instead of six or seven, as should be required for such structures. These beams were built with the usual horizontal re-enforcement only; not even stirrups had been recommended. A single one of some twenty or more similar tests, made at a well known university, on 8x12-inch re-enforced concrete beams of 11-foot span, showed failure at 18,700 pounds. The safe strength, according to generally adopted formulas, if the steel had been strained to its complete tensile strength, should have been about 8,000 pounds, showing a factor of safety a little above two. In all of these cases the beams failed, shearing the concrete as usual, long before the ultimate strength of the steel came into play.

The writer does not believe, however, that the failure of beams re-enforced in the usual manner, at a load less than the theoretically calculated load, is as bad as the fact that the concrete has failed in preference to the steel re-enforcement. He believes that a test structure should fail by the parting of the steel. Concrete, as well as all masonry, is granular and brittle, and fails invariably by a sudden collapse in shear. In order that a structure should carry a moving load, especially in railroad work, it should be an elastic structure capable of yielding under strain and of large deflection before destruction. For this very reason an engineer does not allow a high carbon steel to be used in steel bridge construction subjected to rapidly shifting loads. If the concrete carries an undue proportion of strains, and if this is a brittle material, then indeed such a construction is dangerous, where subjected to sudden impact. It is like dropping an anvil on a cube of glass. If, on the other hand, the principal stresses are taken up by the steel, and if the concrete is subjected to compression alone, and if it is known that at ultimate destruction such a structure fails by drawing the steel in two at place of maximum bending moment, then indeed we have an elastic structure. Good mild steel will stretch as much as twenty per cent. of its length before failure, and a structure properly re-enforced so that slipping of steel is impossible, and where shear, both vertical and longitudinal, are well provided for, should deflect as much as 12 inches or more before failure, depending entirely on the span and depth of beam. Such a construction as this would be scientific indeed. It would possess the rigidity of concrete together with the elasticity of the steel. It would have resistance, and give ample warning before failure when overloaded. Such construction alone seems safe to the writer for use on building and railroad work, and any construction wherein concrete fails by shear, most decidedly dangerous. Almost any structure that can be built of steel can be erected in re-enforced concrete, at an economy of as much as fifty per cent. at times. All of the advantages of steel may be obtained without any of the disadvantages, if concrete is properly re-enforced; and combined with these advantages, are the beautiful and remarkable properties of the permanency of good concrete.

If a material may be subjected to rough treatment should this be a reason for discarding it? If in a structure costing twenty or thirty thousand dollars a saving has been made of from five to ten thousand, would this not be ample to pay for the employment of a good, careful inspector? Why do we insist on a mill inspector, a shop inspector, and a building inspector, for steel work, and on the other hand allow sidewalk contractors to erect our most costly re-enforced concrete structures? Does the blame lie with the contractor? Whoever turns responsible scientific work over to a man lacking knowledge of the materials with which he is dealing, is just as much, and even more so, to blame.

The writer feels himself somewhat at a disadvantage in discussing re-enforced concrete, being a patentee of several methods of re-enforcement; at the same time, self-protection as well as the interests of all engineers specializing in this class of work, demands that some reason be given for the large number of failures repeatedly occurring. In the writer's early practice a large amount of concrete work was done for him by a number of concerns representing well known systems. It was the wretched, unscientific work of these parties which compelled him, for his own self-preservation, to study this new field, in order that he might prevent them from having catastrophies in his own buildings, for which they had previously submitted every sort of guarantee with bonds. Observing these wretched methods of re-enforcement and studying the failure of concrete beams, he decided upon certain methods being most theoretically perfect and subsequently secured patents for them.

Although the writer lays great stress on the nature of the materials used and its mixing, he believes that the matter of re-enforcement is a dozen times more important, and he ventures to say, that even the poorest mixture of concrete, if it were properly re-enforced, would carry large loads before failure. Under safe loading the concrete should not be stressed more than 400 pounds per square inch in compression, and a mixture must be very weak indeed which will not stand four or five times that weight. If the nature of the re-enforcement be such that the concrete is subjected to compressive stress only, and the steel takes all tensile strains whatever their location may be, then failure seems almost impossible under safe loading.

In concrete structures erected by the writer, the centering has at times been removed with perfect safety at the end of three days. Surely the concrete had not set to sufficient hardness to carry heavy strains other than compression at that length of time. Tension and shear had been entirely provided for in these, and the writer knew very well that even at the end of three days the concrete had sufficient hardness to carry three or four hundred pounds per square inch in compression, and, therefore, the safe load.

Proper re-enforcement is the first essential, good material and mixing are only secondary as compared with this. The writer has embedded his system of re-enforcement in a beam of ice of 14 feet span, and otherwise the usual dimensions of a concrete beam, and then imposed heavy loads thereon. Surely, great shearing and compressive resistances were lacking here; surely even the poorest mud concrete should equal this construction, and yet the beam stood up like a rock under loading. Is this sufficient proof that proper re-enforcement has something to do with the safety of re-enforced concrete structures?

A Peculiar Explosion in a Sewer in Greenwich, England, is reported in a recent issue of the "Journal of Gas Lighting & Water Supply." By accident a large quantity of naphtha found its way into a drain on the premises of the Metropolitan Gas Company, and, mingling with hot water discharged from various factories, generated a highly inflammable gas. Men working in the sewers were warned not to take lights into the sewers probably affected, and to be quite safe, the men thought they would test another part before entering. The man in charge of the gang, who was standing about 3 feet from the side entrance shaft, struck a match, whereupon the air round the mouth of the entrance ignited and an explosion followed. The gas in the sewer was then fired, and, running along against the flow of sewage, caused explosions in every side entrance, gallery, and shaft, as well as in the pockets under the manhole covers in the center of the road, blowing them from their bedding. The accident happened at 8.40 A. M.; and fortunately no fatalities resulted.

A Castle of Coal is the form chosen for the exhibit of the Indiana mining industries, at the St. Louis Exposition. It is to be of medieval architecture, 15x15 feet in plan and 30 feet high, built wholly of Indiana coal.

East End and North Facade, Palace of Machinery, Louisiana Purchase Exposition, St. Louis.

The Westinghouse Service Plant at the St. Louis Exposition.

Although a large amount of power for the use of the Louisiana Purchase Exposition will be derived from exhibition apparatus in the Machinery Building, with boilers located in the Steam and Fuels Building nearby, it was decided by the Exposition authorities that it would be best to erect under contract a service power plant for the use of the Exposition which would be more directly under the control of the Department of Works than exhibit apparatus could be. Such a plant is needed for the service, and it is essential that it shall be completed and in operation before the Exposition opens without any of the uncertainties attending the completion of exhibits. It was finally decided to award the contract for such a plant, with a capacity of 8,000 kilowatts, to the Westinghouse Electric & Manufacturing Company. This contract covers the entire power plant equipment with the exception of the buildings and stacks. The engines and generators will be placed in the Machinery Building in a space set aside for the service plant. The boilers will be located in the Steam and Fuels Building 100 ft. distant, which is the building in which all boilers and gas producing apparatus will be placed.

Although this is a service plant in name, it will, of course, be an interesting exhibit. While there will be nothing radically new in its essential elements, it will represent good, modern power-house engineering practice. The reasons urged for the award of this contract to the Westinghouse Electric & Manufacturing Company were that, on account of the many allied Westinghouse interests, it would be possible for this company to handle a large part of the contract without going outside of the Westinghouse companies, and chances for coherent design and prompt completion were better than if the contract were awarded to several companies. Thus, the steam engines will be furnished by the Westinghouse Machine Company, and the engineering and construction of the plant will be done under the supervision of Westinghouse, Church, Kerr & Company. The plant will contain four units of 2,000 kilowatts each. These will be 25-cycle, three-phase, 6,600-volt generators, direct connected to Westinghouse Corliss engines. The generators will weigh, without the bed, 132,000 pounds, and with the bed, 190,000 pounds. The efficiency guarantee is 96 per cent. at full load, 95 per cent. at ¾ load, and 93 per cent. at ½ load. They will operate at continuous full load with not over 35 degrees Cent. rise in temperature.

The engines will be Westinghouse vertical, cross compound, condensing Corliss, running 83 revolutions per minute. They are rated at 2,800 horse-power and have a maximum overload capacity of 5,200 horse-power, the latter capacity being reached at ¾ cut-off in the low-pressure cylinder. The cylinder diameters are 38 and 76 inches with 54 inches stroke. The shaft will be hollow forged steel 31 inches in diameter. In addition to the fields of the generators, the engine will have a fly-wheel of 175,000 pounds weight. The total weight of the engine is 750,000 pounds. It is guaranteed to operate on 13½ pounds of steam per indicated horse-power. Water for condensation will be supplied from a cooling tower having fans driven by electric motors, to furnish air circulation.

The boilers in the Steam and Fuels Building which will supply this plant are sixteen in number, of 500-horse-power each, built by the Babcock & Wilcox Company. Smoke flues will be placed under the floor and run to the stacks built by the Exposition. In addition to the natural draft, fans will be installed to produce artificial draft when needed, in accordance with Westinghouse practice. Roney mechanical stokers will be used under these boilers.

That part of the Machinery Building devoted to the service power plant is spanned by a 40-ton traveling crane. Besides the main units, there will be three 80-kilowatt exciter units, any one of which is sufficient for the entire power plant. These units will be direct connected to vertical cross-compound, condensing Westinghouse engines running 300 r. p. m. The weight of a unit complete is 38,000 pounds.

A Westinghouse switchboard will be installed, consisting of three exciter panels, four generator panels, two main load panels, two incoming feeder panels and twenty-four outgoing feeder panels. The incoming feeder panels are for the current which is to be purchased by the Exposition from the Union Electric Light & Power Company. The two load panels will pass the entire load, one panel being used for each of the two sets of bus-bars. Solenoid-operated oil switches are to be used for the high-tension alternating current, and these will be controlled in the usual manner by low-tension circuit, with switch handles on the various panels. On each generator panel will be three switches, one controlling an oil switch connecting the generator with one set of bus-bars, the other connecting it with the other set of bus-bars, the third being in the generator leads in series with the two just mentioned. The switches will be equipped with time limit release for automatically opening the circuit. Each generator panel will have a power factor indicator and three type F ammeters. Each feeder panel will have three oil switches, two of which are in multiple for connecting to either set of bus-bars, and the third in series with the other two, or the reverse of the generator switching arrangement. Each feeder panel will have also three type F ammeters and one integrating wattmeter.

Although not a part of this service plant, another interesting contract which this company is filling for the operation of the Exposition is for the 2,000-horse-power induction motors to be direct-connected to Worthington centrifugal pumps, to supply the Cascades with 90,000 gallons of water per minute. This will be a remarkable installation not only on account of the size of the induction motors, but on account of the size of the pumps and the high head to which water must be raised, which is approximately 150 feet.

The Cost of Raw Materials for Portland Cement Manufacture.

By Morris M. Green, Professor of Mechanical Engineering, University of Colorado.

The varied sources of raw materials for Portland cement manufacture in the United States are a matter of considerable interest, both to the cement specialist and to the would-be investor in new cement companies. There are in this country mills using coal and natural gas for fuel, and pure limestone, marl and refuse from caustic soda works, as calcareous bases to be mixed with alumina and silica, either alone or associated with some lime, in the form of soft clay, hard shale, blast furnace slag, or a calcareous argillaceous rock like the well known Lehigh cement rock of Pennsylvania. The purity and extent of deposits of cement material can generally be easily determined, but the cost of working the deposits and manipulating the material in the mill is uncertain and is the crucial test of the success of the mill.

Assuming, at first, for purposes of equitable comparison, that all material will be burned in a dry mixture in the rotary kilns, the cost of both components of cement might be divided into three subdivisions, viz.: excavation, drying and pulverizing, assuming all material to be obtained at mill site.

The item of moisture, which occurs largely in some materials, is immensely important. Finely divided material, as marl, containing seldom less than 50 per cent. moisture, even when found in beds above water level, not only takes absolutely more fuel for evaporation of water, but relatively more, as heat recuperation cannot be practiced as efficiently with a loose pulverulent material like marl or refuse from caustic soda plants as with a material like rock which can be worked in vertical dryers.

It is precisely a parallel case to the widely different fuel consumption of the rotary kiln using a powdered material and the old vertical cement kiln using briquettes. Having inspected a large number of mills, during the past year, using all varieties of materials, and having had access to cost sheets, the writer would call attention to the salient points of the different materials. The materials are supposed to be worked in a sufficient quantity for a thousand-barrel mill. Of course conditions vary so much that only a range of cost can be given. Limestone might occur in a 20-foot breast in one place, and in another be so surrounded by dolomitic stone as to require expensive sorting. Hardness also varies. Marl, on the other hand, seldom contains any appreciable amount of deleterious chemical ingredients, as magnesia, but may contain grit or other mechanical impurity. The writer invites comment on this article from cement manufacturers and engineers.

The refuse carbonate of lime from caustic soda plants, which produce caustic soda by adding milk of lime, made from pure limestone, to a solution of carbonate of soda, can be controlled, in its quality, by the management of the caustic plant. The trace of soda remaining in the refuse carbonate of lime does not affect the strength of the cement. We will take the following analysis as representing the composition of an American Portland cement: Silica, 22.05 per cent.; Al_2O_3, 5.36; Fe_2O_3, 3.52; CaO, 63.71; MgO, 0.99; SO_3, 1.77; $Na_2O + K_2O$, 1.50; CO_2, 0.51; ignition loss, 0.55. It is evident that the amount of dry $CaCO_3$ required per 380-pound barrel of cement is about $380 \times 63.71\% \div 56\% = 432$ pounds, or about 450 pounds of dry material containing 95% of $CaCO_3$. The combined weight of dry silica, alumina and iron would be 30.93 per cent. of $380 = 117$ pounds, or about 125 pounds of crude dry material.

In approximate figures, then, the relative quantities of carbonate of lime, silica and alumina, and fuel, per barrel of cement, are as follows: Carbonate of lime, 450 pounds; fuel, 150 to 250; silica and alumina, 125. These figures are very important, inasmuch as the cost of transporting one material or another would have a serious bearing on the location of the mill. The cost of waste from caustic soda plants is given as nothing, because its utilization in cement manufacture saves expense of otherwise disposing of it. From these figures the estimates in the accompanying table have been made:

Cost of Pure Calcareous Bases.

Material	Water in material for 1 barrel cement.	Coal for drying water per barrel.	Excavating cost per barrel cement.	Pulverizing cost per barrel.
Pure limestone	7½% = 36 lbs.	6 lbs	10—15c	7½—10 H.-P. hours
Caustic soda refuse	50% = 450 lbs.	105 lbs.	....	3 — 4 H.-P. hours
"Dry" marl	50% = 450 lbs.	105 lbs.	6—8c by digging	3 — 4 H.-P. hours
Marl under water	60% = 675 lbs.	125 lbs.	2—4c by dredging	3 — 4 H.-P. hours

The only argument the writer has been able to find in favor of cement plants designed to dry marl before mixing, is that with the dry process from 200 to 250 barrels of cement can be turned out per day in a kiln, as against 100 to 125 with slurry. The kiln fuel per barrel of cement, using slurry with 50 per cent. moisture is about 150 pounds of coal. With a marl drying plant and dry process kilns, the kiln coal would be 110 pounds and drying coal 105 pounds, or a total coal consumption, outside of motive power, of 215 pounds. In one American cement plant, using limestone, the waste gases from a kiln producing 250 barrels of cement, are passed at 1.900 degrees Fahrenheit into a vertical boiler, reduced to 600 degrees, and then drawn by induced draft through an economizer where they heat feed water to 200 degrees. One hundred and twenty-five horsepower per rotary kiln of 250 barrels capacity is produced with the waste heat from the kiln, or, in other words, the motive power per barrel of cement is reduced from 1 horse-power to 0.5 horse-power per day, or from about 75 to 37½ pounds of coal, not to mention labor economy in avoiding the handling of coal and ashes. Even with this economy, the process of drying marl would show a higher fuel cost than the slurry process, and the extra expenditure for marl drying machinery and labor would offset extra capacity of the kilns using a dry mixture.

There appears to be a good field for inventive ability in devising machinery for mechanically pressing the water out of marl, as drying it with coal requires excessive fuel and labor, with the present types of dryers. As the means of utilizing the waste heat of kilns using dry limestone are perfected, it would seem hard for mills using a slurry process to make money in competition with them. A rotary kiln turning out 250 barrels of cement from dry limestone, with 110 pounds of kiln fuel per barrel, and by generating steam under boilers with its waste heat, reducing its fuel for motive power per barrel from 75 to 37½ pounds, is a difficult proposition to excel in economy of fuel, labor and capital invested in plant.

Under the head of argillaceous bases we will discuss the following materials, analyses given being of dried samples:

	Hard shale.	Wet clay.	Lehigh cement rock.	Blast furnace slag.
Silica	65.24	65.43	17.32	34.0
Alumina and iron	23.56	22.58	9.11	13.52
Carbonate of lime	...	...	68.91	...
Carbonate of magnesia	...	...	4.28	...
Lime	1.10	2.10	...	48.2
Magnesia	1.12	1.60	...	3.1
Combined water	6.72	6.10	...	...

It will be observed that the Lehigh cement rock and the blast furnace slag contain large amounts of lime, the former in the shape of carbonate, the latter as oxide. The slag has a decided advantage in this respect, as only 56 per cent. of the carbonate of the cement rock is lime. The remaining 44 per cent. is waste material, which requires labor and power in handling, as well as absorbing heat in the decomposition of $CaCO_3$ in the kilns, which might be otherwise utilized. Some of the work of decomposing carbonate of lime in a cement kiln is, in the case of furnace slag, previously done in the blast furnace. It is evident that the addition of only a small amount of lime in the form of pure limestone to the Lehigh rock or blast furnace slag is needed to make a proper mixture for cement. Shale and clay ordinarily contain so little lime that all the lime in cement made from them generally comes from the limestone, marl or chalk added to them. From the preceding analyses is computed the accompanying table showing moisture, weight of crude material per barrel of cement, coal for drying wet material or pulverizing dry material:

Cost of Argillaceous Bases.

Material.	Natural material for 1 barrel.	Water in material for 1 barrel.	Coal for drying water for 1 barrel.	Excavating cost per barrel.	Pulverizing cost per barrel.
Hard shale	125 lbs.	5% = 6 lbs.	1 lb.	2½— 5c	2 — 2½ H.-P. hours
Wet clay	150 lbs.	20% = 30 lbs.	7½ lbs.	7½—11¼c	½— 1 H.-P. hours
Lehigh rock	480 lbs.	5% = 24 lbs.	4 lbs.	6 9c	7½—10 H.-P. hours
Granulated slag	320 lbs.	20% = 64 lbs.	11 lbs.	....	1½— 3 H.-P. hours

The excavating cost of the furnace slag is given as nothing, as its use in a cement mill generally saves expense of hauling it away elsewhere.

The following table shows the relative weights of pure limestone per barrel of cement,

Cost of Limestone.

Argillaceous material.	Material for 1 barrel cement.	Limestone per barrel cement.	Total material per bbl. cem.	Combined Drying coal.	Combined H.-P. hours for pulverizing.	Combined Excavating cost.
	Lbs.	Lbs.	Lbs.	Lbs.		Cents.
Hard shale	125	450	575	7	9½—11½	12½—20
Wet clay	150	450	600	13½	8 —11½	17½—26¼
Lehigh rock	480	125	605	6	9½—13	9 —13
Wet granulated slag	320	210	530	14	6 — 7½	4½— 7

which must be used with the above dried materials, also the drying coal and the power for pulverizing the dried materials jointly.

It will be noticed that the joint weight of the components for slag cement is less than the others, owing to the absence of carbonic acid in the slag. After the slag is dried, the joint weight to be manipulated would be about 465 pounds per barrel only. This should tend to reduce the cost of all equipment previous to and including the rotary kilns. If a combination could be found of a blast furnace furnishing cement slag and a caustic soda plant close at hand furnishing lime waste, it would be an opportunity for a chemical engineer to create wealth from waste. The writer ventures to predict that the future will see a great development of the slag cement industry in the United States. The large steel corporations not only have the material, but have it close to such markets for cement as Pittsburg, Chicago, Buffalo and Pueblo. Its successful manufacture is another tribute to the painstaking research of the chemical engineers of Germany, where it originated. Industrial chemistry to-day owes its success in the business world to its utilization of by-products, as shown by the gas and coke industries, the packing of animal products and refining of mineral and vegetable oils. Slag cement would seem another illustration. Furthermore, it would seem that the utilization of waste blast furnace gases from the blast furnace producing cement slag, as fuel for gas engines to furnish motive power to the slag cement mill, would be an additional economy still open to slag cement manufacturers in this country.

Pros and Cons Relating to the Proposed Union Engineering Building.

Statement Issued by Board of Direction, Am. Soc. C. E.

In Favor of the Union Building.

1. The society now has an opportunity to become one of four equal participants in a gift of about one million dollars to be expended for a modern building adequate for the needs of all four societies for many years to come.

Such a liberal and generous gift has never been offered to the profession before, and such an opportunity to secure a suitable building for a great engineering center can hardly be expected to recur.

By the sale of our present property, which need not be hastened, a sufficient amount can be realized to cover the interest of the society in the land upon which the new building is to be placed, and leave a remainder for broadening the work of the society.

2. It is desirable to secure co-operation between the different engineering societies and the different classes of engineers. Engineers in different lines of work are not brought together as much as men in other professions, and the facility for meeting friends and widening acquaintance by being housed in a common building would be of especial value to them.

Better opportunities for individual intercourse and facilities for more frequent exchang of ideas and experience must be of benefit to the profession.

The present stage of civilization has been marked by a great development in the applications of science, and its advance has been largely the unrecognized work of the engineering profession. Future progress will perhaps be even more marked, and the profession of engineering should take its place as one of the most important agents in the advancement of civilization and the development of the country. It is urged that this project will aid in accomplishing this end.

Joint occupancy and contiguity of the several organizations in a commodious engineering building, centrally located, would tend to the unity and strength of the engineering profession as a whole. The present tendency is toward specialization, and hence a segregation, which is to be deplored, and which a closer association would do much to counteract.

3. Our present building, while adequate for ordinary meetings of the society, is inadequate in some respects for the requirements of the annual meeting—the principal occasion when non-resident members visit the society house. There is no proper accommodation for giving a luncheon on this occasion, unless the business meeting is held elsewhere; and, with the rapid increase in membership, these conditions will grow worse from year to year.

The new building will give much more space and better accommodations both in the business offices and the auditoriums; and ample space for a very largely increased membership in all the organizations. A large auditorium, with seating capacity for one thousand persons, and two or three smaller ones, with seating capacity for 200 to 400 each, will provide for all meetings. Suitable provision can be made for the convenient service of luncheon on any occasion.

The advantages to be gained by the common use of auditoriums, reading rooms, etc., could probably be obtained at less cost of maintenance and operation, than where different establishments are maintained, and the expenses may be partially defrayed by renting office space and auditoriums to other scientific organizations without interference with the work of the constituent societies.

This feature may be of considerable importance until by increase of membership the space becomes necessary for the use of the constituent societies, and when this occurs the societies will be so strong that the burden will be insignificant.

4. The collection of the libraries of the various societies in one building would facilitate greatly making researches, and would result in economy of time and efficiency. Each society would retain control of its own books, stored in separate stacks.

Each society could maintain and increase its library with no less freedom than if it occupied a separate building.

A common reading room would serve for all.

5. The new building, centrally placed between the two great railway terminals, and near the hotel district, will be more convenient to non-resident members, particularly to those leaving on late trains.

The proposed building will be about 2,000 feet from the nearest subway station; 2,100 feet from the Grand Central Station; 3,100 feet from the new Pennsylvania Railroad Tunnel Station (now under way), that is to say, within 10 or 12 minutes' walk from either of these stations. The Sixth avenue elevated station is 1,270 feet, and the nearest East Side elevated station is 2,320 feet distant. The Sixth avenue surface car line is 500 feet away, the Seventh avenue car line is 1,400 feet away; by which cars the ride to the Pennsylvania Railroad station would be two minutes; the Forty-second St. Crosstown line is 1,270 feet away, and the Broadway surface car line 1,000 feet away.

6. Associations of engineers should be mutually helpful. If this society does not join in this project, the burden upon the others will be greater. We are all members of one great profession. We should join hands with our brethren who are engaged in other lines, with the sincere desire that all work together to enhance the strength and influence of the engineering profession as a great unity.

7. The building would be under the exclusive control of the representatives of the four national engineering societies; these representatives forming an executive corporation in which each society would have an equal voice. Such a corporation, made up of the best men in the constituent societies, could be depended upon to deal justly with all.

We should enter upon the project with a firm determination to avoid dissensions and to make it successful and helpful.

Possible difficulties should not deter us from joining in an enterprise which, with proper management, may be made a great benefit to the profession.

The danger that any one of the four great national engineering societies may become unable to pay its expenses in the new building, seems extremely remote, if we believe in the continued future development of our country, in which all branches of the profession of engineering will have an important part; but, if the extremely improbable should occur, and any one of the societies should fail and withdraw, it can hardly be doubted that the others could successfully maintain the building.

Nor can it be reasonably doubted that other engineering or closely allied scientific societies would avail themselves of any opportunity to locate in the engineering headquarters, whenever such opportunity might be offered.

Against the Union Building.

1. A professional society should not accept a gift under conditions which may in the future hamper its independence and usefulness.

It is believed that a greater sense of responsibility is produced, and a greater pride engendered, if the members of any organization feel that its support depends entirely upon themselves.

On the assumption that the engineering building will cost $1,000,000, the increase of nominal assets of this society will be about $250,000. As against this, the society will be deprived of exclusive control of the property it occupies, both as regards its management and the possibility of a change of investment.

The ownership will be inalienable and indivisible, and, with the control of the property, will be in the hands of the executive corporation, in which the society will have but one vote in four. It is to be carefully considered whether the gain is sufficient to compensate for the sacrifice of independence and individuality.

2. In the practical operation of large buildings, the several floors of which are occupied by different families or business firms or associations of individuals, experience does not always show a gain in social or business affiliations or intimacy between the several tenants, simply because of their proximity.

There is no precedent for anticipating a beneficial result, in this respect, from the occupation of different floors of a large building by different societies of engineers, each desirous of preserving its individuality and increasing its membership.

The prestige of the profession of civil engineering cannot be enhanced by the collection in one building of a number of separate organizations with different requirements for membership.

It cannot be regarded as unquestionable that a greater intimacy between the several societies would be mutually beneficial by developing a deeper professional spirit.

The experience of the institution of civil engineers of Great Britain indicates that a certain amount of exclusiveness and conservatism engenders in the members pride in the organization and solicitude for its welfare, and begets in the public a reliance upon its character, which might be jeopardized by such an association with other organizations having different histories, aims and traditions.

If, as may well be feared, joint occupancy of a common building should give rise to dissensions, the result would be a loss of prestige instead of a gain.

3. The present house of the society is a four-story and basement building of fine architectural appearance, planned and built expressly for it, on a 100-foot street, adjacent to two churches, and opposite to an imposing Fine Arts Gallery. It is fully adequate to all the present needs of the society, excepting only on the occasion of the annual meeting. The business offices, library and reading room, will be ample for a considerably increased membership.

When more space is required two or three more stories can be added, or adjacent property can be acquired, when this becomes necessary. The present property is nearly paid for, and the regular annual surplus of receipts over expenditures is steadily increasing; there can be no doubt that the society can make these enlargements or acquisitions whenever needed.

The experience had in the management of high buildings in New York and elsewhere, is to the effect that the cost of operation, per square foot of floor space occupied, is very much greater in a ten-story building with elevators than in a four- or six-story building without elevator service.

It is the opinion of experts in the management of buildings that the expense to this society, by becoming a participant in the management of the proposed building, would be very greatly in excess of its present expenditure for operation of its own building.

It is doubted that a building for a home for the several societies, ten stories or thereabouts in height, giving adequate architectural effect for suitably impressing the general public, and creating a pride of ownership in the minds of the members of the several societies, can be built on the proposed site, on a narrow street, in the middle of a nine hundred-foot block, likely to be occupied by business buildings of greater height.

At some future date, even with the proposed liberal allowance, the space in the proposed building will become inadequate for one or more of the constituent societies; all will certainly grow, but the probability is that some will grow at the expense of the others. In this case the proposed engineering center will be broken up, as there will be no room for further expansion, and there is sure to be diversity of opinion as to which shall go and which shall stay. This emphasizes the objection to joining in a project which makes no provision for growth, or readjustment, beyond a certain limit.

4. With the libraries of the constituent societies under the same roof, there will not be the same incentive for maintaining the completeness of each, as the feeling will be that the other libraries, readily accessible, can be relied upon to contain all books, relating to their specialties, and it might seem a waste of money and space to have in each of the four libraries a copy of the same book; yet it seems desirable to keep the library of this society, which is a general technical collection, larger and more complete than any other similar library in America, as complete at all times as if the society occupied independent quarters.

In case of withdrawal at some future time, the library should be as complete as if there had never been any association. It is probable that donations of publications would be restricted to one copy for the building, the several libraries being considered as one, and thus the growth of our library would be restricted.

5. The new building will be on a 60-foot street in a district changing from a residential to a business character.

The present building is located on a 100-foot street in a growing locality. It is 1,000 feet from the nearest subway station, which is 5 minutes' ride from the Grand Central Station, or by walking 250 feet to the Boulevard surface cars with 8 minutes' ride to the Grand Central Station, or by walking 300 feet to the Seventh avenue surface cars with 8 minutes' ride to the Pennsylvania Railroad tunnel station. There are five surface lines within a quarter of a mile; Broadway 200 feet; Eighth avenue 550 feet; Seventh avenue 300 feet; Sixth avenue 1,200 feet, and Fifty-ninth street Crosstown 800 feet. Two elevated railroad stations are each 1,600 feet distant.

This location is suitable for the purpose, is attractive and accessible from all directions.

The area of the lot on which the present house is built is nearly one-half of that proposed for all four of the societies in Thirty-ninth street.

The price paid for the former in 1896 was $14.48 per square foot; the price we are asked to pay for the latter is $41.89 per square foot, plus the interest to date of occupancy.

6. This society stands for certain principles which individualize its character, among which is the fact that the term "Civil Engineers" used in its title comprehends military, naval, mining, mechanical and electrical engineers, architects and marine architects, as specified in its constitution, all being eligible for membership.

To be housed in the same building with other societies in which different organizations would be shortly termed "Civil," "Mechanical," "Electrical," "Mining," etc., would lead to a restriction of the proper meaning of the name of this society, in the popular estimation, thus detracting from its dignity and destroying its individuality.

7. The management of the new building will be in the hands of an executive corporation representing all the societies, by which corporation space and expense will be apportioned.

Once having committed ourselves to this project, however, we would be unable to withdraw without sacrifice of property, and would be obliged to continue the affiliation with the other societies, even though experiences, now unforeseen, should make it desirable to sever the connection.

The plan of occupation and control of the new building involves an entire and undesirable change in the business management of this society.

Instead of being independent and retaining entire control of its property, as has so far been done with successful results, the society will be obliged to surrender control of its real estate to an organization in which it will have only one-fourth interest, the remaining three-fourths being held by other parties.

The proposed executive corporation is to enter upon a speculative business enterprise, viz., the management of a large building, confessedly larger than is demanded by the present needs of the participants in the ownership, in a locality the character of which is now in a transition state from residential to business occupancy, with no great likelihood of future advance in values. Especially can no increase of value be anticipated for a building designed for semi-public uses, the cost of maintaining which will be very great, and will be constant whether it is fully occupied or not.

Participation in such an enterprise is foreign to the aims and objects of the American Society of Civil Engineers, and should not be entered into.

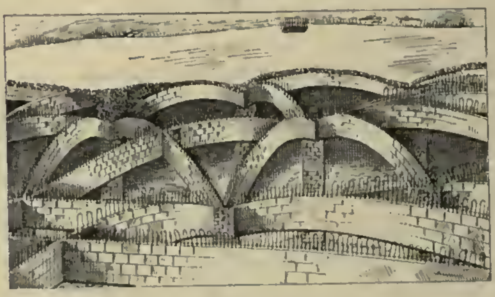
Any loss will fall largely upon the non-resident members of the society, who constitute three-fourths of its membership, and to whom the possession of an inseparable, fractional share of a large building will be of no benefit.

If any of the constituent societies default in the payment of interest, the others would face the necessity of assuming an increased burden or of losing their entire investment.

This society cannot afford to enter into an association in which it might be responsible for the financial failure of others, without adequate protection, which has not yet been assured. This seems a possible danger on account of the present difference in the financial standing of the four national organizations.

The Cottancin System of Tank Construction.

The Cottancin system of tank-building was described and illustrated some time ago in "The Journal of Gas Lighting," London, which says that it has been applied successfully to several large European gas tanks, some of which have been built of it in the outset and others which were built of concrete masonry and had been badly cracked were successfully repaired by the construction of a Cottancin lining. The fundamental principle is the use of bricks through which there runs a basket-like steel core to improve the bond and give tensile strength. The circular walls 4½ inches thick are reinforced by exterior vertical and horizontal ribs of steel cored bricks with their cores tied to that of the wall, and having segmental steel cored brick floors and roof reinforced with steel cored brick ribs supported by steel cored brick columns. The core consists of soft steel wire woven into panels or threaded through the bricks so as to run continuously through the structure and permit very strong connections between the ribs of the walls, roofs and other parts. In the floors steel cored cement shells are sometimes substituted for the brick and are similarly stiffened with radial and circular brick ribs.



Groined Arch Ribs.

The accompanying illustration of a large reservoir at Nemours, France, shows the construction of the groined arch roof with spherical or cylindrical segments of steel cored cement shell 2 inches thick carried by steel cored brick intersecting arch ribs apparently about 3 inches thick and 15 inches deep, through the upper sides of which the core wires project to bond with the segmental roof slabs. A Cottancin lining 2 inches thick was efficient in repairing the leak of a 2,200,000-gallon gas holder tank 95 feet in diameter and 23 feet deep which was built of masonry and concrete nearly 11 feet thick and had split through the whole depth. This system has also been employed for the foundations of many large buildings on soft or wet soil.

Quartz Glass is made by melting pure quartz crystal before the oxyhydrogen flame at a temperature of 1,700 degrees Cent.

Charles Hermany, President Am. Soc. C. E.

The election held this week for president of the American Society of Civil Engineers had a greater significance than any since 1893, for the Institution of Civil Engineers of Great Britain will be the society's guests this fall and upon the new president, Mr. Charles Hermany, will rest an extra measure of responsibility in consequence. Knowingly or not, the society has chosen as its head a man who is particularly typical of the American engineer. He gained his early technical education without any assistance from schools and has accomplished a number of important engineering works as successful as they are novel. For nearly forty-seven years he has been connected with the water works of Louisville, for forty-three years as the chief engineer and superintendent, and during all this time the plant and its management have been regarded as models of their kind.

Mr. Hermany was born in Lynn township, Lehigh county, Pa., on October 9, 1830. His ancestors were among the earliest settlers in that district and the family remained farmers for many generations. He spent his boyhood leading the life of the average youth on a thrifty American farm. The limited schooling of a country hamlet was supplemented by a couple of terms at a seminary at Easton, which developed a natural aptitude for mathematics and a determination to adopt engineering as a calling. But technical education in the present sense of the term was impracticable for him; farm work in the summer and teaching school in the winter left comparatively little time for self-instruction, and yet in three years he had prepared himself so well that by May, 1853, he was given a place of some responsibility in the city engineering department of Cleveland, Ohio. Here he rose rapidly and within a year became the first assistant in the office, a position he held until May, 1857.

At that time the late T. R. Scowden was engaged on a system of water works for Louisville and Mr. Hermany became his first assistant. The plant was completed in October, 1860, and on the first day of the next year Mr. Hermany became the technical and executive head of the works. The operation of this plant is a difficult one, for it involves pumping the supply from the Ohio River, which has a variation of more than forty feet between high and low stages. Moreover, the river is at times very turbid, a condition as hard on the pumps as on the consumers. But in spite of these difficulties there has been no interruption in the supply from the time the works were started.

The Louisville water works of to-day are, of course, far more extensive than when the original plant was put in operation, and all these additions were made from Mr. Hermany's plans and under his direction. The first reservoir, of ten million gallons capacity, was outgrown within twenty years and one of ten times its capacity had to be built. A new pumping station was also needed, the site for which was so treacherous that a pneumatic foundation was proposed for the pumps. The caisson for the purpose was planned and a contract for sinking it was let to experienced parties, but the latter finally preferred to pay a stipulated forfeit to attempting the execution of the work. A second letting brought only bids so high that they were rejected. Mr. Hermany was accordingly forced to undertake the construction of the works by day labor. When they were finished the famous Louisville pump was installed, which for a time held the record as the most economical compound engine ever tested. The fact that the pump has been kept running close to its test efficiency is a good indication of the manner in which the Louisville works are managed.

This noted pumping engine was designed by Dr. E. D. Leavitt and Mr. Hermany, and was built by the I. P. Morris Company, of Philadelphia. It has two vertical inverted cylinders 27.21 and 54.13 inches in diameter when hot, the piston rod of the high-pressure cylinder being connected by a link to one end of a beam and the low-pressure rod to the other end of the beam. The stroke is 10 feet. The cylinders are jacketed all over with steam at boiler pressure, and the two reheating receivers use boiler-pressure steam. The engine weighs far more than any other of the same capacity built up to that time. The duty of the engine per 1,000 pounds of dry steam was 148,655,000, and that of the pumping plant was 137,565,000 per 1,000,000 heat units.

Charles Hermany.

It is sometimes said that true engineering ability cannot be proved save by the test of a serious emergency, when intuition alone can bring order out of confusion. For people who hold this view, it may be worth mentioning that in 1890, when the city was partly wrecked by a tornado, a lofty standpipe at the pumping station was demolished and a water famine seemed imminent. There was no time for rebuilding the standpipe, so Mr. Hermany fixed up what was left of it as an air chamber at the foot of a long force main, and was in this way enabled to maintain the service safely.

The work which most widely established Mr. Hermany's reputation among engineers, was the action he took about nine years ago on the matter of water purification. The Ohio River from which the Louisville supply is drawn, contains at some seasons a large quantity of the finest silt. No water thus laden had ever been treated by slow filters of the European type and an experiment made with mechanical filters of somewhat similar water at New Orleans had been unsuccessful. The Ohio River sometimes contains over 5,000 parts per million by weight of suspended matter and at other times but a trace. Unmistakable signs of sewage pollution have been detected in it. The purification of a water of this character is a difficult task, and in order to determine how it could be done best, Mr. Hermany retained Mr. George W. Fuller to make under his general supervision a thorough investigation of all systems of treatment. These studies were the first ever made on an extensive scale in this country, and they established beyond question the practicability and efficiency of rapid filtration.

In the design and construction of the system of works for the purification of the Louisville supply, Mr. Hermany has shown a marked individuality. He has utilized the two basins of the existing one hundred million-gallon reservoir as subsidence basins. From these the water will pass into a tank, where the coagulant is to be added, and thence to the filters, which are built directly over the clear-water reservoir. Concrete has been used very largely on these works, which form one of the most interesting water purification plants in the country, as is evident from the illustrated description in The Engineering Record of January 5 and 19, 1901.

The experience gained in the design, construction and management of the Louisville water works has naturally brought Mr. Hermany's services into demand elsewhere. As chief engineer he designed and built the water works at Bowling Green, Lakeland, Frankfort and Evansville, while he has been called into consultation on many plants, notably the new works for Cincinnati.

He was elected a member of the American Society of Civil Engineers on January 6, 1869. He served as a director in 1880 and as a vice-president in 1891.

A NEW ENGINEERS AND ARCHITECTS SOCIETY has recently been formed in Indianapolis, Ind. The electrical, mechanical and civil engineers and architects have organized a society with the selection of Mr. C. C. Brown, president, and Mr. Walter Buhler, secretary. The new society starts with nearly one hundred members, who will be divided into sections according to the class of work followed. Each branch will have a separate meeting night, and there will be two general meetings each month. This new organization has made a good beginning and anticipates a useful future.

ENGINE FOUNDATIONS were discussed at a recent meeting of the Engine Builders' Association, by Prof. John E. Sweet, president of the Straight Line Engine Company, of Syracuse. His company, he said, had been setting their direct-connected engines on plain, level foundations without bolts. The engines are aligned in the shop after leveling the base by wedging under three points and when the base is set on the foundation it is leveled by wedging under the same points, then concrete, enough to insure a solid bearing, is inserted, and the rest of the base filled with sand to prevent it from becoming a sounding box. When vibration from an engine is feared, especially where the foundation goes to rock, two inches or so of sawdust are put under the foundation and around the side. So long as air cannot get to the sawdust, this should not rot.

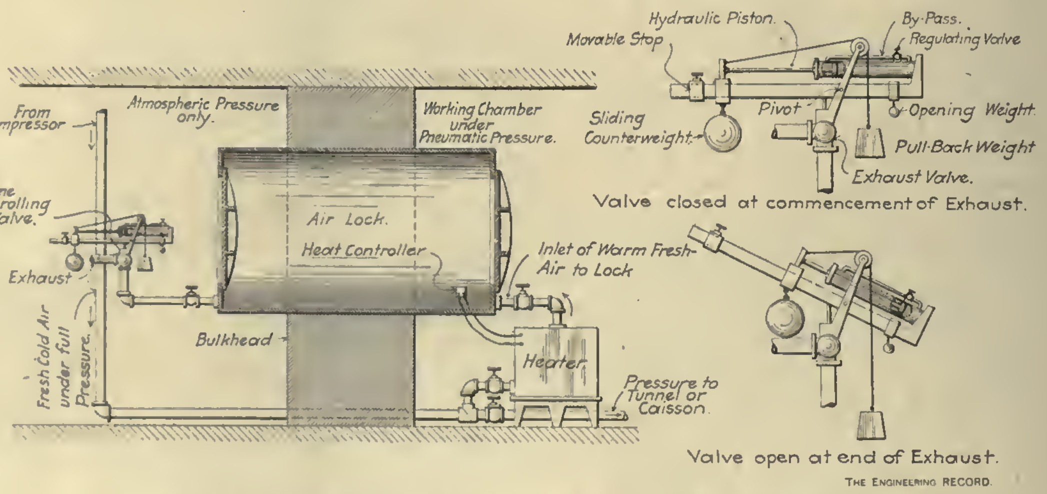
Caisson Disease and a Safety Apparatus for Pneumatic Caisson Locks.

Within the last fifteen or twenty years the use of pneumatic pressure has been greatly extended in foundation work, tunnels, and similar engineering undertakings, and has probably been more widely applied in this country than elsewhere. In New York City alone it has been applied in the construction of numerous foundations for tall buildings. The constantly increasing magnitude of the structures and the frequent necessity of locating them irrespective of foundation conditions, has required the work to be carried to greater and greater depths. This has involved the use of correspondingly heavier air pressures which, in several instances, have exceeded ordinary limits and have caused sickness and death to the workmen. If the water has free access to the working chamber, the pneumatic pressure necessary to exclude it must, of course, equal the hydrostatic head, and amounts approximately to one-half pound per foot of depth from water level to cutting edge. In many cases, however, water is encountered only in veins, or where it percolates through soft material, and develops less pressure head and, therefore, requires less pneumatic pressure to exclude it.

Pneumatic caissons have not been adopted for the foundations of buildings, except in New York, and there they seldom require a pressure much above 20 pounds per square inch. Many bridge piers have been built with similar pressures, but in some cases they have required pressures of nearly 50 pounds; in other cases bridge piers and tunnels have been so deep that the full theoretical pressure would have been much greater than 50 pounds, which has so far been accepted as about the practical limit. The safety and certainty of constructing work under pneumatic pressure is often an inducement to carry it as deep as possible by this method and use the highest permissible pressure. In these cases the utmost precautions have usually failed to entirely prevent injury to the workmen, and it is important to thoroughly understand the effect of the pressure on the human system and to make every provision which can prevent or alleviate injurious results.

The deepest pneumatic work in New York was done in the East River gas tunnel at a maximum of about 114 feet below high tide, and in the foundations for the Williamsburg bridge towers 107.5 feet below high tide, where the maximum pressures were respectively about 50 and 47 pounds per square inch above atmospheric. In the gas tunnel four men died through the effects of the heavy pressure, while none died from that reason on the bridge work. The foundations for the new Manhattan bridge between New York and Brooklyn have been carried to a depth of 92 feet with a pneumatic pressure of 45 pounds, from the effects of which five men have so far died. Heavy pressure has been used in the North River tunnel from Jersey City and will probably be used in the proposed Pennsylvania tunnels across the North and East rivers. Moderate pressure is also being used in the Rapid Transit tunnel from the Battery to Brooklyn and may there be increased to a maximum of about 45 pounds.

Ordinarily, strong young men in proper condition do not suffer from working two four-hour shifts daily under pressures up to 25 or 30 pounds. Above that limit injurious effects may be felt and the length of the shifts is usually decreased to a minimum of about 45 minutes under maximum pressures. For work in heavy pressure the men are subjected to a careful medical examination and only comparatively young and strong men with a good heart action are selected. They are required to avoid dissipation, and precautions are taken to make them emerge slowly from the pressure and remain for some time afterwards in a very hot room, where they are served with strong coffee and are given a long interval of rest between shifts. The wages are increased in inverse proportion to the length of the shift. (In the Williamsburg bridge caissons, the men received a maximum rate of $3.75 for working one and a half hours, in two 45-minute shifts daily.) This, together with the short working hours, gives so much opportunity for dissipation that many of the men abuse themselves with drink and in other ways. To this and to carelessness in emerging too rapidly from pressure nearly or quite all of their injuries from pneumatic pressure are attributed by their employers. No injurious effects are known to result from very rapid entrance into compressed air, although it sometimes produces temporary headache and slight discomfort is always occasioned in maintaining equilibrium between the air pressures inside and outside the body. This is principally felt in the ears, where it is overcome by repeated efforts of the lungs to expel the air while the mouth and nostrils are closed. Most persons after remaining two or three hours in a pressure of 30 pounds or more feel an itching, pricking sensation under the skin on all parts of the body when they emerge from the pressure. This disappears in a few minutes and causes no further trouble.


Hydraulic Piston.
Movable Stop
By-Pass.
Regulating Valve
From Compressor
Atmospheric Pressure only.
Working Chamber under Pneumatic Pressure.
Sliding Counterweight.
Pivot
Opening Weight.
Pull-Back Weight
Exhaust Valve.
Valve closed at commencement of Exhaust.
Time Controlling Valve.
Air Lock.
Heat Controller
Inlet of Warm Fresh-Air to Lock
Exhaust
Fresh Cold Air under full Pressure.
Bulkhead
Heater
Pressure to Tunnel or Caisson.
Valve open at end of Exhaust.
The Engineering Record.

Regulating Valve and Heating Apparatus on Pneumatic Pressure Lock.

No disagreeable or injurious effects are observed while a person is under pneumatic pressure, but after emerging from pressure above 30 pounds some individuals are subject to the "bends," which is the popular term for severe pains like rheumatism which attack one or more of the joints and may last for any time up to 24 hours. Sometimes they are very violent and cause the patient to double up as if with cramps, but it is not recorded that they are ever fatal and when once they have ceased, no further results are felt. The treatment prescribed for them is hot baths, perspiration, reentering the pressure and emerging from it very slowly. The same remedies are also efficient for the itching sensation.

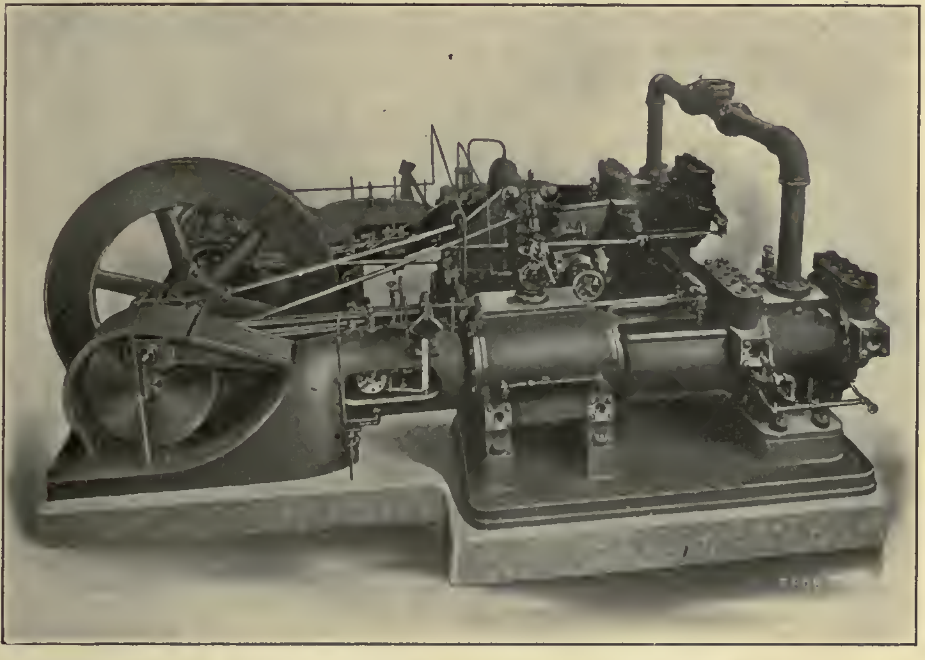
The most serious effect of pneumatic pressure is paralysis, which usually attacks the legs and lower part of the body, and may extend further and become fatal. It occurs within an hour after leaving the pressure, and generally within 10 or 15 minutes. Patients suffering from it are subjected to the ordinary hospital treatment for paralysis. From 2 to 3 per cent. of the men employed under a pressure of 40 pounds are likely to suffer from the "bends" and generally return to work in a day or two after the pain ceases. Less than 1 per cent. of them become paralyzed. It is not recorded that workmen who have suffered from the "bends" have also suffered from paralysis. Paralysis usually occurs without any warning whatever, and it is believed by the men that a little discomfort from the "bends" is desirable as a safeguard against paralysis.

When a man is threatened with bad results from the pressure, they can generally be averted if he can return to the pressure before the trouble has developed and remains in it until it is very gradually released. It is believed that 40 minutes should be taken to emerge from a pressure of 40 pounds above the normal and in general that the time should be one minute for each pound, care being taken to reduce the pressure with great regularity. Ordinarily, however, the time really so occupied is not much more than one-tenth of this. If this rule were rigidly observed and all the workmen were subjected to a rigid medical examination before entering the pressure and were prevented from indulging in excesses, it is believed that there would be few or no casualties due to the effects of the pressure, even when much higher than is now customary.

Eminent German and French physicians and scientists have studied the effects of pneumatic pressure by numerous experiments on men and animals, and their general conclusion is that the bad results are due to the compressed air forced through the lungs into the blood, being liberated there by too rapid diminution of the pressure. One experimenter subjected a great number of dogs, cats, rabbits, guineapigs and other animals to repeated pressures up to 100 pounds, and carefully observed the effects of varying conditions, some of which were fatal and others apparently harmless. He devised means to bleed the animals while under pressure; afterwards the blood was removed, and when it was released from pressure threw off gas which was collected, analyzed and found to be nitrogen. The experiments showed that sudden release from heavy pressures was fatal, but that if three or four hours were occupied in reducing a pressure of 100 pounds, it was harmless.

The generally accepted theory deduced from these experiments and other observations is that under a pressure of more than 30 pounds a considerable excess of air is absorbed in the blood, but can pass off harmlessly if the pressure be very slowly and regularly reduced. If the pressure is quickly reduced, the air does not have time to escape safely and naturally, but is, instead, resolved into its elementary constituents; the carbonic acid is thrown off in the usual way by the lungs, the oxygen is absorbed in the tissues, and the nitrogen is liberated and effervesces in the form of very minute globules. These globules of nitrogen are forced with difficulty through the capillaries and produce the itching and pricking sensation always experienced after heavy compression. If these globules are too numerous to be absorbed, they combine in larger bubbles which reach the heart and produce embolism, interfering with its action, and when driven through the arteries and veins produce paralysis or collect in the joints causing the "bends." The same effects have been produced by injecting nitrogen gas into the veins of animals. Thus paralysis similar to that of the caisson disease has been induced without placing the subjects under pneumatic pressure at all.

The obvious way to prevent "bends" and paralysis from pneumatic pressure is to insure a sufficiently slow and regular reduction of the pressure. As the locks in which the men emerge from the working pressure are usually very small and are likely to be crowded full, the air would soon become vitiated if the occupants were obliged to remain, as they should, for half an hour or more in emerging from a heavy pressure. Besides this, the reduction of the pressure causes a corresponding fall of the temperature, making the interior of the lock very uncomfortable. To avoid these troubles a safety apparatus has been invented and patented by Mr. W. I. Aims, engineer of the gas tunnel which was built under the East River several years ago, and described in The Engineering Record of March 10, 1894.


The Cincinnati Compressor for the St. Louis Exposition.

This new safety device has two parts. One part is an apparatus for heating and forcing a constant supply of fresh air into the lock to keep the atmosphere very warm and pure during the time that the pressure is being reduced. The other part is a locked device for regulating the outlet which reduces the air pressure in such a manner that the rapidity of exhaust is beyond the control of the men in the lock, who are very liable to hasten it without regard to safety. The essential features of the apparatus are shown in the accompanying diagram. The fresh air is forced by a compressor through a heating apparatus controlled from within the lock. The exhaust from the lock escapes through a pipe and special valve that is commanded by a counterweighted lever. The lever rests on top of the valve stem and forces it downwards, tending to close the valve. It is pivoted horizontally to a bracket a short distance from the valve stem and is counterweighted on both sides of the latter. The principal counterweight is on the long arm of the lever beyond the valve stem and when this arm rises, the valve stem is forced upwards by the pressure of the air in the lock and allows it to escape in proportion to the movement of the lever. The counterweights are proportioned and adjusted so that when the large one engages a stop near the end of the long arm, it will just close the valve against the initial lock pressure. The smaller weight is set on the short arm so that when the large weight is moved near the fulcrum its moment will revolve the lever into an inclined position and allow the valve stem to rise and completely open the valve. The large weight slides freely on the lever and is pulled towards the valve stem and fulcrum by a counterweight. Its motion in this direction is resisted by a balanced hydraulic piston, which moves in a cylinder having both ends connected by a by-pass commanded by a regulating valve. This valve can be set so as to allow the piston to move at any rate of speed under the force exerted by the suspended weight. This regulates the valve and the latter gradually opens at any required speed and allows the air to escape from the lock in any given time. This apparatus is beyond the control of the men and makes it impossible for them to tamper with the exhaust. It maintains a regular diminution of pressure regardless of the amount of fresh air introduced into the lock, and therefore enables the warming and ventilation to be conducted independently of the exhaust. A modification of this system is effected by placing the time-control valve on the fresh air inlet pipe and starting the latter under full pressure when the lock doors are closed. The exhaust outlet which is proportioned to correspond with the maximum pressure is then fully opened and permits a constant discharge, while the supply of air is gradually diminished, thus eventually securing the complete and regular reduction of pressure in a given time. This method is less desirable than the first because it limits the quantity of fresh air. If the locks have no other valves under the control of the workmen, they cannot hasten the operation or emerge too soon, because it is impossible for them to open the exit door until the pressure is completely exhausted.

Mr. Aims is the engineer for the New York Tunnel Company, Mr. Andrew Onderdonk, contractor, which is building the New York Rapid Transit Tunnel from the Battery to Brooklyn. The pressure on that work is now 10 pounds and may eventually rise to 45 pounds. When it reaches 25 or 30 pounds, Mr. Aims intends to apply the above described apparatus to the locks.

The Cincinnati-Gear Compressor for the St. Louis Exposition.

The central compressed air plant at the St. Louis Exposition will contain two main compressing units; one cross-compound, two-stage, Cincinnati-gear compressor, having 13 and 24-inch steam cylinders, 22 and 14-inch air cylinders and 24-inch stroke with a displacement at 125 revolutions per minute of 1,300 cubic feet per minute, and one cross-compound, two-stage, Meyer-gear compressor, having 12 and 20-inch steam cylinders, 18 and 11-inch air cylinders and 18-inch stroke, with a displacement at 100 revolutions of 530 cubic feet per minute. The first machine is to supply the general compressed air requirements of the Exposition, while the second is to supply the transportation exhibits. The larger machine is of special interest as being the first compressor of its type publicly exhibited, although a number of similar machines have been, and are being, installed in private plants. A 1,500-foot machine is at the present time being placed in the Jersey City power-house of the Central Railroad of New Jersey.

The air valve gear is the distinguishing feature of this machine, combining in an ingenious manner the positive action, noiseless operation and durability of the mechanically moved valve with the elasticity of the poppet valve. The noise and wear of the poppet valve, due to the impact of the valves closing at the reversal of stroke, is eliminated by mechanically closing the passages underneath the poppet valve, and leaving a cushion of air upon which the latter seats. The action of the valve gear is indicated in the accompanying engravings, showing the general arrangement of the cylinder, and the position of the valve at various points of the stroke.

At the beginning of the forward stroke of the piston, the mechanical valve A as shown in the sketch is just closing the port B, the discharge edge of A being line in line with the upper edge of the port B, and the valve moving in the direction shown by the arrow C. After the piston advances a short distance, the valve has reached the position shown in dotted line, in which the inlet edge of the valve D is just coming in line with the lower edge of port B. The valve continues to move in the direction of the arrow C until about mid stroke, when it reverses to the direction shown by arrow E, bringing the valve back to the dotted position at the end of the stroke. On the return stroke, the valve still moving in the direction of the arrow E, returns at the beginning of compression to the position shown in full line, the discharge edge of valve A being in line with the upper edge of the port B and opening.

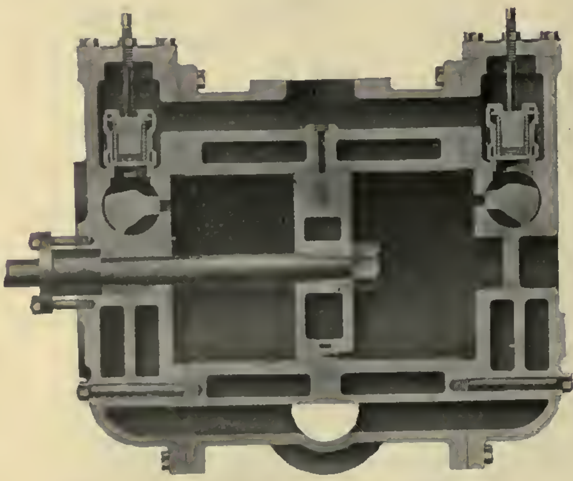
After the mechanical valve opens, the poppet valves G, which have had the entire return stroke in which to seat, prevent the flow of air back from the discharge passages to the cylinder, and remain closed until the pressure inside the cylinder slightly exceeds the pressure in the discharge passages. The poppet valves G thereupon open and remain open until the end of the compressing stroke is reached, at which point the valve A, which in the meantime has changed its direction to that shown by arrow C, has resumed the position shown in the figure, thus leaving a volume of air under discharge pressure in the space between the mechanical valve and the poppet valve, permitting the light springs back of the poppet valves

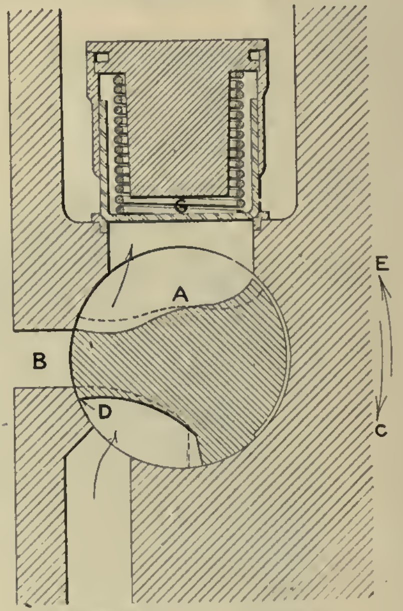
G to seat them easily and gently during the return stroke.

It will thus be seen that the three fixed points in the compression cycle, namely, the opening of the inlet, the closing of the inlet and the closing of the discharge are positively and mechanically controlled; the opening of the discharge, which is the only variable point in the cycle, is controlled by the automatic poppet valves, which are relieved, however, of the necessity for quick closing, so as to be free from the objectionable features of noise and rapid wear.

Sample cards from one of these machines show a steep expansion line on the air cards, indicative of small clearance and a high volumetric efficiency of the machine and the large valve area is indicated by a practical co-incidence of the inlet and atmospheric lines and by the uniform discharge line. A rounded admission of the steam cards, which might, in ordinary engines be deemed objectionable, is due to the maker's practice of giving the steam valves a slight negative lead to off-set the expansion pressure at the beginning of the air cards.

These machines are built by the Laidlaw-Dunn-Gordon Company, of Cincinnati, O. The steam and air cylinders are joined in the direct line of thrust by heavy cast-iron housings and are supported by bed plates under their entire length, avoiding the objectionable features of over-hung cylinders. The steam valve-gear is of the four-valve type. Steam distribution is effected by means of short, double-ported, slide valves, working at either end of the steam chest on a valve face as close as possible to the cylinder bore, the port volume being restricted as far as the large valve area will allow. The exhaust valves are of the Corliss rotary type and are placed at the bottom of the cylinder. This construction has been followed in order to produce a valve gear having the essential advantages of a Corliss, namely separate passages for the steam and the exhaust with corresponding reduction in cylinder condensation, together with short, straight ports and small clearance. On the other hand any complicated releasing gear has been eliminated, the action being positive throughout.


Longitudinal Section of the Air Cylinder.



Valves of the Air Cyliader.

The Tenth Anniversary of the American Society of Heating and Ventilating Engineers.

The American Society of Heating and Ventilating Engineers celebrated in New York City this week the tenth anniversary of its institution. In addition to such papers as regularly present themselves at the stated meetings of the society, several contributions, more or less historical in nature, were received, commemorative of the society's attainments during its first decade. The first session, on the afternoon of January 19, was devoted to the receipt of reports of officers and committees. The president, Mr. H. D. Crane, of Cincinnati, said in his address that the society is a substantial reality which will survive because the members have learned of its personal benefits. He paid a tribute to Mr. W. M. Mackay, who since the organization of the society has served it in some conspicuous capacity. As secretary, Mr. Mackay submitted a report which showed a net addition of some thirty members, making the total membership 204, not including a number of applications which have not yet been considered. The report of finances showed a substantial increase in the cash balance in the hands of the treasurer. The Board of Governors' report stated that the 1903 volume of transactions was practically ready; that the proposed amendments had been adopted; that the establishment of local chapters was not considered at present advisable; that while the proposition that the metric system should be the legal standard in the United States was voted down by a majority of 11 votes in 89, as was the proposal that it should be the standard in transactions with the Federal Government by 5 votes, the proposition that legislation should be undertaken which would promote its adoption was favored by a vote of 41 to 39; that the Carnegie Institution was considering suggestions regarding research work in heating and ventilation; and that the revision of the constitution and by-laws with a revised list of members would soon be forwarded to the members. The final copy of the uniform contract, embodying changes suggested by the society and by the Master Steam Fitters' Association, was presented by Mr. S. A. Jellett. It was voted to request the Board of Governors to name Detroit as the place of the summer meeting.

The remainder of the afternoon was spent in discussing two topics of which the first was, "In making screwed joints, is it better to use some compound or make them up iron to iron with no compound?" Mr. H. J. Barron did not believe in the use of red lead or of a mineral paint and in this Mr. A. A. Cary concurred, stating that as some lubrication is desirable in making a joint he found a thin mixture of linseed oil and graphite very satisfactory. For high-pressure work with flanges, Mr. Crane employed the linseed-oil-graphite mixture, painting the gaskets also; in plants having an oiling system he found it necessary to use black asphaltum of the consistency of soft butter, as other preparations would leak. Mr. Cary said that there was much of bad pipe and fittings on the market, and he felt that if the use of the so-called dope were suppressed, so that poor thread work is not hidden in order to pass inspection, it might result in more careful attention to the details of pipe manufacture. The second topic developed into a consideration of the need of ventilation in furnace heated residences. The popular ignorance of the necessity of furnishing means of egress for the air which must be displaced by the incoming hot air was referred to at length. The question was suggested as to whether or not the amount of air which certainly does find its way into the ordinary furnace-warmed house gives a requisite degree of ventilation, and the whole matter was referred to the Board of Governors for the attention of the committee on standards.

At the opening of the evening session, the following officers were announced elected: President, Andrew Harvey, Detroit; first vice-president, John Gormly, Philadelphia; second vice-president, R. C. Clarkson, Philadelphia; secretary, W. M. Mackay, New York; treasurer, U. G. Scollay, Brooklyn; Board of Governors, H. D. Crane, R. C. Carpenter, Ithaca, N. Y.; C. B. J. Snyder, New York; A. E. Kenrick, Brookline, Mass.; and J. J. Blackmore, New York.

Mr. Jellett then read an interesting history of the society, showing how the development of commercial affairs had forced the issue for more scientific studies and he referred to Mr. Barron as the founder of the society. He felt that a good deal had been accomplished, mentioning among other things the adjustment with the American Institute of Architects of the proper rates of compensation for engineering services and the production of the uniform contract. A résumé of the papers presented in the past ten years was certainly impressive of the substantial character of the society's technical records. An extended discussion succeeded this historical sketch as to the office of the society to secure and preserve records in detail of the different types of heating systems in different types of buildings, and this subject was referred to the Board of Governors.

The session was concluded with a discussion on the advisability of using smaller sizes of pipe in hot water heating systems in greenhouses. The belief seemed to be that smaller pipes were better, provided the boiler and firebox capacity were large enough, so that the capacity for storing heat is equivalent to the system having large pipes. Then the system would not be subject to the heat losses sometimes arising during sunny days when the roof lights have to be opened to dispose of the surplus heat, and on the other hand would have the advantage of not requiring constant attention during severe nights. Some, however, preferred steam systems for large plants, over the small-pipe large-capacity hot-water system, on the ground that quick heating with nightfall is more easily secured, and the plant can be left without heat during the day.

A review of some heating literature was presented by Mr. H. J. Barron, of New York, who discussed briefly papers which had been read before the National Association of Master Steam and Hot-Water Fitters, previous to the organization of the American Society of Heating and Ventilating Engineers, and also before the British Institute of Heating and Ventilating Engineers. It is a valuable compilation to anyone desirous of learning the sources of information for a history of the art, besides being an index to instructive publications which are still of practical value.

The second paper of the afternoon session of January 20 was read by Capt. Anders B. Reck, of Copenhagen, Denmark, who described the hot water heating apparatus in the Schioldann Institution in that city. It will not be possible to refer to this paper at length in this issue, but the general character of the system described, which is one of hot water employing steam as the heating medium, was discussed on page 75 last week. It is intended to present later the special data included in the paper and brought out in the discussion.

The next paper was presented by Mr. Charles F. Hauss, of Antwerp, Belgium, espousing the cause of the metric system. The result of the vote taken by the society in pursuance to the action of the summer meeting, was noted in a preceding paragraph. In the discussion there was indicated a preponderance of pro-metric advocates.

In the evening the usual dinner was held at the Arena.

Test of Hot-Air Radiators.—The next paper was a record of a test of a hot-air heating apparatus using radiators instead of registers. It was read by Dr. George M. Aylsworth, of Collingwood, Ont., who described his system at the Niagara Falls meeting in July. This was reviewed at length in these columns on July 25, 1903, it will be remembered, accompanied by illustrations of the radiator and of the hot-air piping system connecting the hot-air furnace with the radiators, somewhat after the fashion of the ordinary hot-water heating system. Briefly, the radiators are constructed of thin sheet metal forming air conduits 1x7 inches in cross-section and arranged in a sort of zigzag path upward and downward from inlet pipe to outlet, so that the distance the air travels approximates 9 feet where the inlet and outlet are but 2 feet apart. The radiator consists of one or more sections, each presenting in the average size 14 square feet of radiating surface.

The apparatus tested is installed in a building in Collingwood, Ont., about three-quarters of a mile from Georgian Bay from which it is subject to high winds. The building is a two-story, isolated, brick-clad dwelling particularly unprotected from the wind, and has ten rooms, exclusive of closets and halls. The trial was made during the eight days following the completion of the installation. The pipes, supplying heat to the bathroom and a bedroom over the pantries, pass from basement to the first floor through a lath and plaster partition next the kitchen and pantries. As there was no fire in the house, or means of making any, except the furnace, the kitchen and pantry absorbed most of the heat through the partition that was intended for the bathroom and bedroom mentioned, so that the two latter rooms are not included in the temperature record though the heat was constantly turned on them.

The furnace has a fire-pot 16 inches in diameter and its capacity with registers is estimated at 7,000 to 12,000 cubic feet by its manufacturers. The space heated in this test is 13,400 cubic feet (ground floor 6,450 cubic feet; first floor 6,950 cubic feet). The outside doors and windows have 415 square feet of which 56 are in the kitchen and pantries, leaving 359 square feet. The outside walls have 2,720 square feet of which 480 are around the kitchen and pantries, leaving 2,240 square feet.

From these data the author calculated that in accordance with the formulas of Prof. Carpenter, the radiating surface needed for hot-water heating would be 508 square feet and in accordance with another authority, 448 square feet, giving an average of 478 square feet. In the present case there were 350 square feet of radiation in the hot-air radiators, or 37 per cent. less than the average cited.

For the test the temperatures outdoors were obtained from the meteorological station at Collingwood, and in the accompanying table the second column gives the highest and lowest outdoor records. During the first and second days there were high winds; during the fourth, doors were open a good deal by masons at work; on the night between the fourth and fifth days there was a severe gale, as there was also during all the following nights; in the morning of the sixth day the fire was out; and also on the morning of seventh day. The temperatures are given at 9:30 in both morning and night, beginning at 9:30 P. M. on the first day. On the night between the tenth and eleventh days the temperature reached 15 degrees Fahrenheit with a gale of wind and the temperatures were 60 and 58 on the ground floor and 57 and 54 on the first. The author said this result was obtained without crowding fires. The amount of coal burned through the first three days was 183 pounds and through the remaining five days, 350 pounds.

Temperatures in Hot-Air Radiation Test.

No. of day.	Outdoors.	—Ground floor.— Highest.	Lowest.	—First floor.— Highest.	Lowest.
1.....	28-0	66	63	62	56
2.....	25-4	62	60	60	58
		66	63	60	57
3.....	35-24	64	63	60	57
		66	63	59	56
4.....	34-27	64	62	59	56
		66	64	60	56
5.....	35-11	70	68	62	58
		70	66	62	58
6.....	27-10	67	64	58	56
		67	66	64	62
7.....	35-27	74	72	68	66
		70	64	60	57
8.....	38-19	68	66	62	60
		65	62	60	58
9.....	20-0	60	58	57	54
		66	64	60	57

The second paper of the Thursday morning session was presented by Mr. Hauss, giving a table of heat transmission coefficients of building materials. This will be found elsewhere in this issue. Mr. A. M. Feldman referred to the tables published by Mr. Alfred R. Wolff and printed in this journal December 30, 1899, and these he felt ought to be appended to the paper. It was stated that all such tables were traceable to the experiments of Péclet, but Mr. William G. Snow explained that Mr. Wolff's coefficients had been changed in some particulars to accord with his experience. With regard to the heat transmission from the heating surfaces of hot air furnaces, Mr. Snow thought that the maximum figures given in the paper, 750 to 850 thermal units per square foot per hour, were none too high. Assuming that 3 pounds of coal are burned per square foot of grate per hour and 8,000 thermal units are capable of being utilized from each pound of coal, he calculated taking an average furnace having 20 square feet of heating surface to 1 square foot of grate, that 24,000 pounds thermal units are utilized per hour per square foot of grate or 1,200 units per square foot of heating surface. A motion was carried referring to the committee on tests the investigation of the relative value of prime and extended heating surface.

Oil Burning in the boilers of the power plant of the North Shore Railroad running from San Francisco to San Rafael, Cal., is accomplished in a marine-type oil furnace, designed by the Babcock & Wilcox Company. The bridge wall is moved to the rear of the boiler, giving the furnace a length of about 10 feet, and the burner extends from the front of the boiler and reaches clear to the bridge wall, where it points forward, directing the flame toward the front of the boiler. The boilers are set facing the engine room, placing them under the observation of the engineer. The plant was designed by Messrs. Charles C. Moore & Company, of San Francisco.

Letters to the Editor.

Theatre Fires.

Sir:—I wish to express to you my appreciation of your complimentary note in the editorial relating to "Theatre Fires." My two books on the subject seem to receive considerable attention at this time, but this is quite natural after such a terrible catastrophe. What makes me feel sad is that it should require such an accident to wake up the authorities, and furthermore, the fact that surely within four weeks the lessons will be forgotten. I believe your valuable paper could do a good thing and render the best possible service to humanity by calling attention to the fact that rather than have "Theatre Commissions" only after a fire, we should have *constant* watchfulness, and the fulfilment of the *existing laws* on theatre safety.

There is absolutely no excuse for the appalling loss of life in Chicago. The safety of the public in all such places depends primarily upon proper and sufficient exits. We cannot here have, as they do in Europe, theatre buildings standing entirely free in a block. But we can have sufficient exits, and if these were all used nightly and made known to the theatregoers, there would be no such calamities. Much more might be said concerning this latest accident, but really the measures to be taken for safety are quite obvious. Moreover, the guilty should be punished, and this reminds me that the "New York Evening Post" is in error in stating that in no case have the guilty parties been punished. I have in my library on "Theatres," a special book on the trial of the managers and directors of the Vienna Ring-theatre fire. Several of these were sentenced after the fire to several years' imprisonment.

Very sincerely yours, Wm. Paul Gerhard.

New York, Jan. 13.

Heating Costs of Various Systems.

Sir:—The article in The Engineering Record of December 26 is a fair exposition of comparative costs for various heating systems, and since the fan system has been gone into in greater detail than others, we could wish that a statement had been made in regard to what was actually covered by the heating costs given in the table, and whether exhaust or live steam was used.

It may be assumed from the fact that most of the buildings mentioned are factory plants, that exhaust steam would be available for the most part and that the cost of boilers would not be included, but that all other expenses, such as steam and return connections, also foundations for apparatus, are included. If this is the case, the costs in most cases are higher than contracts placed during the last year would show.

As is pointed out by Mr. Holbrook, the cost of installing the fan system of heating is uncertain, depending more than any other on the type of building and the consequent variation in the expense of distributing air ducts. Then, again, it is not always possible to locate the fan and heater advantageously so as to avoid a long main duct, or the use of cranes may require the use of brick ducts below the floor, another expensive item.

Comparing Mr. Holbrook's table with some installations taken at random for various size factory buildings, we know of a machine shop of about the same capacity as No. 2, which, by an exceptionally fine location for the apparatus, was heated at a cost of $0.00225 per cubic foot, and another containing 248,000 cubic feet, the cost of which was $0.00444. In the latter plant, a large amount of piping was required. Another installation is the case of a five-story factory building, containing 507,000 cubic feet, the cost of heating being $0.0037. This also took a very large amount of distributing piping. A regular type factory building, similar to "B" in Mr. Holbrook's list, which we have on record, cost $0.00224 and another, with 875,000 cubic feet, at $0.00206.

A fan system as installed in tannery buildings is quite a different proposition from a factory heating plant, and as a comparison with Nos. 7 and 9, we find the case of a tannery building containing 448,000 cubic feet, the cost of the heating plant being $0.00528 per cubic foot, nor do we think this is excessive for a carefully designed plant.

Nos. 14 and 16 in Mr. Holbrook's list are plainly exceptional cases on account of the small amount of distributing piping which was necessary. No. 15 is evidently a similar case, although the weight of iron ducts is not given.

As a comparison with a building of this class, we find a machine shop with 5,590,000 feet cubical contents, the cost for heating being $0.00116, and for regular type factories, with what may be assumed as an average amount of distributing piping, $0.00216 for a building of 2,440,000 cubical contents, and $0.00234 for another with 1,516,000 cubical contents.

These instances include direct-attached engines, but do not include boilers. If an average is of any service, it might be said that for regular type factory buildings with cubical contents from 500,000 to 3,000,000, the heating cost will be about $0.00225.

Yours very truly, Buffalo Forge Company.
Buffalo, Jan. 12.

Superheated Steam.

Sir:—I have read with considerable interest the editorial in your January 2nd issue, discussing the economy of superheated steam in the light of information derived from tests made by Prof. Jacobus on a 400-horse-power Corliss engine. It seems to me that too little attention is given to the simplicity of form of the engine in question, which gives a coal consumption per indicated horse-power as low, and possibly lower, under equally favorable conditions, than would be realized by any other engine of this class. The advocates of superheated steam give a good deal of prominence to the claim that by its employment an engine of the plainest type is put far above its class in the matters of fuel and steam economy.

In this engine the low-pressure piston is but three times the area of the high, which is a comparatively low ratio and enables the use of a smaller low-pressure cylinder. Steam jackets, separator and water relief valves are omitted, while the steam pipe may be of less diameter and the condensing apparatus smaller than would be required for saturated steam. As whatever is done to simplify the construction of an engine tends to reduce the first cost and expense of maintenance, this should be credited to superheating. Full account should be taken of the sustained economy of operation at partial loads and the freedom from annoyance due to the presence of water in the steam. The same is true of the actual saving in the steam consumption. This has a commercial value quite apart from the account of fuel since the saving in steam consumption means a saving in feed water as well as in the boiler power. If by the addition of one superheater 20 per cent. of the boiler power is put in reserve, the plant is a gainer to this extent. In many power stations the cost of feed water amounts to several thousand dollars a year, and it can be easily shown that the reduction in these bills, due directly to superheating, is sufficient to pay a handsome dividend on the cost of installing superheaters. It would be manifestly unfair to rate the value of superheating by the amount of fuel saved when there are so many other contingent advantages.

Are you not too low in your estimate of a fuel saving of but 5 per cent. for a superheat of 150 degrees? It is undoubtedly true that the amount of saving to be attributed to superheating varies with the class of engine considered—increasing rapidly as the type of engine becomes less refined.

There was published in your journal of May 19, 1900, a test by the writer of a slow running duplex pump of about 100 horse-power in which the steam was expanded only about eight times while passing through three successive cylinders. In this case there was a fuel saving of from 11 to 12 per cent. by superheating about 125 degrees Fahr. In still less refined types of engines the saving will be upwards of 25 per cent.

Owing to the recent extensive introduction of superheaters in this country, it is probable that much data of American origin will soon be available, and, whether moderate superheating or high superheating becomes more general, it will certainly be surprising if we do not follow the example of Europeans, whose steadfast adherence to the principles of superheating is the result of long experience.

Yours truly, E. H. Foster.
New York, Jan. 13.

Subaqueous Tunnels.

Sir:—With regard to your recent article on an "Improved Method of Subaqueous Tunneling Under the Harlem River," and the possibility of applying the same system in situations like that of Chicago, I would state that in the location of two of the traffic tunnels (Washington Street and Van Buren Street), under the Chicago River, the clear distance between docks is 148 and 180 feet respectively, and at LaSalle Street, 280 feet; in addition there is a swing bridge on the top of the Washington Street tunnel. There are also movable bridges on each side of each tunnel and in no case more than 400 feet distant on center lines. These restrict the channel of the river at Van Buren Street to one passage 80 feet wide, at Washington Street two channels each 40 feet clear between docks and center pier; at La Salle Street the channel over the tunnel is clear, but obstructed by the protections of the two swing bridges on the sides, practically to two passages of 60 feet each. In addition to these obstructions, buildings five to seven stories high are built on street and dock lines, the foundations of which would be undermined by deep dredging unless carefully protected. The channel of the river cannot be closed even temporarily at any time.

As these tunnels will have in all probability to be remodeled and lowered in the future to allow a greater depth of water, it will be seen that the difficulties in the way will be great, for the existing structures must be removed before the new work is done. Various schemes have been suggested, but no action has been taken as yet. Whether some modification of the system adopted at Harlem River can be utilized or not is a problem which will have to be solved within a few years or the tunnels abandoned, which is not likely.

The articles on the "Works at the Harlem River" I have read with great interest, and from the successful results of the "caissons" for the first part of the work, I see no reason for failure on the one proposed, though I cannot understand why the angle iron under the outer flange of the tunnel lining was not arranged to sink into the top of the sheeting instead of being outside. In the first position it would make a more airtight joint and would still have value in keeping the sheeting from spreading. It appears to me this joint may cause trouble as the cast and wrought-iron flange is very rigid and not yielding to any slight inequalities. A rubber tube or other cushion may be placed on top of the sheeting to make a tight joint.

Yours truly, Samuel G. Artingstall.
Chicago, Ill., Jan. 11.

A Municipal Lodging House, London.

A municipal lodging house, capable of housing a population of 814 lodgers, has been built at Deptford, London, by the London County Council and the Metropolitan Borough Council of Deptford, each of which contributed one-half of the cost. It is the result of a long agitated scheme to replace an area of old buildings which were in a very unsanitary state, but it appears that it is not the first structure of this character, as one was opened in Drury Lane, in 1893.

The Deptford house stands on a site of 39,793 square feet area and is six stories in height, exclusive of the basement. Its facades are of red brick relieved with Portland stone dressings and the upper part of the main frontage is finished with cement rendering. The roofs are covered with green slates. On the ground floor there is a spacious dining room, a reading room, a smoking room, locker room, barber, tailor and shoe-making shops, shoe-shining rooms, lavatory, a feet-washing room, bathrooms, dressing rooms, lodgers' wash-house and latrines. Besides these there is the administration section with the superintendent's quarters, linen stores, establishment scullery, kitchen and store rooms and a fumigating room. The five upper stories contain 814 cubicles, so-called, with toilet rooms on each floor.

The dining room has an area of 6,067 square feet, including space around a hot plate where lodgers may do their own cooking. Fixed teak tables and seats are provided to accommodate 440 men at one time. Sinks near the hot-plate chamber allow for preparing the food, and these are fitted for hot and cold water. A cylinder is fixed at each end of the chamber with a constant supply of boiling water for making tea. The smoking room has a floor area of 2,031 square feet and fixed teak tables and seats for 104 men in addition to movable easy chairs. The room is heated by means of three open fireplaces, which are arranged to discharge warm air into the room. The reading room has 3,057 feet of floor space and is equipped similarly to the smoking room with accommodations for 176. It has in addition two polished teak bookcases containing books for the use of the lodgers. The foot baths consist of nine troughs, divided by glazed fire-clay slabs, and supplied with hot and cold water.

Each cubicle floor is separated into sections, containing 14 to 22 cubicles, by division walls, to provide for the isolation and disinfection of sections in the event of contagious disease. Each lodger has an independent cubicle, having a minimum width of 4 feet 10½ inches, an area of 36 square feet and lighted by a separate window. The heights from floor to ceiling are 8¾ and 9 feet. Partitions between cubicles are 7½ feet in height; the wall adjoining the corridor, 6½ feet, to insure ventilation. The partitions on the first floor are of concrete slabs coated with plaster and have been adopted experimentally. Each cubicle contains an iron bedstead with a spring mattress, and the whole can be folded back against the partition. Each floor has three fire hydrants with hose pipes. According to the "Surveyor," a charge of 6 pence, or 12 cents, for a cubicle a night is made, in order to pay expenses, as shown by the experience of the Drury Lane venture.

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Concrete-Steel Construction.

Concrete-steel construction is passing through the stage of maltreatment usual to the rapid adoption of any new process or material of exceptional merit, the character of which is simple enough to lead all sorts of people to believe they know how to treat it in both design and construction. The combination of concrete and steel for structural purposes is old, Kirkaldy having tested it in beams nearly fifty years ago, but in spite of its age little has been known of its real nature and capacities until the past few years. The refinements of its theories have not been as generally recognized as they should be and engineers even have failed to scrutinize sufficiently either the character of the steel reinforcement or the concrete not only offered but used under their supervision. There seems to have been universally prevalent the idea that almost any kind of a combination of Portland cement, sand, gravel or broken stone or cinders and steel will somehow or other under any circumstances whatever produce one of the best structural materials used in modern engineering. It has not been supposed that in this combination it was necessary to deal with its principal element as a most sensitive material, made either valuable or valueless by slight differences in treatment, or that its essential advantages can only be developed in design by a much more careful theoretical treatment than is necessary in the design of steel beams.

Concrete-steel has one characteristic that renders imperative the greatest possible care, both in design and construction, viz., the process of manufacture of the material is concurrent with the building of the finished structure. There is consequently no opportunity to test the material before the structure is completed, as there is in a steel bridge or building, and reject it if not satisfactory. The faults of manufacture manifest themselves only in the weakness or failure of the structure, and this is precisely why so large a number of concrete-steel failures, mostly or all in buildings, have been lately recorded. The first step toward failure has been taken by entrusting the design not to an experienced engineer, but perhaps to a mason or some other inexperienced or indifferent person unqualified to determine either the character, amount or distribution of the steel reinforcement or to prescribe the manner of mixing the concrete and putting it in place with the steel. The natural consequence is a product called concrete-steel, but which in reality fails to possess even one true feature of resistance of that admirable product. The superficial examination of even one sample of that kind of "concrete-steel" is sufficient to indicate the real origin of the difficulty. In such cases nothing is more common than to find considerable portions of the gravel, broken stone or cinders with a large proportion of voids unfilled with mortar and with the cement in the latter so indifferently mixed with the sand as to give it little capacity for resistance. Again, in these cases of failure the steel reinforcement is sometimes of such a character as to prevent any computations being made to show its resisting capacity and this condition may be supplemented by a most indifferent bond between the steel and the concrete.

The attractiveness of a new material capable of yielding excellent results has been seized upon by incompetent parties careless of almost every element of the problem except putting in place something that may be paid for. They fail to realize, as do their clients, that the concrete employed in concrete-steel construction should be of even better quality than that used for ordinary masonry not only as to the quality of the component parts, but also as to the care with which the admixture is attained and that there is required a most intelligent use of both the concrete and the steel in the completed combination. The concrete is placed in smaller masses of far less thickness than in ordinary masonry and it must be so treated or disposed in place as completely to enclose the steel bars or rods and make with them an absolutely continuous bond or joint. The conventional agreement to neglect tensile resistance of the concrete makes no compensation whatever for any defect in manufacture. On the other hand there is no nicety or refinement of admixture or degree of perfection in putting the concrete in place which is not perfectly practicable of attainment with reasonable care and without material increase in cost, but it is unqualifiedly imperative that the best class of workmanship in every respect should be found in concrete-steel construction.

This is not saying that a rich concrete must necessarily be used because it is perfectly legitimate, in fact it is judicious, to make use of the balancing of the sand, gravel and broken stone or cinders so as to reduce the volume of cement to the lowest practicable amount, but scrupulous care should be exercised to grade the various sizes of those components to a true balance and then secure the actual filling of all voids with the cement. The result will then be an actually solid mass in which the concrete holds the steel with a continuous bond permitting no sliding or stripping of the rods if they are of the proper form and section.

In the case of steel beams or girders the recognition of certain elementary values of the transverse shear is all that is necessary, but in a concrete-steel beam much more is required. The transverse shear, particularly at the ends of the beams, is still a most important element especially as the shearing resistance of concrete is low. More than this, however, is the necessity of determining the longitudinal shearing resistance of the bond between the steel reinforcement and the concrete because the tension in the steel is given by this bond. These essential elements in the designing of concrete-steel combinations have not yet received sufficiently extended recognition, although they are recognized and provided for in some of the best designs at the present time. It is decidedly interesting to observe that the theory of internal stress in bent beams finds its most extensive application up to this time in the practical designing of concrete-steel members. The tests to failure of a considerable number of concrete-steel beams verify in a striking manner many of the features of that theory and demonstrate conclusively that its application is essential in safe design.

The concrete-steel combination is one of the most valuable materials developed in recent years in engineering construction. It has a wide field of use and its extensive application has already led to results of great value both in economy and in durability by making the employment of masonry easy and attractive where it had hitherto been impossible. Such failures as have resulted do not in any way militate against its value, but they have demonstrated with absolute conclusiveness the same necessity of intelligent design and equally scrupulous care in construction as has long been demanded in steel structures and other rational works of the civil engineer.

Who Is a Civil Engineer?

There seems to be a great difference of opinion concerning the definition of the term "civil engineer," and as a matter of interest rather than of any particular importance, it is worth some consideration. Originally, of course, the term was used to designate all engineers not employed in military work, and some men of the highest distinction in engineering circles have recently insisted that this definition remains accurate to-day. George S. Morison, in his remarkable volume of essays entitled "The New Epoch," upheld this opinion with characteristic vigor. He based his argument on Thomas Tredgold's famous definition of civil engineering, made in 1828, as the art of directing the great sources of power in nature for the use and convenience of man. This definition embodied in the charter of the most powerful engineering society in the world within sixty years of the date of Watt's first engine, has certainly done much to unite the members of the profession. Mr. Morison states with entire frankness that had the profession remained unnamed until the end of the last century, it is possible that what is now called by a single name would have been divided into several professions. In the charter of the Institution of Civil Engineers it is expressly stated that the real extent of civil engineering is limited only by the progress of science, and that its scope and utility will be increased with every discovery and its resources with every invention. Hence it is claimed that civil engineering, according to the best definition, is comprehensive of all branches.

While Mr. Morison accepted this well known definition as the correct statement of the nature and scope of civil engineering, even at the present time, he gave the term "civil engineer" a much more restricted meaning than is commonly understood. If his view is accepted, some of our technical schools are making a mistake in conferring a C. E. degree after a four-year undergraduate course. In his opinion the civil engineer is one competent to design and direct engineering works, two-fold attainments which it is manifestly impossible to teach completely in a school course. Under this definition anyone competent to design and construct engineering works is a civil engineer. "He may be a railroad builder, he may be a skilful surveyor, he may be a mechanical engineer, or he may follow any other specialty; but whatever he does he must do it not as a skilful workman, but as one qualified to design. Any man who is thoroughly capable of understanding and handling a machine may be called a mechanical engineer, but only he who knows the principles behind that machine so thoroughly that he would be able to design it or to adapt it to a new purpose, whatever that purpose may be, can be classed as a civil engineer. Any skilful sewer-builder and pipe-fitter may claim to be a sanitary engineer, but only the man who approaches his work with the intelligent knowledge of the conditions which sanitation involves can be classed as a civil engineer. Any man who knows how to work a mine may be a mining engineer, but only he who understands why he works his mine as he does, can be called a civil engineer. Any well-practiced electrician may be classed as an electrical engineer, but only one whose practical knowledge is based on the intelligent study of electricity can be called a civil engineer."

It is probable that the comprehensive nature of the engineering profession was never better stated than in these words of one of America's greatest engineers. Yet they fail to find entire acceptance with the majority of men competent to design as well as to direct engineering works, because of the objection to the use of the word "civil" as a designation of the highest grade of engineers. For many years The Engineering Record has endeavored to preserve this old meaning of civil engineering as the name of a true profession and not a craft, but the trend of general usage renders such a position untenable any longer. The necessity of a term having the significance attached to "civil engineer" by Mr. Morison may be admitted frankly, without accepting that term as the proper name for the most competent men of all specialties.

The actual meaning of the term "civil engineer" among engineers is the best indication of Mr. Morison's error. The American Society of American Engineers draws a distinction between the various classes of engineers in its Constitution, which reads: "A member shall be a civil, military, naval, mining, mechanical, electrical or other professional engineer, an architect or a marine architect." Moreover, if civil engineering were as comprehensive as Mr. Morison's arguments asserted, the "Transactions" of such a representative organization as the American Society of Civil Engineers would contain papers and discussions of interest to the men engaged in military, mining, mechanical and electrical work. This has not been the case, for when Secretary Hunt wrote his "Historical Sketch of the American Society of Civil Engineers," only 5.99 per cent. of the published papers had been on mechanical engineering, 1.37 per cent. on electrical engineering and 0.24 per cent. on military engineering. The volumes of "Transactions" since that book was printed are equally marked by the absence of papers on electrical, mechanical and marine engineering.

If the current understanding of the term "civil engineer" is at variance with the comprehensive definition by Mr. Morison, which is not even sustained by the Constitution and publications of the American Society of Civil Engineers, it is necessary to suggest some new definition. Civil engineering is certainly not the cob after mechanical engineering, mining engineering, electrical engineering, chemical engineering and all the other specialties have been shucked off. It is the engineering profession of a quarter century ago; the others are new professions and their importance in comparison with civil engineering depends very largely on how far they have profited by the experience of the civil engineers in their fight for recognition as professional men. Civil engineering to-day, as formerly, is the art of supplying works for facilitating commerce and for meeting the public necessities of cities. Some readers can doubtless improve on this definition, which is put forward more to bring out discussion than as something in which The Engineering Record takes pride. Railways, bridges, canals, river and harbor improvements, tunnels, water and sewerage works, pavements and the like fall under this head, while power plants, machinery, electrical apparatus, ships, mining works and fortifications belong elsewhere.

The engineering profession is too comprehensive to be grouped to-day into but two divisions, military and civil. To insist that every non-military engineer able to design as well as direct works is a civil engineer is to cling too strongly to the past. It would be logically as correct to restrict the term engineer to the man who works a catapult in a circus, for in old Roman days an engineer was the heavy artillerist who threw bowlders and sheaves of spears and other unpleasant things by means of machines. If "engineer" is restricted to its first definitely fixed meaning, we will have to call one man a sewerer, another a waterist, another a bridge builder and so on. Of course this is absurd. The electrical engineer, the mechanical engineer, the marine engineer and the other followers of the new branches of engineering admit that the civil engineers have the strongest professional society, that their work and their papers are exceptionally free from the taint of commercial interest, and that they have done more than any other branch of the profession to make the importance of engineering recognized by the public. But these members of the new branches, while glad to work with civil engineers, will never consent to be called civil engineers. Although they represent comparatively young branches, they believe their specialties are advancing so rapidly that the day is not far distant when electrical and mining and mechanical engineering will be everywhere reckoned as having a history as important, if not as comprehensive, as that of civil engineering. They are proud of their work and animated by the certain knowledge of great achievements in the future, and refuse to bury their identity under the name of an older specialty which has already reached in many of its departments the condition where progress means standardization rather than marked improvements.

Meeting the Cost of Sewerage Systems.

The city of Taunton, Mass., is now considering various methods of meeting the cost of the extension of its sewerage system and the construction of sewage disposal works, a subject which has probably received a greater amount of study in Massachusetts than in any other State. Under the laws of the commonwealth, at least one-third of the cost of a sewerage system must be assessed on abutting estates, but the method of raising the remainder of the money is left to the local authorities, subject to the control of the courts. The subject is one on which a great difference of opinion exists, and one in which the courts of different States find points on which to disagree. In fact there will always be some divergence of opinion concerning the correct method of meeting the costs of this class of public service, because there will always be a variety of opinions concerning the relative fairness of different methods of levying assessments.

The old-fashioned way was to charge the cost of any sewer work to the abutting property owner, whether it was a ten-inch lateral or a four-foot main sewer, and if a man was so unfortunate as to live on a corner lot he paid for the sewers in both streets. It was useless to protest, because no better plan had been devised. In place of this unjust system of raising the funds for the work, a great number of plans have been proposed from time to time, but of them the one which seems to meet the needs of Massachusetts communities most closely embraces a general assessment of a part of the cost, made on the ground that a sewerage system improves the public health of the community as a whole; an assessment of another part of the cost on the basis of the frontage and area of abutting property, and the assessment of still another part of the total expense in proportion to the water used on the premises or the character of the buildings on it, or the like.

The method of assessment which the city of Taunton has under consideration is of this last class, and has been outlined in a report by Mr. F. Herbert Snow, who was probably the first engineer in the country to work out the plan on a practical scale. This he did while connected with the public works of Brockton, Mass., and the method has given satisfaction there, so far as this journal has been able to ascertain. As proposed for Taunton, the assessment on abutting property will be at the rate of twenty cents per foot frontage on each street where a sewer is laid and two and four-tenths mills per square foot of area of such estates within one hundred and twenty-five feet of the street. Where property lies on two intersecting streets, the frontage assessment is to be made on the longest side and on not more than sixty feet of frontage on other streets. No area is to be assessed more than once, no matter how many streets it may abut on. If property is so located that by reason of its elevation or any other cause it cannot make use of the sewerage system, it is not to be assessed until improvements have made the system of value to it. While this regulation enables the local assessment on such property to be evaded for a time, the property is of course liable for the proportion of the cost of the sewerage system which is raised by general taxation. This is, of course, but just, for the presence of sewers near real estate increases its value considerably. The annual operating expenses for these works, together with the fixed charges due to them, are to be met by rentals based on the class of building, amount of water delivered to the sewer or otherwise, as the commission may determine.

This plan is of interest because it is proposed for use in a place where the annual charges include the cost of operating sewage disposal works, as is the case at Brockton. These disposal expenses are considerable, and the idea of assessing them on those people using the sewers seems equitable. While the plan may appear complicated, and actually is somewhat intricate, nevertheless after it is once worked out and all the data collected for preparing the bills, the clerical work of looking after the accounts is a routine matter. This system has aroused considerable criticism so far as its applicability is concerned to localities where disposal works are not needed. It is manifestly unjust to assess on the abutting property the cost of all work done in front of it, but there seems to be little objection by property owners to assessing on them the cost of a 10-inch sewer and then raising the remaining sum needed for construction by a general tax on all the district benefited by the system. The cost of repairs and maintenance is met by general taxes, just as is the cost of repairing streets and water mains. Which system of raising money for sewers will best suit a given case, is a matter to be settled only after a full consideration of the engineering features of the problem and with an intimate understanding of the temperament of the average taxpayer. It is a subject in which absolute justice and strictly engineering principles have to be tempered with certain allowances for human foibles. If these weaknesses are properly regarded, sewer assessments should not be particularly difficult to establish in a fairly satisfactory manner in any city.

National Aid for Road Construction.

Within the last fortnight The Engineering Record has received what purports to be an extract from the Congressional Record, although that ponderous publication must have changed considerably of late, if the document sent under the frank of Walter P. Brownlow, M. C. from Tennessee, is an extract, verbatim et literatim, from its pages. The covers bear pen and ink sketches by T. S. Sullivent, the caricaturist, to illustrate conversations between a farmer and his team of horses, while the contents is a mass of figures and statements compiled in a fashion which is doubtless intended to interest a farmer but will probably make him very tired if he is moderately intelligent. Yet the pamphlet contains the text of an important bill which merits much careful consideration. It is unfortunate that this bill is brought to the attention of the public in such a manner, wholly out of keeping with the gravity of the subject, and readers of The Engineering Record who receive the pamphlet are advised to read it in spite of its trashy appearance.

The purpose of the bill, which was introduced in the House by Mr. Brownlow and in the Senate by Mr. Gallinger, is to assist road construction by national appropriations equal in amount to those made locally. It is proposed to spend $8,000,000 a year for three years in this manner. The money is to be apportioned among the States in proportion to their populations, not less than $250,000 being available for any one State. In case a State does not avail itself of the assistance to which it is entitled, the money is to be apportioned among those States which desire aid. The bill provides for the machinery of administering such assistance, which will be in charge of a bureau of the Agricultural Department. It is apparent that in drawing up the bill a careful study was made of the facilities for national road supervision already existing in Washington, and the organizations of the State highway offices in Massachusetts, New Jersey, Connecticut and New York have received careful attention. Whether the organization proposed in the bill is the best for the purpose is a subject on which those who have long been in close touch with such work are most competent to speak; on the face of it, the scheme seems a comprehensive one calculated to enable the work to be inaugurated with success. But it is not so much the details of the bill which deserves the attention of the people, as it is the principle of national aid itself. While the subject can be settled in Congress alone, it will unquestionably be decided by an adverse vote unless the people of all sections of the country indicate their desire to have such a measure passed. It is probably for this reason that the country is being flooded with the pamphlets mentioned, which urge all in favor of national aid to signify to their congressmen their approval of the bill. As there are many readers of The Engineering Record who will receive this request to use their influence for the measure, it is worth while examining the justness of such an application of national funds.

It is important to notice in the first place that the national aid will only be given to those States or parts of States where an equal sum will be raised for the purpose. In other words, the $24,000,000 of federal funds, which will be spent if the bill becomes a law, will be supplemented by an equal sum from the sections of the country where the roads are built. There are some sections in the West and South where roads are much needed for their development. The construction of inexpensive highways in these sections would eventually so increase the taxable valuation of property that a State as a whole is warranted in appropriating a considerable sum in order to secure the national aid for road building in such districts. The State which waits for its resources to be developed is like the business house which does nothing to extend its trade; some States have already learned by experience the great good which a department of publicity calling attention to their natural advantages can render.

Every year the country spends many millions of dollars to improve the rivers and harbors of the country for the purpose of facilitating commerce. This money is not spent for the benefit of the people living along such waterways, but for the country at large, for the experience of many centuries and countries has been that the increase in the commercial position of any community is accompanied by a growth in the country's prosperity. National wealth is merely the sum of the wealth of many communities, and to-day the success of one community means an advantage to all others with which it does business. This is because the means of communication between different cities are so good that the conditions which affect the prosperity of one are soon felt in all in the same section. The construction of steam and electric railways and the improvement of rivers and harbors have made the handling of merchandise between cities a simple matter, both expeditious and cheap. Very little has yet been done, however, to make the handling of materials between farms and cities any easier. The one-third of the people of the United States who live in cities and towns are enabled to ship their supplies and products in a fairly satisfactory manner, but the two-thirds of the population who live in the country are still without such advantages in the way of roads as the farmers of Great Britain, Germany and France enjoy. The United States is, of course, very young and has not had the centuries of civilized existence which are responsible for many of the highways of Europe. Whether national aid for roads will make the farmers' lives any more pleasant and their work any more profitable, is a question which must be settled by experiment. But the possibilities of improvement are so vast, the results of any real increase in the value of agricultural land would be of such national advantage, that this journal believes the bill should be passed. The arguments in its favor are the same as those for the national improvement of rivers and harbors, and the country is surely able to undertake such an experiment.

Notes and Comments.

NATURAL FILTERS have been constructed at Springfield, Ohio, to increase the yield of a system of ground-water works recently built. The water is drawn from a gravel bed 15 to 26 feet in depth, and before the recent improvements were made the water level in the pump well sunk in this gravel was only about 4 to 6 feet above the bottom. A small rock-fill dam was thrown across a creek and the water diverted in this manner to a reservoir 160 feet long, 60 feet wide, and about 8 feet deep. From this reservoir the water is distributed in open-jointed vitrified clay pipes over the gravel bed, and there is some percolation into the gravel through the bottom of the reservoir. Since these works were put in operation the water in the pump well has risen about 10 feet and the works have proved able to furnish all the supply needed. This system of natural filtration to increase the yield of a gravel bed is not strictly novel, for several such installations have been described in The Engineering Record. It is of sufficient rarity, however, to merit mention, for it affords in some cases, as at Springfield, a method of securing an additional supply of good water at a small cost.

THE TESTS OF ELECTRIC RAILWAY EQUIPMENT at the Louisiana Purchase Exposition promise to be of high value. A second meeting of the Commission having the subject in charge was held in New York on January 27 at which Mr. J. G. White, chairman, and Messrs. H. H. Vreeland, James H. McGraw, George F. McCulloch and W. J. Wilgus were present. A great deal of interest has been manifested by engineers in the proposed tests and the utility of the data which will probably be obtained in this way is not to be overestimated. The tests are expected to stimulate in a marked way the development of electric traction along lines leading to improvements in different classes of service. With this idea in mind, the work of the Commission has been separated into four main divisions, and special committees of engineers who are specialists in the several divisions of electric railway work have been appointed to prepare schedules for the tests of the equipment offered in each class. These committees are as follows: First, on city and suburban equipment; second, on interurban equipment; third, on heavy traction equipments; fourth, on new systems of electric traction. These committees are expected to report to the Commission before February 22, in order that their reports may be discussed at the next meeting of the Commission, on February 29. It is evident from the manner in which the Commission has undertaken these tests that they will be in no sense perfunctory, but will prove fruitful of results of value to all who are interested in electric traction.

The Craig Goch Dam for the Water Works of Birmingham, England.

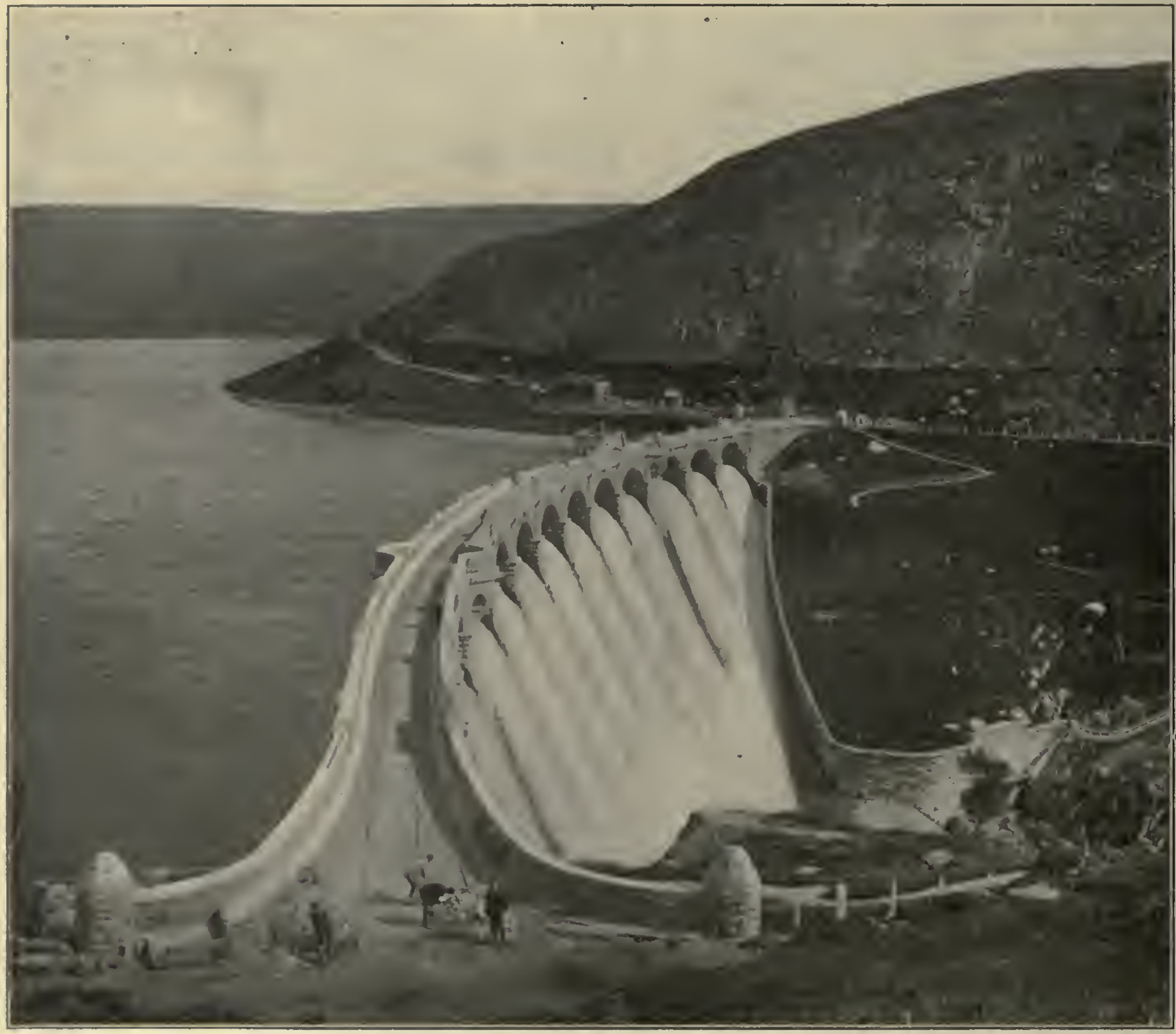
March 7 and December 12, 1903, this journal reproduced a number of views of well known European dams, calling particular attention to their architectural treatment. Herewith are presented two views of a large masonry dam recently completed for the water works of Birmingham, England, which make an interesting addition to the collection. The photographs were kindly sent by Mr. James Mansergh, M. Inst. C. E., the engineer of the works. The Craig Goch dam is the highest of several now under construction to form a system of reservoirs and the first to be completed sufficiently to permit its reservoir to be filled. When the views were taken water was flowing over the crest, and shortly before, the level of the reservoir was 18 inches above the crest of the dam.

The reservoir is located in Elan Valley, Radnorshire, Wales, is 2½ miles long and has a depth of water of 135 feet below the crest of the dam.

The treatment of the superstructure of the dam carrying the road recalls the arches on the top of the Vyrnwy dam. Unlike the five other masonry dams on these works, this dam is of the arched form, as shown by the views. Like them, however, it is built of large blocks of stone only roughly shaped and embedded in Portland cement concrete, for the hearting, and is faced with heavy broken coursed rock-faced grit or conglomerate closely jointed, on both upstream and downstream faces. The dam is nearly 80 miles from Birmingham. Further details of the dam are withheld from publication at present, as the works are to be the subject of a paper to be presented to the Institution of Civil Engineers.

The water works, of which the Craig Goch dam is a part, form one of the most extensive English water-supply undertakings attempted in recent years. Operations were commenced nearly twelve years ago, and there is still considerable work remaining to be done. The total storage capacity of all the impounding reservoirs when completed will be about 18,000,000,000 imperial gallons. The principal basin, known as Caban Coch reservoir, and its dam were described in the issue of this journal of June 21, 1902. The construction of a portion of the large aqueduct, some 74 miles in length, for conveying the water from the Caban Coch reservoir to the 200,000,000-gallon Frankley distributing reservoir, just outside Birmingham, was described in the issue of September 29, 1900. A part of the system known as the first instalment of Elan water includes those works necessary for storing and conveying the waters of the Caban Coch, Craig Goch and Pen-y-Gareg reservoirs, and has been estimated to cost nearly $29,000,000.

The care bestowed upon architectural details, as shown by the pictures, is worthy of attention.



Craig Goch Dam for the Birmingham, England, Water Works.

The Des Moines River Viaduct of the Chicago Great Western Railway.

Part I.—Substructure, Towers and Truss Spans.

The Mason City and Fort Dodge branch of the Chicago Great Western Railway, or Maple Leaf route, crosses the Des Moines River and valley at the city of Fort Dodge, where the valley is about 1½ miles wide and the river is about 160 feet below the level of the prairie. In the valley there is a single track steel viaduct 2,582 feet long and 134 feet high from low water to base of rail. It crosses five highways, the river channel, about 200 feet wide at low water and 700 feet wide at highest flood, the freight yard of the Minneapolis & St. Louis Railroad and the single track of the Illinois Central Railroad. There are four deck pin-connected Pratt-truss spans of 219 feet 4 inches each, supported on steel towers and spanning the low water channel, part of the high water channel and the freight yard. The remainder of the structure consists of alternate 38-foot and 75-foot plate girder spans supported on steel towers. The track on the viaduct is without grade or curvature and nine of the towers are from 113 to 80 feet in height, to the base of rail. All tower masonry is carried up above the highest freshet level, and the viaduct and bridge tower piers adjacent to the intersected railroad tracks are carried up 10 feet above them in order to oppose masonry rather than steel work to the possible impact of a derailed train. In all other places each post is seated on a separate masonry pier with the top kept as low above the surface of the ground as practicable.

The piers are located in soil of a heterogeneous character, consisting of rich loam, sand, peat, coal, marl, soapstone, iron pyrites, gypsum, vermilion, sand-rock, several varieties of clay and slate, all, in one case, within a depth of 15 feet. The material was not in regular layers and displayed a great variety of brilliant colors. In some cases the excavation was carried to a depth of 15 feet. The lower parts of the pits were filled with 1:2:6 Portland cement concrete made with Omega cement supplied by the Chicago Crushed Stone Company. The concrete in the bottom was rammed hard against the walls of the excavation and where it extended within 4 feet of the natural surface of the ground, it was faced with paving blocks of Kettle River sandstone. In all pedestals the upper part of the concrete was built to a batter; the slope was made 1:3. Above the foundations the piers, varying from 10 to 150 cubic feet each, were built of rubble stone. The top three courses of piers and pedestals were made of Kettle River sandstone dressed to lay with ¾-inch joints. The river is subject to a rise of about 20 feet above low water, which brings the flood height to the bottoms of the top courses of the river piers.

The concrete was mixed by two Ransome machines and one Smith machine driven by Fairbanks-Morse gasoline engines. It was delivered to the work in cars, buckets, derricks, wheelbarrows and through chutes, according to the relative location of the piers and mixers and as much as 140 yards were placed in an excavation at the top of the hill in one day of 10½ hours. In extremely cold or changeable weather no concrete was laid, but when the temperature was between 20 and 32 degrees Fahrenheit, concrete and stone masonry was laid, using water in every 18 gallons of which 1 pound of salt was dissolved for a temperature of 32 degrees and one additional ounce for each degree below 32. The temperature was assumed at the lowest point which it was expected the mercury would reach in six hours. In freezing weather both sand and water were warmed, but not enough to make the mortar set too quickly.

Craig Goch Dam, and Reservoir, Radnorshire, Wales.

Where the new concrete was joined to the old, the surface of the latter was scabbled to make it rough; was well moistened and was covered with a thin layer of neat cement before laying the new concrete. Generally stones were set in a face to which other concrete was to be joined so as to project about 6 inches beyond its surface and serve as dowels for the new concrete. No stone masonry was laid on the concrete until the latter was set hard, usually about a week old. Every tower post was anchored by two upset 2-inch screw rods which had bottom heads bearing on a pair of 12-inch transverse channels back to back engaging the lower sides of four 8-inch reaction beams parallel to the axis of the viaduct. These anchorages were provided at every pedestal, although in many cases no uplift could be calculated by the ordinary formula.

The viaduct superstructure has medium steel riveted members manufactured without reaming and is proportioned for the dead load and for a live load consisting of two 154-ton engines coupled together and followed by a train load weighing 4,000 pounds per linear foot. Each engine has a wheel base of 48 feet and has four pairs of drivers 5 feet apart with loads of 42,000 pounds on each axle. The other axles have 30,000 pounds each, excepting those under the pilot, which have 20,000 pounds. The truss spans have two ordinary Pratt trusses with vertical end posts supported at lower chord level and with sub-divided panels carrying the center points of the top chord on sub-vertical posts connected to the middles of the diagonals and braced there with counter-sub-diagonals.

The trusses are 22 feet 2 inches apart and 38½ feet deep on centers. They are divided into seven equal panels and carry plate girder floor-beams resting across the top chords and riveted to them at panel points and sub-panel points. They are of ordinary construction with standard top chords made with a 24-inch cover plate, two 4x4-inch top flange angles, two 4x6-inch bottom flange angles and two 20-inch and two 10-inch web plates. The top chord section has a maximum area of about 68 square inches and is made in two panel lengths about 60½ feet long spliced on the sides of the panel points away from the center. The bottom chord is made of 8-inch eye-bars and has a maximum cross-section of 66 square inches. The main diagonals are made with 6-inch eye-bars, and the sub-diagonals are each one pair of 5x1-inch eye-bars.

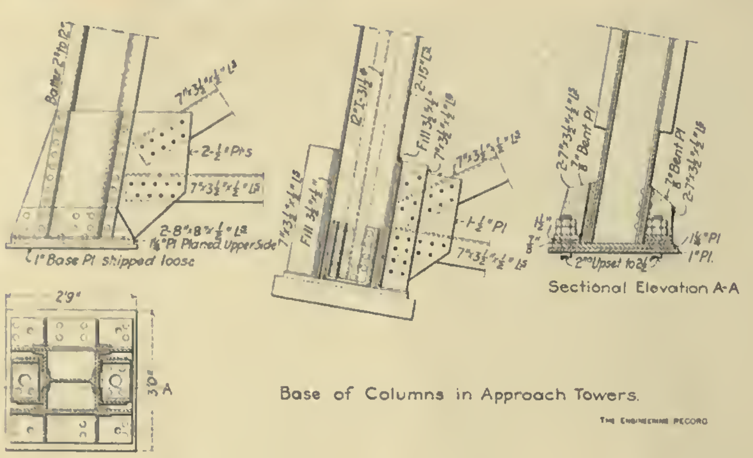
The main vertical posts are made with built channels latticed on both flanges and the sub-vertical posts are made with 12-inch channels latticed. The end panels of the bottom chord are made with pairs of 15-inch channels latticed. The top chord pins are 5½ inches in diameter, except those at the ends, which are 7 inches. The bottom chord pins are 7½ inches in diameter at the ends and 6 inches elsewhere. The diagonal main ties are made in two lengths for each panel and connected by 5½-inch pins. The main vertical posts are connected by transverse struts at the top and bottom; the former are each made with a pair of 4x6-inch angles and the latter with two pairs of 4x3-inch angles. Between them the transverse panel is sway-braced by single 4x4-inch angles.

The sub-vertical posts are similarly braced, except that the lower strut consists of a pair of 6x4-inch angles and the sway brace diagonals are single 3x3-inch angles. From the middle of the lower strut a single 3x3-inch vertical angle serves as a suspender to support the two bottom lateral diagonals at their intersection. The bottom laterals consist of single 4x4-inch angles throughout, riveted to horizontal plates which are connected to the lower ends of the vertical posts by pairs of flange angles riveted to the webs of the latter. The end posts of the trusses are braced with an intermediate horizontal strut and two panels of sway bracing, having two angles in each diagonal.

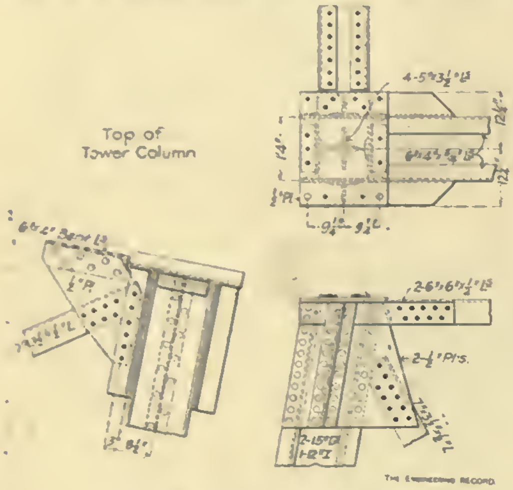
All main truss members are pin-connected except that the upper ends of the vertical and sub-vertical posts are field-riveted to jaw plates which are shop-riveted to the webs of the top chords and project below their lower flanges. The floor-beams are plate girders 41 inches deep made with single web plates and with pairs of 6x6-inch angles and single 13-inch cover plates for each flange. The floor-beams rest across the top chords of the trusses and have wide horizontal plates riveted across the ends of their lower flanges, which serve as additional connections to the top chords and to receive the field rivets through the top laterals consisting of single 4x4-inch X-brace angles in each panel. The floor-beams have standard web connections to the 27-inch stringers and the latter have their bottom flanges field-riveted to the diagonal angles. The four spans are alike.

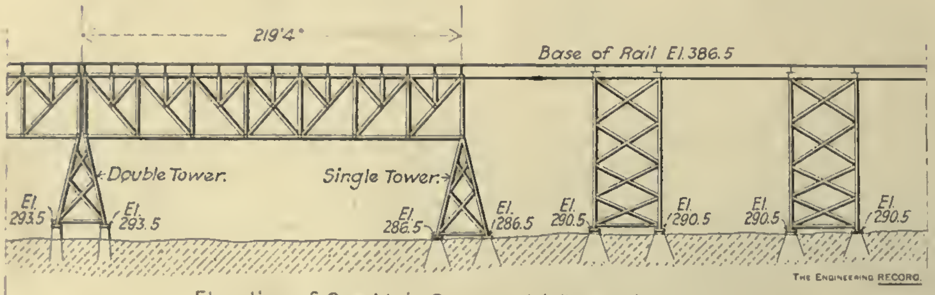
These spans are supported, as shown in the general diagram, on wedge-shape towers each having four steel posts. The tower posts are battered 1:4 in the longitudinal planes of the viaduct posts, which are battered 1:6 transversely. The towers which support only one span have the center lines of their posts intersecting on the end lower chord pin. Those which support two spans are truncated pyramids with the center lines intersecting the lower chord level 3 feet apart. It was considered that the use of these A towers was very satisfactory in reducing the uplift, for which special provision would otherwise have been required. If towers had been used similar to those for the plate girder spans, there would have been considerable longitudinal thrust due to trains on the 220-foot span with only the dead load of the tower to resist the uplift. With the arrangement designed, whenever the maximum longitudinal thrust occurs there is also a live load to help resist it so that in no case will the ordinary formulas for longitudinal thrust and wind pressure show any uplift on the masonry.

The top of each of the three intermediate towers supporting the truss-spans received the fixed and expansion ends of the 219-foot trusses, all of which were arranged to expand toward the center tower. The vertical end posts of these trusses had their bottom pins fixed in the tops of the towers so that the posts acted as rocker-bents, allowing the top pin to move back and forth longitudinally on the arc of a 38-foot

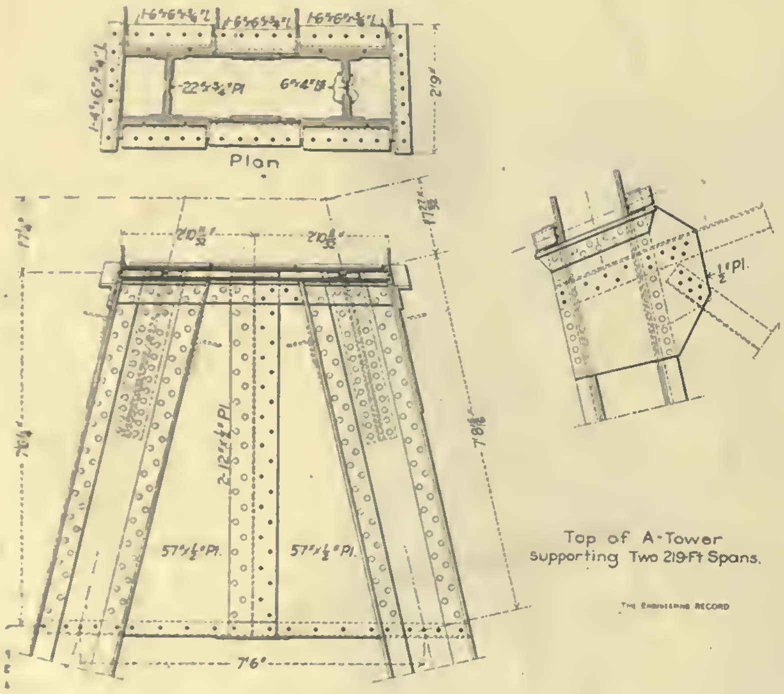


Base of Columns in Approach Towers.

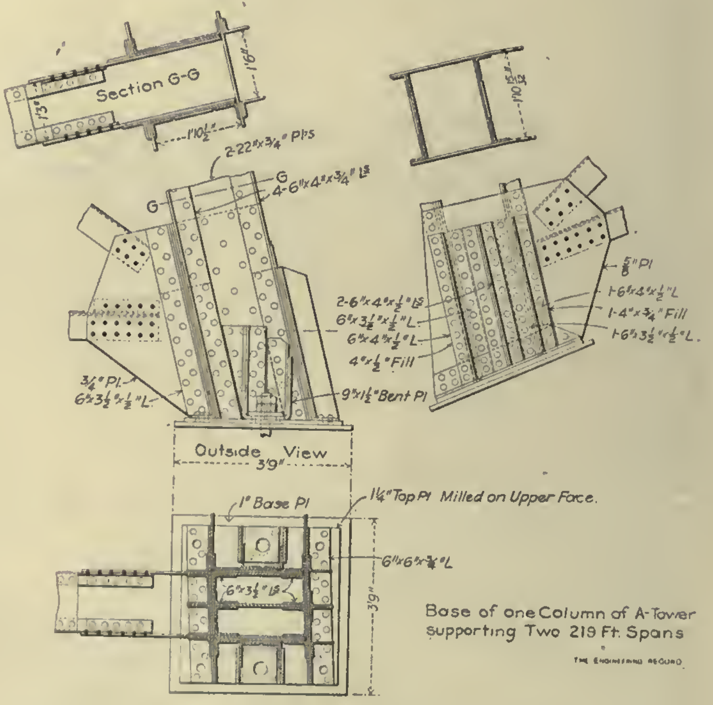




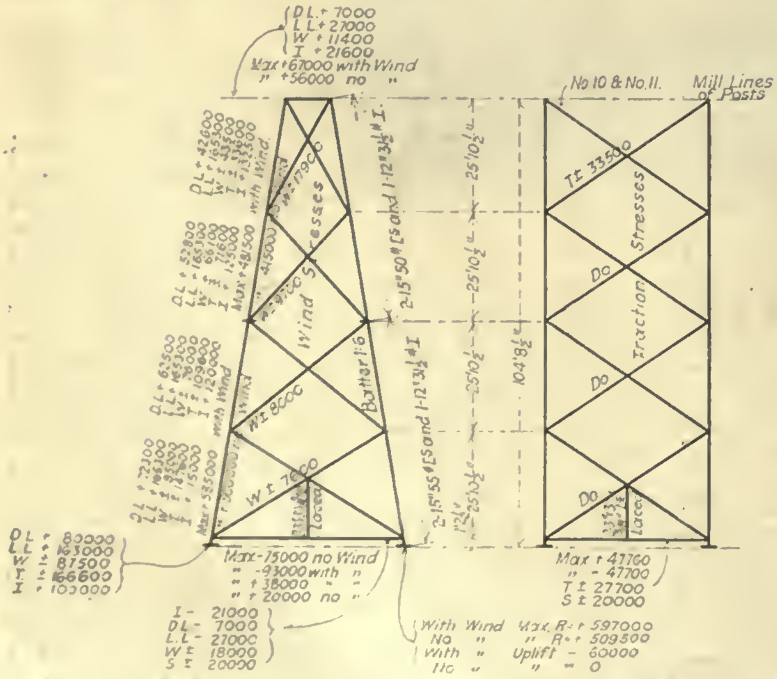
Elevation of One Main Span and Adjacent Approach Spans.



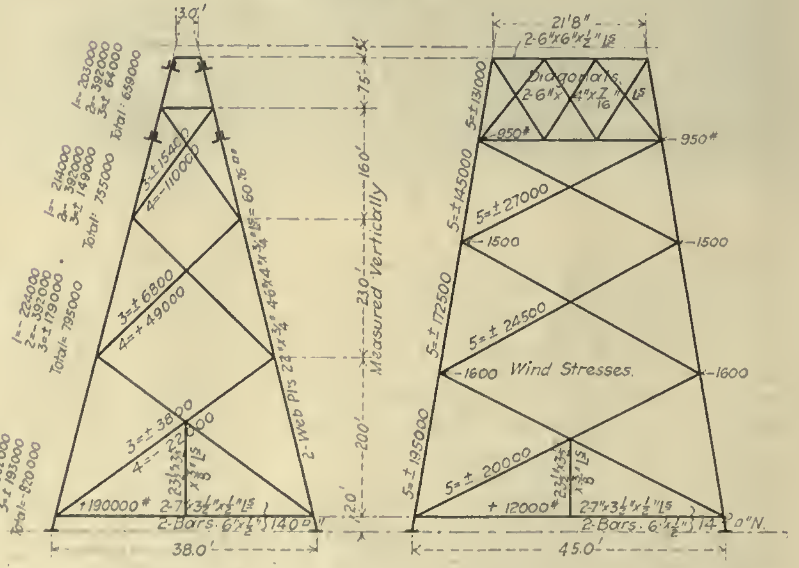
Top of A-Tower Supporting Two 219-Ft Spans.



Base of one Column of A-Tower supporting Two 219 Ft. Spans



Approach Tower.



Longitudinal Elevation. Transverse Elevation

Tower 28-29.

All Longitudinal and Transverse Braces, 2-7"x3½"x½" Ls Latticed

Double Tower carrying Main Spans.

THE DES MOINES RIVER VIADUCT: SOME STRESS DIAGRAMS AND STRUCTURAL DETAILS.

circle. The expansion in the lower chord was provided for by slotting the end strut to receive the end lower chord pin. The bottom laterals were attached directly to these struts and thus the stresses were transmitted continuously to the piers.

The three intermediate towers were essentially alike except in height and the two end towers differ from them chiefly in the weights of the cross-sections and in the connections at the top to support one truss instead of two. The principal materials and stresses for one of the intermediate towers is shown in the diagram marked "28-29," in which stresses marked "1" are dead load, "2" live load and impact, "3" traction force, "4" live load and impact when only one span is loaded, "5" wind. The tower stresses given do not include the wind stresses. The pressure on the pier under a light train and wind load is 34,000 pounds downward and under a full train and wind load is 73,000 pounds downward.

All longitudinal and transverse bracing not otherwise marked consists of pairs of 7x3½x½-inch angles latticed. The tops of the column webs are united by longitudinal plates 7 feet deep, as shown in the detail, and these webs are stiffened by two transverse diaphragms on the center lines of the columns. Each plate is made in two pieces spliced by a pair of cover plates on the center line of the tower shop-riveted to one part so as to make jaws engaging the other plate and field-riveted to it. These plates and the sides of the columns have horizontal angles riveted through them at the top to form seats for the pedestals carrying the end lower chord pins of the trusses. The caps of the end towers differ from the intermediate ones, as shown in the detail, having their adjacent column flanges mitered and field-riveted through the bent angles and having only one stiffening diaphragm, which is vertical and in the center of the combined section.

The bases of the columns in all the towers were substantially alike and were made, as shown, with vertical reinforcement angles and projecting gusset plates for the longitudinal and transverse struts and braces. The lower part of each column is made with ten pairs of flange angles and two single angles arranged so as to practically splice the connection plates to the column and make them continuous with the cover and web plates. The viaduct towers are each made with two vertical transverse bents 38 feet apart on centers with their columns battered in the transverse plane and parallel in the inclined longitudinal plane. The columns are X-braced in from one to four panels, according to height, in the longitudinal plane. In the transverse planes they are X-braced in corresponding panels and have no horizontal struts, except at the top and bottom of the transverse bent and at the bottom of the longitudinal bent. The stresses and dimensions of one of the tallest towers is shown in the diagram, where DL indicates dead load stress, LL live load stress, W wind stress, T traction stress and I impact stress.

The towers are substantially alike except for the varying dimensions, and all bracing is field-riveted, as indicated in the accompanying details of the caps and bases of one of the column posts. Each post is made of an I-beam and two channels without cover plates or latticing and the anchor bolts take bearing on U-bars riveted between vertical angles on the webs of the post channels. The base plates are extended to nearly 3 feet square and stiffened by vertical reinforcement angles with bearing on the horizontal flange connection angles. The cap plates extend longitudinally over the flange connection angles, which are reinforced by bearing on the ends of vertical angles. The main viaduct girders are seated on the column caps, to which they are field-riveted, as indicated by the open holes in the plan of the cap.

(To be continued.)

Frenchman's Bay Coaling Plant.

The United States naval coal depot at Frenchman's Bay, Maine, is favorably located on a flat sandy beach with a regular slope to water of 32 feet depth at a distance of about 300 feet from the shore line, where it rapidly deepens and affords excellent opportunity for the approach and sheltered mooring of the largest battleships. The plant consists of a steel pier and a steel and masonry storage shed, with tracks and conveying and handling apparatus, having a capacity for the storage and rapid delivery of 10,000 tons of bituminous coal. The design and conditions are such that this capacity can be greatly increased by extensions to the coal shed without enlarging or changing the pier or the loading and conveying apparatus. Two duplicate traveling unloading towers are provided, and there are four main lines of tracks extending through from the end of the pier to the rear of the coal shed, besides several loops and branches increasing the capacity at both ends. The plant has an independent installation of steam power to operate the machinery and is also designed to receive auxiliary power from the battleships in case of emergency.

General View of the Frenchman's Bay Naval Coaling Station.

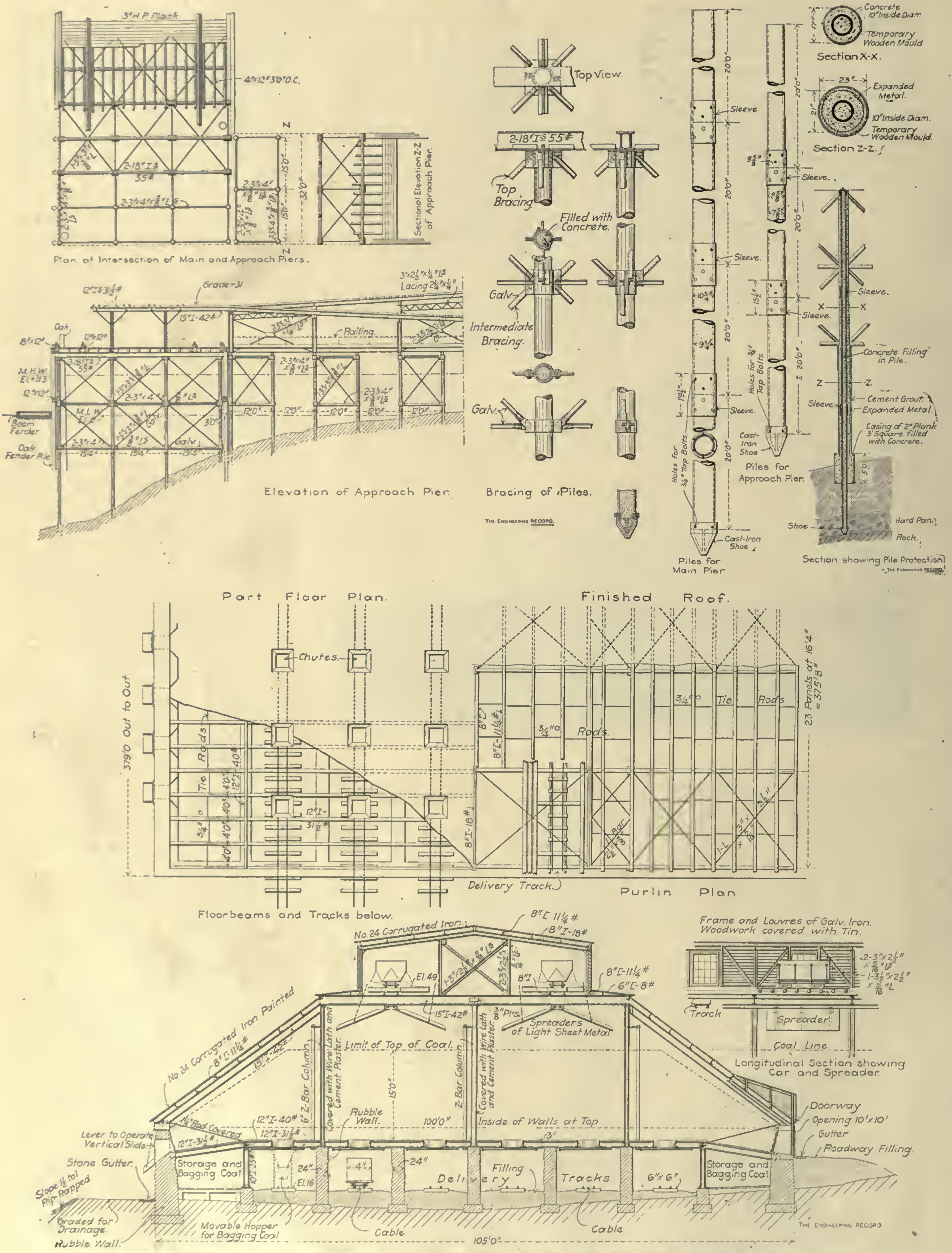
The 380x105-foot steel storage shed, about 90 feet in extreme height, is situated at the water's edge approximately parallel with the shore line. From one end of it an approach pier 32 feet wide and about 300 feet long extends at right angles to it and to the main pier, 48 feet wide and 400 feet long, connecting them and forming the third side of a rectangular construction which encloses a 300x400-foot open slip giving sheltered access for vessels on the shore side of the main pier, where the water is about 30 feet deep at low tide. On the opposite side of the main pier the water is much deeper and vessels can be moored there to receive and discharge coal. The deck of the main pier is 19 feet above mean low tide, and on it there extends from end to end a track of 32 foot gauge with two steel unloading towers 130 feet high and 34 feet long. Each tower has horizontal booms, 54 feet above the deck, which extend 75 and 35 feet beyond the outer and inner faces of the pier respectively and carry the coal buckets traveling from end to end.

The tower has between its columns a clearance 30 feet wide and 21 feet high, in which four narrow-gauge coal tracks are carried on bents elevated about 10 feet above the level of the deck. These tracks connect with those on the approach pier at right angles to the main pier. Two of the latter are incoming tracks graded up to the top of the storage sheds for delivery of coal from the ships to the bins, and the other two are outgoing tracks graded down to the surface of the ground at the shore, for delivering coal from the bins to the ships. The tracks run from the extremity of the main pier through the storage shed, at both ends of which they are connected, by loops and switches, with four other lines of tracks, which make eight in all, and serve the whole area of the shed. The cars are operated by cables driven from the power plant on the pier, and the tracks are arranged on grades so that the loaded cars are pulled up and the empty ones returned by gravity, both for delivering coal from the ships to the shed or vice versa.

The tracks are level, except on the approach pier between the main pier and the storage shed, and the four main tracks are arranged in pairs connected at both ends by loops, so that the cars have a continuous movement around the circuit, always in the same direction, on the same track. At the entrance to the main pier, and at the entrance to the storage shed, switches are provided connecting the incoming and outgoing tracks in the former case, and loops and spur lines in the latter case, so that cars may be diverted from one service to the other, or may be returned to their tracks without passing over the several loops in the continuous line of the lower grade tracks, in the latter case. The spur tracks in the lower part of the storage shed are graded to return the unloaded cars by gravity. There are, of course, separate cable systems for the incoming and outgoing cars. The ropes are driven at a speed of about 200 feet per minute.

The capacity of the conveying system is limited by that of the unloading buckets in the towers. Each tower can operate a one-ton bucket simultaneously on each arm and can unload about 150 tons of coal an hour, thus giving the whole plant a capacity of 3,000 tons in ten hours, which is as great as can be secured without materially increasing the length of the main pier and adding more towers, so as to allow more than one boat to be unloaded on each side at the same time. The capacity for coaling ships from the stock in the shed is considerably greater, and is estimated at a maximum of 50 tons an hour for each hatch in operation. The coal is discharged by automatic dump-cars through chutes inclined downwards from the outside elevated tracks on the main pier to the hatches on the decks of the vessels alongside, so that the speed is only limited by the number of cars in service and the rapidity with which they can be filled through the chutes in the storage shed and dumped in the vessel.

The deck of the main pier is continued at the same level through the approach pier and below both of the inclined service tracks. It is accessible by an inclined approach from the



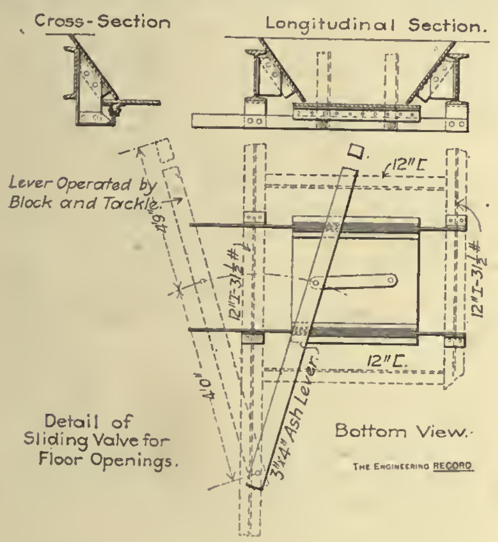
FRENCHMAN'S BAY COALING STATION: DETAILS OF THE FRAMING AND THE CONCRETE-STEEL PILES.

level of the ground floor of the storage sheds and is planked over so as to afford a driveway for carts, by which coal can be delivered from the hoppers of the storage bins to the vessels in case the conveying apparatus should be disabled. Special provisions are afforded for different methods of handling coal by hand and with carts, trucks and ships' tackle, and in bags and baskets, so that the greatest speed may be secured by using different methods together, and that the service may not be crippled by a breakdown of any one method.

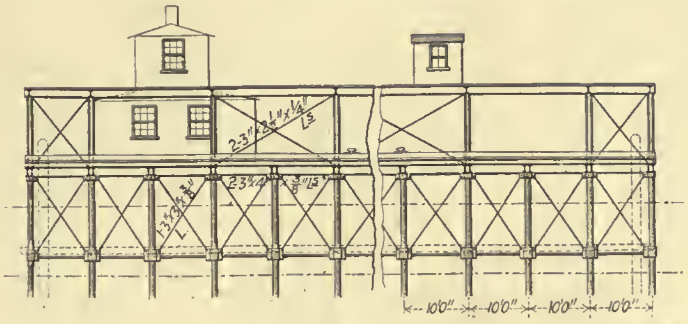
The machinery is of standard design, with interchangeable parts, and is provided with a large number of spare pieces for prompt renewals. The construction is as simple as possible, so as to prevent delay in repairs and enable them to be made on the spot, where there are no convenient machine shops. Provision is made for weighing the coal in and out of storage, scoop shovels and buckets are provided and the apparatus is adjustable for service with vessels of all classes. The machinery is well protected from the water and is arranged to be quickly started after periods of idleness, and to require as few men as possible for its operation. All the machinery is in duplicate, so that one tower and one set of tracks may be out of service without impairing the efficiency of the other. The construction throughout is fireproof, and is designed to secure great stability, rigidity and durability.

Fire protection is afforded by three hydrants on the shore side of the storage shed, each sheltered in a wooden building, frost proofed and supplied with 100 feet of 2½-inch hose. A frostproofed 2½-inch fire line is extended along the approach pier and a face of the main pier, with hose connections to supply fresh water to the hoisting towers, cable machinery house and to vessels. A 2½-inch jacketed steam pipe is also laid from the cable engine house along the face of the main pier and has connections to receive steam if necessary from the boilers of the war ships alongside so as, in emergency, to operate the cable and hoisting plants independently of their own steam power. The machinery for the cables is installed at the extremity of the main pier in a small steel frame house, sheathed with corrugated iron. Another small steel frame building near the opposite end of the pier contains the scales for weighing the coal received and delivered as it passes through on the dump cars.

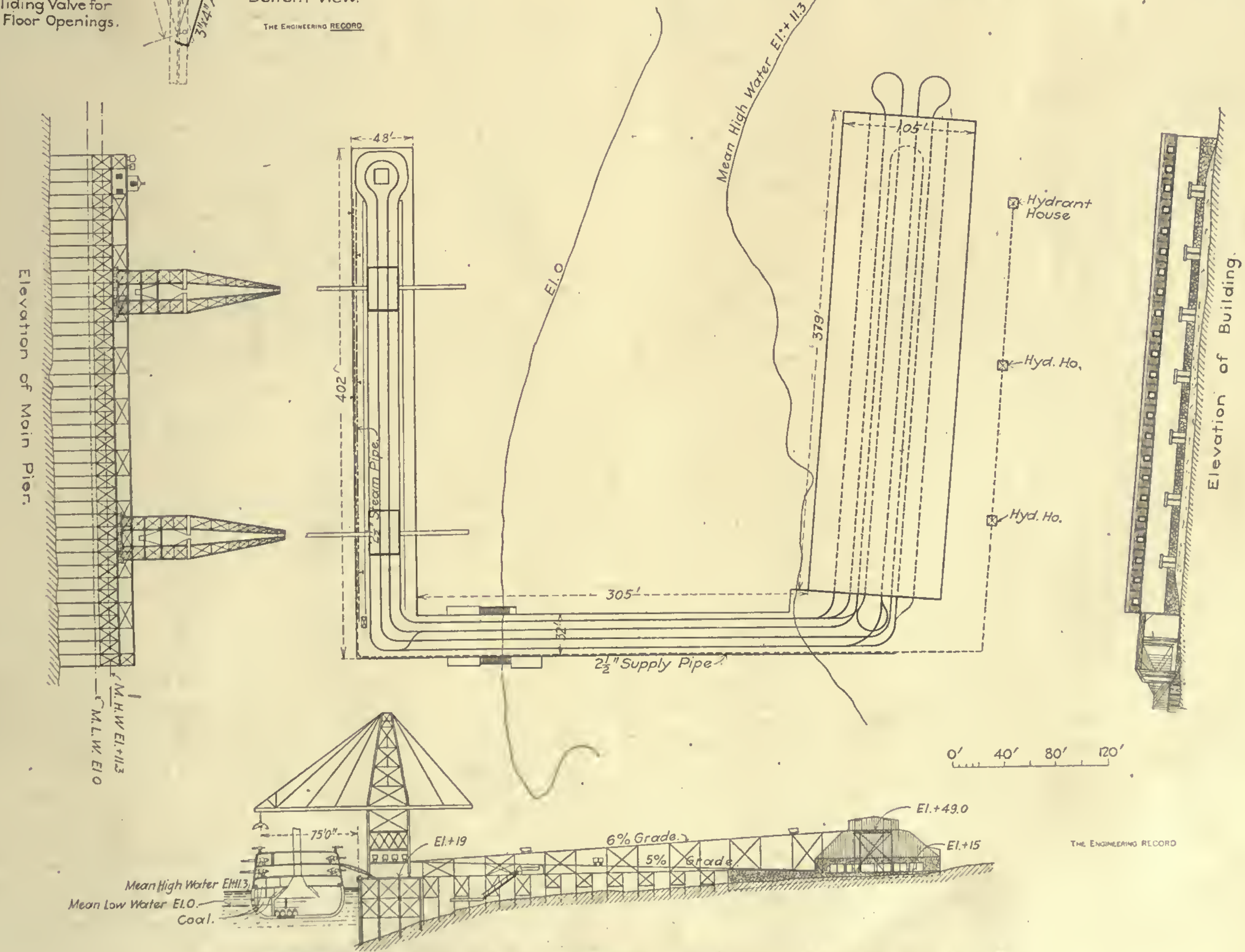
The towers are of riveted steel construction, as shown in the different sections and elevations, and have a rectangular base and conical top, from which adjustable guys support the booms, which are pivoted at their inner ends and may be independently raised or lowered. Each boom is laterally braced by wide horizontal struts and has a trolley track on which the bucket hoist can move from the end of the boom to the center of the tower or may even engage the other boom and move to its opposite extremity so as to convey coal from one ship to another on the opposite side of the pier. The buckets discharge through a hopper in the center of the tower, delivering coal to cars on either one of the inbound cable tracks. The first floor of the tower is about 22 feet above the deck and on it are enclosed the engines and machinnry for hoisting and conveying and for moving the tower. The upper floor at boom level is merely a working platform for the attendants who operate the buckets. There is no platform at the top of the tower, but a heavy framework there sustains the sheaves for the cables which raise and lower the booms. Each tower is equipped with separate engines for the bucket hoisting, for the trolley service and for the tower moving, besides the



Detail of Sliding Valve for Floor Openings.



Elevation of Main Pier.



FRENCHMAN'S BAY COALING STATION: GENERAL PLAN AND ELEVATIONS.

boiler, the water tank, coal bin and the hand windlass.

The engine room is enclosed with corrugated iron sheathing, has a tar and gravel roof and is accessible by a stairway. The upper parts of the tower are accessible by ladders, and the hopper is provided with a light steel cover to protect the coal which may be stored there to the amount of about 25 tons. During an official test a maximum speed of 150 tons an hour was attained in transferring coal from a liner to the storage bins with a single tower.

The main pier has four-pile transverse bents 48 feet long and 10 feet apart longitudinally. The piles are steel tubes ½-inch thick and 10 inches inside diameter. They are made in three or four 20-foot sections spliced by outside sleeves and braced longitudinally and transversely by horizontal and diagonal angle struts which extend about 10 feet below low water and are riveted to collar plates made in semi-circular halves and flange-bolted around the piles. All steel work is galvanized below high water level and has three coats of asphalt paint above. Above low water level the connections for the braces are field-riveted, below low water level they have pin-connections made by divers. The piles were shod with conical castiron points bored to fit the piles and afford finished bearing for the ends of the pipe and were tap-bolted. The splices were made with bored sleeves ½-inch thick with shop-driven countersunk rivets for the lower section and tap bolts for the upper sections. The ends of the pile sections were faced to make butt joints and turned to a driving fit in the sleeves.

The piles were driven by a 2,000,pound hammer assisted by an hydraulic jet through a nozzle fastened to the pile point and withdrawn after the pile was driven. They were driven to the solid rock through about 12 feet of sand, gravel and clay and 2 feet of hard pan. After each pile was driven a diver made an excavation around it in which was set a rectangular wooden casing 3 feet square and 5 feet deep which was sunk to its full depth below the bottom of the bay or until hard bottom was reached at a less depth. The casing was filled with 1:3:6 Portland cement concrete, in the upper part of which was sealed the lower end of a concentric sheathing 22 inches in diameter, made of 3-inch No. 10 expanded metal wired in position and extending up to the lower horizontal struts. Outside of the expanded metal a concentric wooden sheathing 1 inch thick and 24 inches in diameter inside was set and filled with 1:2 Portland cement mortar made very thin. The pile protection was continued from the lower bracing to the cap by building a concentric wooden casing 17 inches in diameter inside and filling it with 1:2 Portland cement mortar. The work wss done by experienced divers, and great care was taken to make strong joints at the different sections of casing and to thoroughly seal them so as to enclose the pile in a water-tight monolithic concrete shell completely protecting it from contact with salt water at any point. The wooden sheathing was removed after the concrete was thoroughly set, and is not shown in the diagram of the completed pile. The interior of the piles was filled with 1:3:5 Portland cement concrete made with ½-inch broken stone, rammed with a heavy iron rammer.

The face of the main pier was protected at the corners and intermediately by six clusters of sixteen battered yellow pine piles 80 feet long, which were riprapped at the bottom and drawn together at the top with several turns of heavy galvanized chain. The pier was provided with boom fenders, and had mooring cleats and bollards 50 feet apart. Horizontal X-bracing was provided at high water level and at the tops of the piles. The pile caps were riveted to sleeves, and the latter were made adjustable so that the floorbeams could be set at the required level irrespective of the exact position of the pile tops. The transverse floorbeams consisted of pairs of I-beams seated on the cap plates and spliced together with web plates. These carry 4x12-inch longitudinal joists, 3 feet apart on centers, which rest across their top flanges and are bolted to transverse connection angles. To them are spiked the deck planks. The rails which support the traveling towers are each carried on lines of 12x12-inch timbers supported on the upper flanges of a pair of 12-inch longitudinal I-beams riveted to the transverse floorbeams. Both the inbound and outbound cable tracks for the coal cars are carried on steel transverse bents in the planes of the pile bents which rise about 10 feet above the level of the deck. Each bent has two riveted columns 15 feet apart, which are pairs of latticed channels and support transverse floorbeams 25 feet long. Each end of the floorbeam cantilevers 5 feet beyond the columns and the extremity is supported by a kneebrace. The transverse beams carry four lines of longitudinal stringers and each stringer supports one cable track.

The connecting pier is similar to the main pier, except that its piles are 7⅝ inches in diameter inside, and that there are only three in each transverse bent. Longitudinal bracing in this pier is not continuous as in the main pier, but pairs of bents are braced together so as to make alternate towers and open spaces. The pier supports the four cable tracks on an elevated structure with four vertical columns in each transverse bent. These bents are seated on alternate pile bents and have the two center columns higher than the outer columns so as to provide for the ascending grade of the inbound track and the descending grade of the outbound track. The pier has horizontal diagonal bracing between the tower bents, and is provided near the main pier with stairs on each side leading to a floating landing stage. The deck is planked so as to afford passage for carts or trucks, and the sides are protected by an iron rail. At the top of the landing stairs davits and a shelter are provided for a rowboat.

The coal storage shed consists of a steel platform and roof supported on stone walls, calculated to support and shelter a pile of coal 15 feet deep, 100 feet wide at the base and 60 feet wide on top which, allowing 45 cubic feet per ton, will hold 10,000 tons of coal. This arrangement gives a natural slope to the sides of the coal pile, and, relieving the sides of the house from all pressure, leaves only the vertical weight of the coal and the roof of the shed to be supported. This makes a very simple design for the building, which has the side roofs parallel to the slope of the coal pile and a few feet above the latter. The building is divided into four aisles by three longitudinal rows of interior columns, which carry horizontal beams over the top of the coal pile, and support the inbound tracks on which coal is delivered from the vessels. These tracks are enclosed by a low monitor with double-pitched roof.

The main roof is composed of transverse I-beams supported on the columns and on the tops of the outside walls, which rise about 3 feet above the top of the bin floor. The floor and the interior columns are carried on longitudinal masonry walls which are about 8 feet high above the surface of the ground. Between the outer rows of columns and the outer walls there are lines of short columns carrying the floor. These columns and the longitudinal walls divide the space underneath the bin floor into eight longitudinal galleries, in six of which there are surface tracks where cars can be loaded by chutes through the bottom of the bin, about 12 feet apart longitudinally. The two outside galleries are arranged for storage and for bagging coal.

Coal is delivered in the monitor by side dumping cars which discharge their contents on suspended sheet iron spreaders. These spreaders are movable on trolleys running on the center lines of the cable car tracks, and their wings may be raised or lowered to divert the coal to different parts of the building. The coal is delivered from the bins through floor chutes which are closed by horizontal sliding gates operated by levers in the galleries underneath. In the gallery on the shore side next the outer wall the bin floor is sloped a little toward the outer wall and chutes through the latter are controlled by vertical sliding gates through which the coal can be delivered to wagons or trucks outside the building. In the gallery next the outer wall on the bay side the bin floor is similarly sloped, and the roof is provided with a dormer in every panel, below which there is a 10x10-foot two-leaved hinged door affording access from the outside roadway for carts which can enter the building to deliver or receive coal. The coal is piled up to a maximum height of 4 feet above the floor at the outer wall and is retained there when necessary by movable flash boards protecting the entrance for the carts.

Ventilation is afforded for the storage sheds by open louvres in the walls of the monitor and by windows in the dormers on the shore side. Four-inch perforated vertical pipes are set about 32 feet apart throughout the bin reaching from the under side of the floor above the top of the coal so as to afford an opportunity to insert thermometers and determine the temepratures of the coal at any point. The bin is divided into four longitudinal parts by means of partitions made with concrete and wire laths on steel frameworks in the planes of the columns. There are also three transverse partitions of similar character, thus dividing the bin into sections so as to enable the coal to be easily removed in case the temperature becomes too high. The floor is made with solid concrete arches of 4-feet span and 3-inch rise carried on the lower flanges of 12-inch transverse I-beams. The I-beams are supported on the longitudinal walls which carry the columns and separate the track galleries. The arches are 12 inches thick at the crown, and are made with 1:3:6 Portland cement with 2½-inch gravel or broken stone. They are finished with a 1-inch layer of 1:2 Portland cement mortar. The chutes in every panel of the floor are lined with ¼-inch plates riveted to angles bedded in the concrete. They are closed by sliding doors about 2 feet square with link connections to hand levers under the floor.

The columns are enclosed with expanded metal and cement mortar to protect them from contact with the coal. The shore wall of the building is supported on three rows of spruce piles 3 feet apart on centers cut off above mean low water. All their foundations are carried down below grade and backfilled with sand rammed in 6-inch layers to make a surface for the delivery tracks. The roof is covered with No. 24 corrugated iron on 8-inch channel purlins of 16-foot span and 4 feet apart on centers. Alternate panels are X-braced with flat bars and angles.

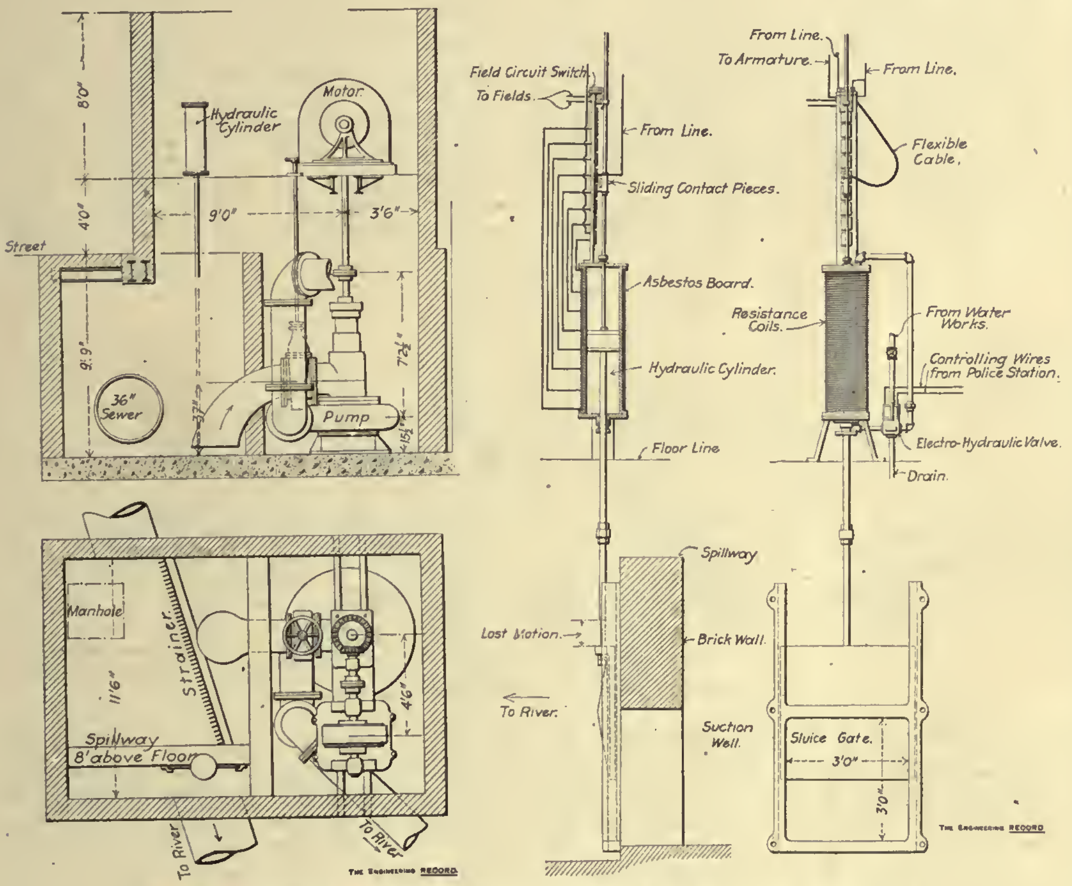
The walls are of granite masonry laid below water level in 1:3 Portland cement mortar and above water level with 1:2 Rosendale cement mortar. All steel was made by the open hearth process, and was specified to conform to the usual requirements for bridge and structural work. Portland cement was required to develop a tensile strength of 400 pounds when seven days old, and Rosendale to have a tensile strength of 110 pounds at the same age. The contract for the construction of the coaling station was awarded to Messrs. Snare & Triest, New York, on their competitive designs and estimates, which were approved by Rear-Admiral R. B. Bradford, chief of the Bureau of Equipment, United States Naval Department. The J. A. Mead Manufacturing Company, New York, installed the coal handling machinery, and all work was done under the inspection of Captain L. C. Logan, United States Navy. Mr. J. A. McNicol was engineer in charge of design and construction for the general contractors, to whom acknowledgment is made for the data used in preparing this article.

Philippine Island Coast Lines and Harbors are being surveyed by the United States Coast and Geodetic Survey. The total length of the coasts is estimated to be over 11,400 miles, about twice that of the United States, or one mile to each square mile of area. For the States the latter proportion has the value of 1 to 555. There are nearly 1,700 named islands and some 3,000 islets can be counted. No place on any island is over 60 miles from the sea.

Sleeping Cars of a New Type have been introduced by the Midland Railway Company, of England, on some of its trains. The cars are 60 feet long, 9 feet wide, with berths 6 feet 2 inches long arranged transversely, and a full-length corridor. All berths are on the same level; two of the compartments each accommodate two persons; the remaining six compartments have one berth each, but two of them may be converted into a double compartment by means of a sliding door in the partition. There is a smoking compartment at one end. Efficient roof ventilation is provided, which can be augmented in summer time by lowering the side windows and inserting a wire gauze dust screen in the openings. The cars are built with a clerestory roof, which makes the compartments lofty and airy.

Electric Pumping Plant at Mobile, Ala.

An electrically operated centrifugal pump fixed for control from a distant point and a sluice gate opened and closed automatically according as the pump is idle or working are the features of an electric pumping plant which has been installed at Mobile, Ala. The pump was furnished under the specifications of Mr. J. N. Hazlehurst, M. Am. Soc. C. E., chief engineer of the Board of Public Works of Mobile, calling for an electric centrifugal pump having a capacity of 18 cubic feet per second against a head of 5 feet, with control of operations as stated. In connection with this apparatus it was also specified that a 36-inch sluice gate should be furnished equipped for control from the same distant point. The details of the construction were not given, but bidders were requested to submit plans showing proposed arrangements. The results are indicated in the accompanying drawings, which are those of Messrs. A. M. Lockett & Company, contracting mechanical engineers, of New Orleans, who designed and built the plant.



Mobile Pumping Station and the Gate-Closing and Motor-Starting Device.

In explanation of the service for which the apparatus is intended, it is necessary to state that the congested business section of Mobile is drained by a system of pipes which discharge into a 36-inch outfall discharging into the Mobile River at the foot of St. Francis Street. This outfall is at all times submerged, and in the time of a heavy rain-storm the pipe is not sufficient to carry off the sudden downpour. As the result considerable trouble has been experienced with the flooding of some of the streets, and the retardation of the current by the tide has caused a considerable amount of deposit in the sewer. The engineer's intention was to provide a means of increasing the capacity of this pipe and also of pumping all of the water out of it so that it might be flushed and cleaned. His idea was to locate at a point near the outlet a pumping station, placing therein a centrifugal pump of sufficient capacity to take care of the storm water, this pump discharging over the bank of the river above high tide. It is, of course, necessary to have a valve in the 36-inch pipe to prevent the return of the water from the river while the pump is in service, and it is also desirable to have the apparatus controlled from some point like the police headquarters, where the pump can be promptly put in service at any time during the day or night. The pump selected for this work by the contractors is a Worthington vertical-shaft, submerged-type centrifugal, having inlet and outlet 18 inches in diameter. Inasmuch as economy of operation is regarded of minor importance, the pump is designed to be driven by a horizontal motor with level gears instead of with a direct-connected motor which being special would cost more money.

For opening and closing the 36-inch sluice gate an Engberg electro-hydraulic valve having an 8-inch cylinder with 36-inch stroke is used. The electric part of this mechanism consists of a powerful electric magnet, the current for which is furnished by a cell battery located at the local police headquarters. When the circuit is completed by a contact switch at the police station the electric magnet operates a small pilot valve which admits water under pressure into a small cylinder; this in turn actuates a three-way valve, admitting the city pressure above or below the piston dependent on the position of the gate at the time when the circuit is completed. It would have been practicable to have controlled the motor with one of the motor starters now on the market, but the contractors decided to make use of the hydraulic cylinder for starting the motor and accomplished that purpose in the following manner:

They had the Interstate Electric Company of New Orleans construct a straightway rheostat with the contact blocks arranged on a frame bolted to the top of the water cylinder. The cylinder head was fitted with a small stuffing box and a ½-inch brass rod was attached to the main piston rod of the Engberg device, and on this rod was arranged a shoe which slides up and down on the contact blocks of the rheostat. For convenience the resistance coils of the rheostat were wound round the cylinder, being insulated from the cylinder and from each other. On account of the desirability of magnetizing the field of the motor before turning the current on the armature, a small switch is to be arranged at the top of the rheostat to be thrown the moment the piston begins its travel from its top position. As the rate of travel of the piston can be controlled at will by regulating the valve on the water supply, an appreciable time elapses after the current is turned on to the fields before the shoe comes in contact with the second block. The first block, of course, is blank and no current is on the motor when the piston is at the extreme top of its stroke; as the shoe travels downward it throws out the resistance coils successively until it reaches the bottom where the gate is closed and all of the resistance is cut out. Whenever it is desired to stop the pump the operator at police headquarters throws in the knife switch, which completes the circuit of the electric attachment to the Engberg valve, and the piston begins to ascend, gradually throwing in the resistance until the current is cut off of the armature and immediately thereafter, also cutting the current out from the fields.

In connection with the Engberg device there is an electric alarm which informs the operator by the ringing of a bell whether the motor has been started. The operator throws the switch to the starting contact point and immediately throws it back to the alarm contact. If the bell rings it shows that the motor did not start, but if the bell does not ring it shows that the motor has started, as the alarm wire remains grounded until the three way valve operates. The plant is now in successful operation.

Referring to the drawings it will be noted that part of the bottom of the pump house forms a basin into which the 36-inch pipe discharges on reaching the building and from it continues on leaving, the electrically operated gate being fitted in the outlet. The suction pipe of the pump is submerged in the basin, and the protecting strainer consists of a vertical grating dividing the chamber in two parts. The grating is built of ½-inch round wrought-iron rods 6 feet or more in height, spaced on 1½-inch centers, and supported by a frame work of 4x6-inch timbers, to which they are fastened by staples.

Rubbish Incineration in New York City and the Design for the New Stanton Street Incinerator.

About two years ago Dr. John McGaw Woodbury, commissioner of street cleaning for New York City, proposed to build an incinerator to aid in the disposal of the bulky house refuse, including boxes, paper, cast-off shoes, old mattresses, Christmas trees and a great variety of other more or less combustible articles, after the objects having any marketable value had been picked out by trimmers. Mr. H. deB. Parsons, M. Am. Soc. C. E., was engaged to prepare drawings and specifications for an experimental plant on a practical scale to embody the commissioner's ideas and give them a working test. This plant was erected on one of the city's piers on the North River, at the foot of West Forty-seventh Street, as described in this journal April 19, 1902, and during its operation for the past one and one-half years the incinerator has been carefully studied, many improvements in details being effected.

In the course of a discussion on the sanitary disposal of refuse, at meetings of the American Society of Civil Engineers, a little over a year ago, Mr. Parsons made some interesting and instructive remarks based on experience in connection with the Forty-seventh Street incinerator, parts of which are quoted:

"The rubbish collections in New York City weighed, on the average, about 250 pounds per cubic yard. In Boston they weigh about 202 pounds per cubic yard. These rubbish collections have been divided as follows:

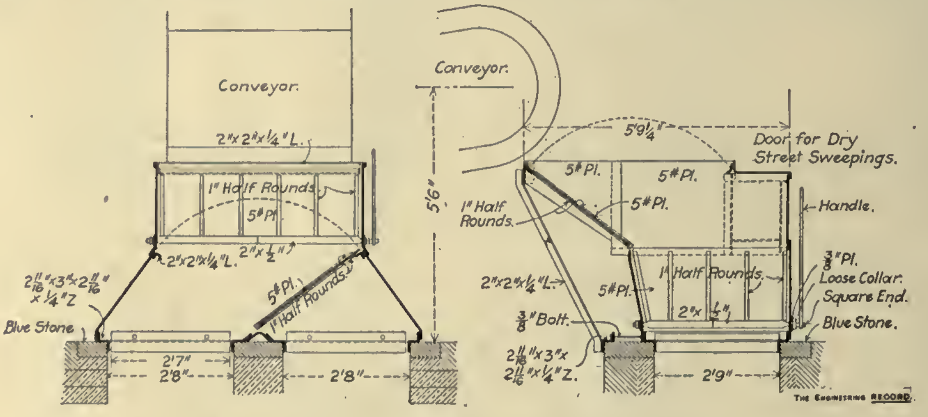
	By weight.	By volume.
	Per cent.	
Combustible material	60	37
Incombustible material (valueless)	5	3
Marketable material	35	60

"The rubbish is picked over at the dumps by a trimming contractor, who pays the city for the privilege. The value of this marketable material to the city is about $3.20 per ton. The Commissioner of Street Cleaning has stated that this figure is too low; probably it should be increased 50 per cent. It is figured as follows: The average rubbish collections are 300 tons per day, or 1,800 tons per week, of which the marketable or salable material is 35 per cent., say 600 tons. For this the contractor pays the city approximately $1,920, or at the rate of $3.20 per ton.

"The record of this incinerator is as follows: The number of loads of rubbish brought to the Forty-seventh Street incinerator per day: Maximum, 80; minimum, 20; average, 44.2. The 44.2 loads per day weigh about 61,000 pounds, or 30.5 tons. Of this amount about 75 per cent., or 22.87 tons, was consumed; 5 per cent., or 1.5 tons, was incombustible; and about 20 per cent., or 6.1 tons, was trimmed. Much more than 20 per cent. could have been trimmed, but the incinerator burned the material so fast that the contractor did not have time to separate it out. The incinerator contains a grate surface of 90 square feet, and the stack is 120 feet high. The average weight of the material consumed per hour is 5,720 pounds, or 63.5 pounds per square foot of grate per hour. Taking a stormy day when the material was brought to the incinerator wet, the smoke was seldom visible for more than about 75 feet from the top of the stack, and then only during the period of stoking one of the grates.

"An analysis of the cost of incineration compared with removal of material by scows is as follows: First, the final disposition by scows, as formerly practised. Assuming the same figures as now obtained at the incinerator, namely, 30½ tons of material per day, on the average, the cost of removal of that material, figured at 15 cents for towing, and two days' hire of the scows (one for loading and one for towing) at 23 cents, comes to about 38 cents per ton. Owing to the bulkiness of rubbish, only about one-half tonnage can be put upon a scow, the tonnage being figured by volume, which makes the disposal of the material come to something like 80 cents or more per ton by weight. Therefore, 24.39 tons at 80 cents cost the city $19.51 for removal. The 6.1 tons, making up the 30.5 tons, which is saved by the trimmers, at $3.20, also figures $19.52; thus, practically, the cost of removal by scows was offset by the receipts from trimming.

"Second, by incineration. The result is approximately as follows: Received from trimming 6.1 tons at $3.20, $19.52 per day. Received from the city ash collections, which at this dump amount to about 600 tons per day, and which are made salable at, say, 5 cents per ton when freed from the rubbish, $30. Total receipts to the city, $49.52. The cost to remove the incombustible material, 1.5 tons, at 38 cents, 58 cents; cost of burning, interest and repairs on the incinerator, estimated, at $7 per day; labor, feeding and firing, four men, $10 a day; ash removal, $1 a day; total, $18. Net gain, therefore, to the city, $30.94 per day; yearly gain, more than $9,000.



Rubbish Hopper for Stanton Street Incinerator.

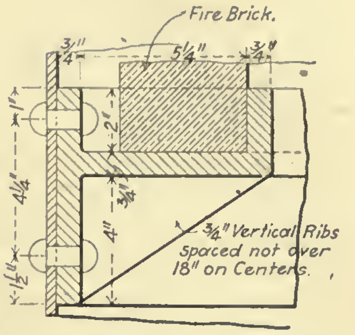
"The ashes produced by the incinerator are very light, completely burned, and, owing to the large quantity of wood from which they are produced, have some value as a fertilizer, and are used by the Park Department for spreading on lawns and around trees. The improvements added to the original design are an unloading floor and a belt conveyor, which should increase the amount of material trimmed, that is, the marketable material; and should reduce the cost of labor. Probably the services of two of the men now required could then be dispensed with."

The belt conveyor just mentioned is 104 feet in length between end shafts and was installed by the Jeffrey Manufacturing Company, of New York City. The rubbish, after being trimmed, yielded, on an average, when burned and the hot gases passed through the boilers, 4.4 horse-power for each cubic yard. At present about 100 cart-loads of rubbish are brought to the Forty-seventh Street plant during each eight-hour working day, and at the same ratio it is estimated that this quantity produces sufficient heat to generate 240 horse-power per hour for a ten-hour day. If its value be taken at $50 per horse-power, this would be $12,000 for the year, or, if utilized for electric lighting, it would be sufficient to run over 300 arc lamps or about 3,750 incandescent lamps. Thus far only two 50-horse-power vertical tubular boilers have been installed, and when the plant is in operation they are usually blowing steam at the safety valves. Much heat is wasted because there is at present no requirement for it, but it can be utilized at any time. This incinerator could readily deal with 150 loads of rubbish per day.

Owing to the good measure of success attained in the Forty-seventh Street installation, a second plant has been planned on a larger scale and of a more permanent type of construction, the drawings and specifications for this incinerator also having been prepared under the direction of Mr. Parsons. It is designed to have considerably more than twice the capacity of the first incinerator, and is to be located on Tompkins Street at the foot of Stanton Street beside the East River. Of the information gained from operating the Forty-seventh Street station, full advantage has been taken in designing the new plant, which differs in several important respects, although the principles on which it is based are the same. At the new plant it is proposed to burn street sweepings as well as the residue, after trimming, of the rubbish collected by the paper carts. Other differences will be noted by studying the drawings and descriptions published herewith and comparing them with the article printed in April, 1902.

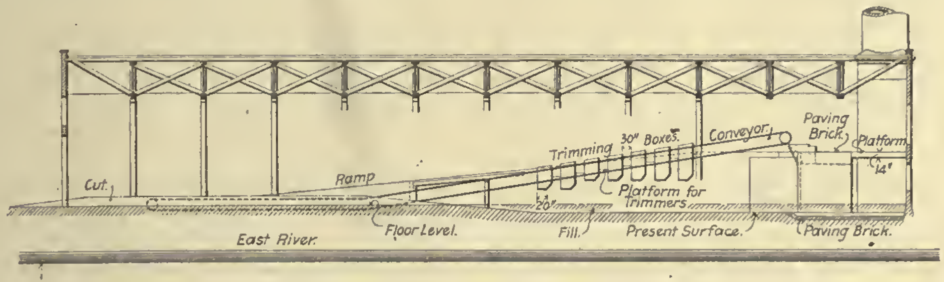
The general arrangement of the Stanton Street plant and a number of its details are shown by accompanying drawings. The building is to be 75x180 feet in plan and 24 feet high to the eaves of the double-pitched roof. The walls are to be of brick 12 inches thick, reinforced on each long side by eleven pilasters, which will also carry the wooden roof trusses, and are to be pierced by a large number of windows, many of them 15 feet high, thus providing for ample illumination in all parts of the building. There will be four doors in the north, or Stanton Street end, one in the south end and three in each side, each large enough to admit teams, so that the collection carts can enter and leave by different doors, thus avoiding interference, and the wagons removing the baled trimmings can pass through the building from one side to the other. The floor, excepting the small area at the furnaces, is to be of rammed earth, which will be paved at a later date as may be found most desirable. Foundations for the walls, for the row of 12x12-inch wooden columns to support the center of the roof trusses, for the furnaces and for the chimney will be of concrete, and piles will be driven beneath the chimney.

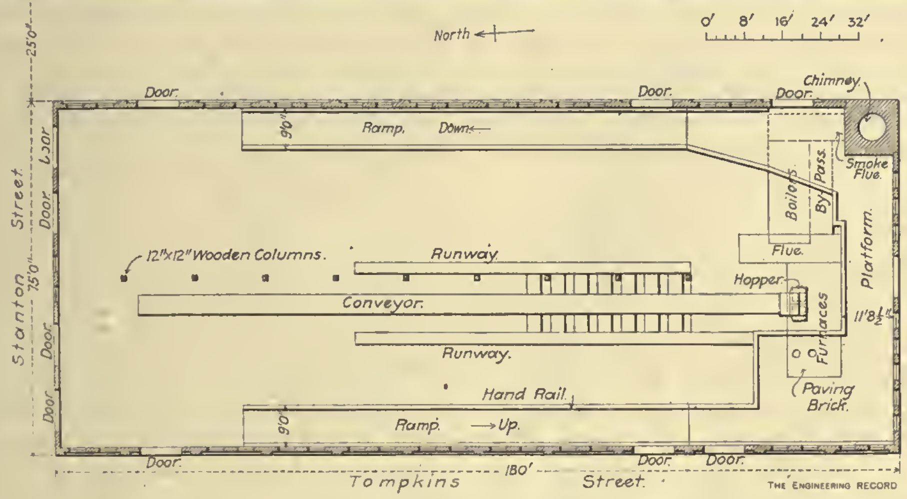
The chimney will be at the southeast corner of the building, 125 feet high and 5 feet in diameter inside the lining at the top. Alternative bids were asked for a fire-brick-lined steel stack and a brick stack of the Alphons Custodis Chimney Construction Company's special type for high temperatures, the stack being required by the specifications to be capable of

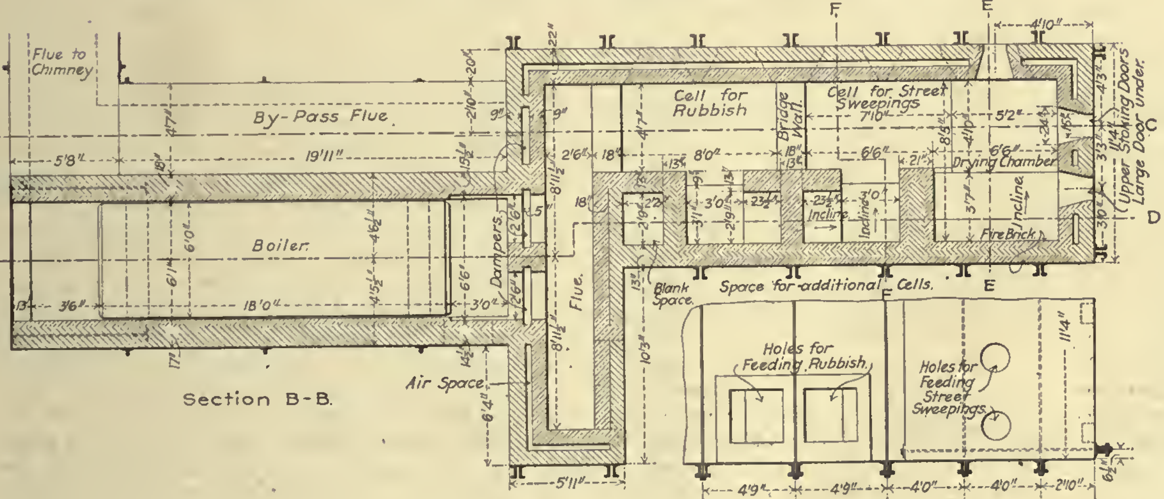


Support for Lining.

THE ENGINEERING RECORD

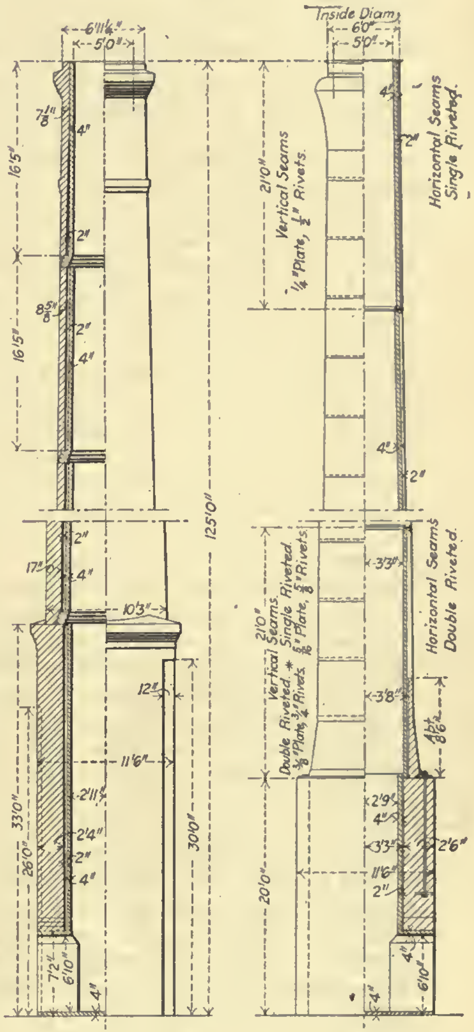






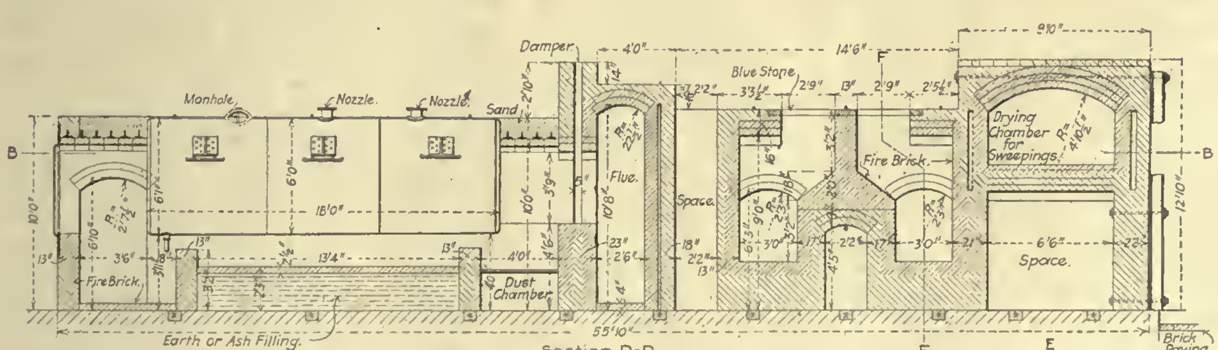
Section B-B.

Part Plan of Top.

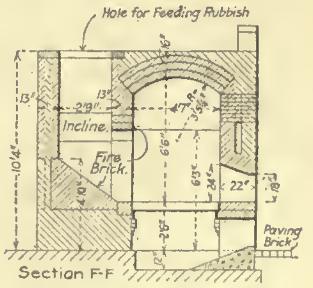

6'11 1/4"
5'0"
Inside Diam. 60"
5'0"
16'5"
21'0"
Vertical Seams 1/4" Plate, 1/2" Rivets.
Horizontal Seams Single Riveted.
16'5"
125'0"
10'3"
21'0"
Vertical Seams Single Riveted 5/16" Plate, 5/8" Rivets.
Horizontal Seams Double Riveted.
33'0"
11'6"
30'0"
26'0"
20'0"
Double Riveted, 3/8" Plate, 3/4" Rivets.
6'10"
7'2"
6'10"

Alternative Designs for Chimney.

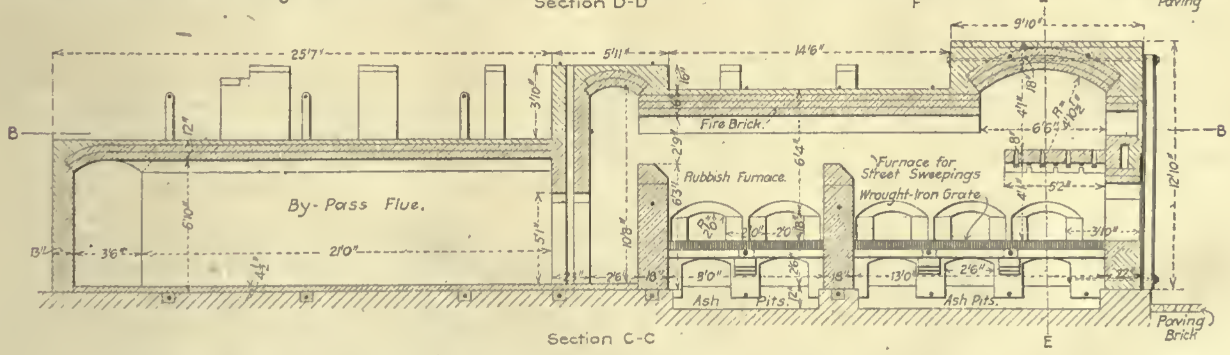
THE ENGINEERING RECORD



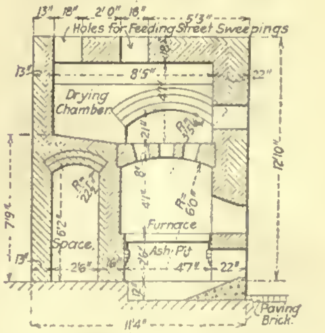
Section D-D.



Section F-F.



Section C-C.



Section E-E.

THE ENGINEERING RECORD

STANTON STREET RUBBISH INCINERATOR, NEW YORK: GENERAL PLAN AND DETAILS OF FURNACE AND CHIMNEY.

enduring a temperature of 1,200 degrees Fahrenheit. Both designs for the chimney are shown, but the brick structure was preferred and, furthermore, the bid for it was $500 lower than for the steel stack. Natural draft only will be used for the plant, but it is believed that with the chimney of the size designed, a strong draft will be obtained. The areas of the holes in the furnaces through which the rubbish and street sweepings will be fed and the areas of the stoking doors are so proportioned to the area of the top of the chimney that it is believed there will always be a strong suction inward at charging and stoking openings, so that neither flames nor dust can be carried by a back-draft into the building.

The incinerator proper will be placed parallel to, and about 11 feet from, the southerly end wall. It contains two cells for burning rubbish, one of which has an upper grate for drying and burning street sweepings. As designed originally, there were two other cells like those shown, but which the limitations of the appropriation made it necessary to omit at the present time. These additional cells, however, can readily be added whenever they may be needed. The total area of the grates is 189 square feet, not including the upper fire-brick grate for street sweepings. From the furnaces or cells the hot gases are led through suitable flues through and under a horizontal tubular boiler 72 inches in diameter and 18 feet long, and thence to the base of the stack. A by-pass flue leads around the boiler, giving direct connection from the furnaces to the chimney. On three sides of the incinerator there is to be a wooden platform about 13 feet above the floor, to and from which the carts containing street sweepings will pass on wooden ramps 9 feet wide and 94 feet long, one against each long wall, with its foot 40 feet from the Stanton Street wall, as shown. The sweepings will thus be taken directly to the charging platform over the furnace, the full carts ascending by one ramp and the empty carts returning down the other.

The general rubbish collections, however, will be dumped near the northerly end of the building and fed on a conveyor, similar to the one at Forty-seventh Street, 280 feet long and 4 feet wide, leading from a trench lined with 12 inches of brickwork, 5 feet 3 inches wide by 4 feet 4 inches deep inside, sunk into the floor with its end about 17 feet from the north wall, to a hopper over the furnaces. The apron of the conveyor is to be made up of flights of steel of No. 12 gauge, double-beaded, each 6 inches long and 4 feet wide, with a side guard 6 inches high at each end, properly shaped to permit turning at the sprocket wheels without leaving open spaces between successive flights. The flights are to be carried on two strands of malleable iron roller chain running over four sprocket wheels of 27½-inch pitch diameter. Between the sprocket wheels at each end of the conveyor the chain rollers will run on 3x2-inch steel angle rails fastened by countersunk bolts and spikes to the supporting structure. The conveyor is to be driven by a steam engine, preferably of the horizontal crank-and-flywheel type, of sufficient power to give the belt when fully loaded a speed of about 70 feet per minute. The contemplated working speed will be between 35 and 40 feet per minute. This conveyor structure, or runway, is to be situated with its axis very nearly on the center line of the building, thus including the row of wooden columns supporting the roof. Its upper part will be inclined to correspond to the difference in elevation between the two ends of the conveyor. This structure will be of wood and will support also two rows of trimming boxes, of the shape indicated in the drawings, between which the belt will pass. Outside the boxes, on each side of the structure, there is to be a footway 30 inches wide, with a handrail. The boxes are to be made of spruce, hemlock or pine, without covers or bottoms, and separated by level platforms about 2 feet wide on which the trimmers will stand. Chutes of rough sacking will be fastened to the bottoms of the boxes, and the materials thrown into each will be directed into a flat open box on the floor until a sufficient quantity is in place to make a bale. Following the practice at Forty-seventh Street, the baling will probably be done simply by the men trampling the stuff down and wiring it. It is possible, however, that a simple baling press, which would accomplish more satisfactory results, may be installed later. Wood was adopted for so much of the interior construction chiefly because of lower first cost, shorter time required for construction, and the avoidance of possible trouble with labor unions. The fire risk is said to be small, and the wood is regarded as quite satisfactory.

The hopper into which the conveyor is to discharge the materials remaining after trimming, is to be so arranged as to permit feeding alternately into either of the two openings in the top of the furnace now to be built or into either of two corresponding openings in the duplicate furnaces if they should ever be built. This is accomplished by means of two swinging defectors or trap doors, the upper of which locks the lower in position, so as to keep the unused openings closed and prevent back-drafts. The hopper will be built of ⅛-inch steel plates reinforced with angles. Its design is shown in sufficient detail to make further description unnecessary. An opening, 13 inches wide and 15 inches high, shown in an upper corner of one side of the hopper, is provided for shoveling in dry street sweepings in case the cell for burning sweepings is not in operation or if the sweepings are so dry as to make it unnecessary to pass them through the drying chamber to be described below.

The parts and details of the plant described in the preceding paragraphs are important, but the main interest is in the details of the furnaces and their appurtenances. The structure will be built chiefly of hard-burned red brick, lined with firebrick wherever exposed to hot gases, properly tied and braced with iron and steel shapes and furnished with iron doors and frames. In general there will be air spaces between the firebrick and the exterior walls. The arrangement and some details are shown, but require explanation. Street sweepings dumped on the upper platform will usually be shoveled through two 18-inch circular holes into the rear part of a drying chamber 6 feet 6 inches wide by 8 feet 5 inches long, the fore part of the bottom of which is to be a flat-top arch of special interlocking firebrick. The charging holes have cast-iron cover plates and a small part of the platform immediately surrounding them will be paved with paving brick. The arch forming the bottom of the drying chamber is perforated with twenty-four tapering holes 2 inches wide by 10¼ inches long on top, through which the hot gases will rise from the combustion chamber or furnace below. In one side of the drying chamber there will be a stoking door and opposite it there will be a large opening in the wall and floor, through which the dried and partially coked sweepings may be pushed so as to fall into the furnace.

The furnace will be 4 feet 10 inches wide by 13 feet long, substantially the whole bottom being a grate made up of beveled wrought-iron bars 5 inches deep, ½ inch thick at top and 3/16 inch thick at bottom, 4 feet 6 inches long, riveted together through their centers and ends into groups of three with spacing pieces of the same cross-section inverted. These grate bars will be supported on cast-iron bearing bars let into the brickwork. Similar grates have been in use at Forty-seventh Street for over a year and have not burned out, as predicted by some observers. This apparently is due to the fact that, although the fire is at times very hot, there is no body of nearly incandescent coals next to the grate, but rather a thin bed of ashes, because materials of the nature fed into the furnace burn almost wholly from the top. The bars frequently warp, but are readily removed when the furnace is not in use, and straightened by hammering. The simplicity of this type of grate is one of its chief advantages, since the incinerators are manned by unintelligent employes. Furthermore, rocking grates or other somewhat complicated types would give trouble on account of the considerable quantities of wire which find their way into the furnaces. On one side of this furnace for sweepings there will be three counterweighted cast-iron doors sliding in vertical grooves and covering openings about 2 feet wide and 18 inches high, for stoking. In the forward end of the furnace there will be an opening about 4 feet 10 inches wide and 3 feet 3 inches high, also covered by a counterweighted sliding door, through which old mattresses, Christmas trees and other large objects can be fed into the funace. This opening is somewhat larger than the largest object which has so far been brought to Forty-seventh Street, and anything too large for this will have to be broken up.

Adjoining the furnace for street sweepings there will be a 4½x8-foot cell for the miscellaneous rubbish, which will be fed through one of the two square holes in the top of the furnace, beneath the hopper. When fed through one of these holes, the rubbish will fall down a square shaft with an inclined bottom at right angles to the rubbish cell; from this incline it will slide on to a wider incline parallel to the axis of the cell and be distributed somewhat over the grate, as shown in the drawings. If fed through the other hole, the rubbish will, in a similar manner, reach the rear part of the sweepings cell. The second cell will have a grate like that in the first, and the gases from the first cell will pass through the second to the transverse flue, which it is intended to build long enough to accommodate the two additional cells which may be built in the future. Through two openings in one wall of this flue the gases will pass to the space at the rear of the boiler and then beneath the boiler and through its tubes to the flue leading to the chimney; or, should the boiler be out of use, the gases will pass through another opening into the by-pass flue and so more directly to the chimney. The dampers mentioned are to be 2 feet 11 inches wide, two of them 4 feet high and the other 5 feet 4 inches high, made of firebrick tiles 4 inches thick, bound together by a 1¾x½-inch flat steel frame let into a groove in the four edges of the tiles. These dampers are hung by chains, and will be raised and lowered from the top of the furnace. It is not quite accurate, although convenient for purposes of description, to designate the cells as if one were for street sweepings and the other for rubbish exclusively, because, as will be observed from the description, each cell will be used for burning both rubbish and sweepings.

This incinerator is intended to dispose of the collections now sent to the Stanton Street and the Clinton Street docks, amounting on the average to 210 loads of rubbish and 50 loads of sweepings per day. The paper-cart bodies have a capacity of 4½ cubic yards, but the loads are usually heaped and average over 5 cubic yards. The sweeping carts carry 1½ cubic yards per load. The district served is on the lower east side of the city, occupied largely by the poorest class of tenement houses, and has been described as the filthiest in New York. The rubbish contains a much smaller proportion of marketable material than that going to Forty-seventh Street, as much of the wood and similar materials which the denizens of the district can use for fuel are culled out before the rubbish is collected. The sweepings vary greatly in quantity from time to time—there being none at all when the streets are covered with snow—and contain a considerable percentage of refuse thrown from the houses, usually at night, some of which should go to the garbage can and other into the sewer. In the fruit season large quantities of fruit parings are swept up. The sweepings are collected in the mornings, and so would be delivered to the incinerator in a comparatively brief time. The platform in the building, however, will be large enough to store a considerable part of the collection so that it may be burned at a convenient rate.

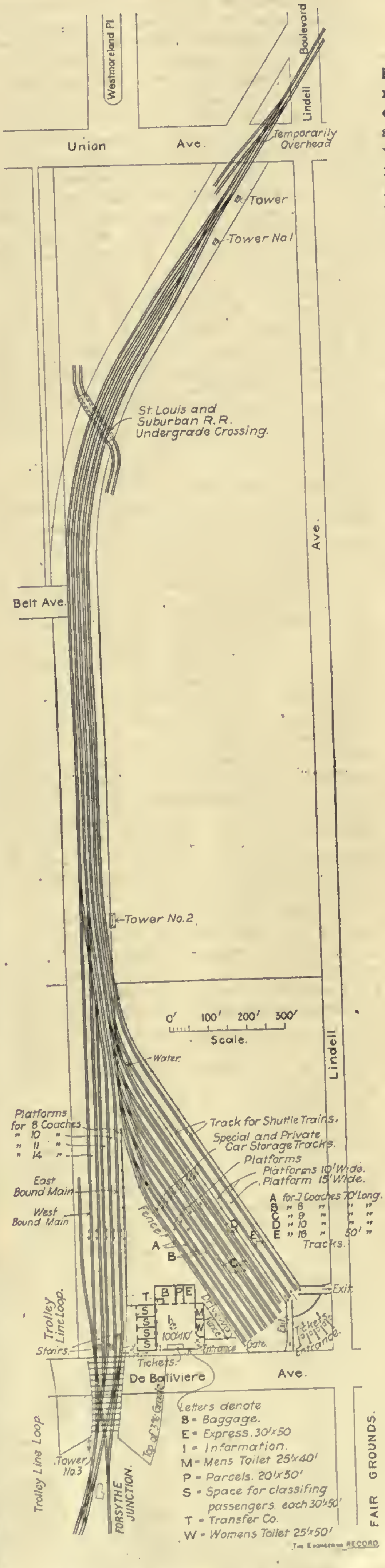
One of the advantages of the large building will be that the carts can be unloaded under cover and out of view from passers-by. The floor space around the lower end of the conveyor is large enough to permit storage of the rubbish when received too rapidly to be handled at once, and some of the mattresses, wooden boxes and similar easily combustible material will usually be saved for starting the fires in the morning, so that steam may be raised quickly in the boiler, or for special uses at other times.

Some of the details of this plant would have been designed differently but for the restrictions imposed by city regulations and the limitations of the appropriation, which was $30,000. The details were clearly shown and specified, and the several bids received came very close to this estimated cost. These bids were printed in the contracting news column of this journal December 19, 1903. Messrs. Williams & Gerstle were the lowest bidders, at $29,318 for the whole plant, excepting the foundations to be built by the city, with a deduction of $2,389 for the ramps and platform for the sweepings carts if the department should decide to build the latter with its own labor. The construction of the plant is at present delayed by an injunction brought by some parties in the neighborhood, based on the claim that the location selected was designated as a "public space" or street, and cannot now be closed.

THE SPANISH WAR VETERANS' ATHLETIC ASSOCIATION will hold a tournament March 5 in the armory of the Twenty-second Regiment, N. G. S. N. Y., in New York City, the net proceeds of which will go to the treasuries of the corps and commands, some twenty in number, in the vicinity of New York. These funds are to be used to aid needy members of the associations and the families of deceased veterans. Moneys for charitable purposes are disbursed under scrupulous supervision and only in the most worthy cases. President Roosevelt, members of the Cabinet, Senators and other prominent men have donated cups for prizes in the tournament. Further information may be obtained from and subscriptions should be sent to General Eugene Griffin, corps commander of the State of New York, at 44 Broad Street, New York City. As many engineers were engaged in the war, as members of the engineers corps or otherwise, this announcement will probably interest a large number of readers of this journal.

The St. Louis Exposition Terminal of the Wabash Railroad.

The accompanying diagram gives the general layout of tracks adopted by the Wabash Railroad Company for its terminal at the grounds of the Louisiana Purchase Exposition. The station will be located at the corner of De Baliviere and Lindell Avenues, directly opposite the main entrance to the Exposition grounds. The grade of De Baliviere Avenue will be lowered temporarily during the exposition, so that visitors using the trolley cars will be able to walk under the railroad tracks in passing between the street car terminal loops and the entrance. There is some talk of widening the avenue between the terminals and the entrance, so as to form a large plaza. This will not only improve the appearance of the locality, but will tend to make it somewhat easier to handle the crowds.



World's Fair Terminal, Wabash Railroad.

It will be noticed that the railroad terminal is in two divisions. The five main tracks are for the through trains east and west between Tower 2 and Forsythe Junction. The passengers from these trains will be discharged on the platforms between Tower No. 2 and De Baliviere Avenue, and will walk to the stairs at the west end, where they will descend to the street or the depot, as they may elect. Returning passengers must pass through the classifying stiles in the depot into rooms where they will be held until their trains are ready.

The second division of the terminal is arranged for the two shuttle tracks, which will be kept clear of other traffic as far east as Union Avenue, at which point they will converge with the other main tracks into the double track running to the Union Station in the city. All the shuttle train business will be handled through the station at the corner of the railroad property directly facing the main entrance, and tickets will be collected at turnstiles before passengers enter the trains. The exits are independent passages on each side of the station.

These trains will be made up of specially constructed cars without steps. Transverse seats will be used, arranged somewhat like those of an open street car, and there will be a door on each side of the car at every seat. Elevated platforms will give access to these cars, so as to avoid any steps retarding the entrance or exit of passengers. It will be noticed that the platforms for leaving these trains are distinct from those by which they are entered. By running the trains on two-minute intervals, it is estimated by Chief Engineer W. S. Newhall that 36,000 people can be handled in an hour, with 1,200 people on each train.

In the operation of these shuttle tracks, the trains will head in. An extra engine will couple on to the rear to carry it on its return trip, while the engine which brought it in will become the extra for the next train. For this purpose it will pull out and lay in the clear on the cross-over near the word "Water" in the diagram.

It is of interest to mention that there will be a new railway route to the exposition grounds via the Merchants' Bridge, the West Belt Line of the Terminal Railroad Association and the Wabash Railroad. The other route is via the Merchants' Bridge or Eads Bridge to the Union Station, from which place passengers will go to the grounds by the Wabash shuttle trains, street cars or other means of transportation.

The signal towers have been designed for the following machines: At Union Avenue, 12 signal levers, 8 switch and derail levers, 9 facing point locks, 2 double slips, 1 movable point frog. At the World's Fair tower, 19 signal levers, 17 switch and derail levers, 2 double slip levers, 1 movable point frog lever and 12 facing point lock levers. At Forsythe Junction, 17 signal levers, 14 switch and derail levers and 9 facing point locks.

Notes on Railway Construction from the Resident Engineer's Standpoint.

A paper read before the Iowa Engineering Society,
by F. C. French, Assoc. M. Am. Soc. C. E.

It has been stated by a well known railway engineer that "reconnaissance is to a location as scouts to an army."" Carrying out the metaphor, location, then, is the mobilization of forces and the manœuvering for position, while construction is the rearing of fortifications and thorough preparation for the battle of existence in the competition for traffic. In the growth of our engineering societies, through the helpful discussions at our meetings, the topic of ordinary railway construction has received but little attention and, as a result, the comparatively young engineer has no fixed methods or standards for his guidance. Each must go his own way, unconscious of any general demand for certain particular requirements or grades of work as are common in most other lines. The long and valuable experience of one good engineer contributes nothing to his neighbor, unless that neighbor may happen to have come under his personal instruction.

The object of this paper will be to touch upon and call attention to some of these points of obscurity, in the hope of contributing something along the line of an approach to a uniformity of practice in handling the vital problems confronting the younger, and possibly some of the older, construction engineers. The intent is not to state the practice of any particular road, but to call attention to the points of difference of a number of roads and points ignored by a great many. Minor items may be given undue importance simply to call attention to their general neglect of mention. Such a comparison, based upon some years of actual experience, must of necessity be out of date in some instances, and to avoid this, I have recently obtained the practice of fifteen roads west of Chicago, from their chief engineers, and compiled results therefrom.

Assuming, then, that the great economic question of location has been properly solved, through a judicious use of its scouts, the reconnaissance, the resident engineer arrives upon the ground and is confronted with a company agent who is bargaining for right of way and promising crossing concessions at impossible places in exchange for a small reduction in the price per acre, and working under instructions to secure a uniform width of 100 feet of way, regardless of streams, borrow pits, waste banks, or other difficulties. The author has gleaned from experience, but has been unable to verify his judgment from many other sources, the following requirements as to widths of right of way required, and tries to impress the right of way agent with their importance:

For banks from	6 to 8 ft.	in height,	120 ft.	of width
	8 to 10 ft.	"	140 ft.	"
	10 to 12 ft.	"	160 ft.	"
	12 to 14 ft.	"	180 ft.	"
	14 to 16 ft.	"	200 ft.	"
	16 to 18 ft.	"	220 ft.	"
	18 to 20 ft	"	240 ft.	"
	20 to 22 ft.	"	260 ft.	"
	22 to 24 ft.	"	280 ft.	"
	24 to 26 ft.	"	300 ft.	"
Cuts with waste banks,	4 to 6 ft.	deep,	100 ft.	width
	6 to 8 ft.	"	120 ft.	"
	8 to 10 ft.	"	140 ft.	"
	10 to 12 ft.	"	160 ft.	"
	12 to 14 ft.	"	180 ft.	"

Wherever there is probability of damages to adjacent property from wash of waste banks, an additional width of 10 to 20 feet is necessary. A width of at least 200 feet is also advisable at the crossing of all important streams. When owners of land will sell the earth off of additional ground wanted at a reasonable figure, 100 feet of width will be ample, if a double-track railway, with slopes for excavation and embankment can be placed thereon, but the 200 feet at streams is important in either case.

Before actual construction begins, the sites of all bridge openings should be sounded to determine the character of the foundations required, and from these results, bills of material made out and requisitions for same sent to the chief engineer. The soundings may readily be made by a party of three men and foreman, provided with the following equipment: One team and wagon, one sounding rod (sectional), one drill (1-inch bar 8 feet long), two pipe wrenches, 2 rod clamps for raising rod, two water pails, one ax, and one spoon.

A convenient sounding rod is made by the ordinary pipe fitter, by taking sections of 1-inch gas pipe 10 feet long and into each end of each section welding a 6-inch piece of ¾-inch gas pipe, so that the end projects ⅞ inch. This end is then threaded on the outside and a connection of sections made by uniting them with an ordinary ¾-inch union 1⅝ inches long, threaded inside.

The drill is a 1-inch rod 12 inches long and pointed as an ordinary rock drill, with its cutting edge widened to 2 inches, 1 inch back from the point and tapering back to the shank. The shank is then drawn out to ¾ inch and threaded to fit an ordinary union. Several drills should be provided to avoid delays of working with dull tools. A couple of small holes near the bottom of the pipe attached to the drill will relieve the air pressure when lifting in a sticky hole. This sounding rod and bit can be used as an ordinary churn drill.

The clamps are pieces of iron similar in shape to an ordinary wrench and made to fit the pipe snugly, so that when a lever is put under the handle end, the clamp will jam the pipe and the pipe be withdrawn. Two clamps are used to relieve any bending strain. Where rock is near the surface, pits will give much better results. Notes of the position of the pits or soundings, as well as depth and character of material encountered, must be taken on the spot and plotted later in the office.

The resident engineer's force as a rule consists of an instrument man, a rodman, tapeman, team and driver, and he should as quickly as possible have them check all curves and tangents and put in spirals, the length of spiral depending on the road in question to some extent. Run check levels over the residency and report at once any errors found in location levels. Put a bench mark close to each bridge for cut-offs and foundation elevations.

Engineers must carefully reference the beginning and ending points of all curves and points of compound curve; also all other important points. This may be done by setting two hubs at angles of 45 degrees and 135 degrees on each side of the tangent, say 100 feet from the P. C. or P. T. The hubs should be driven down level and guard stakes placed for witnesses. In this manner the point may be replaced by measurement or intersection or both. In timbered country the reference points may frequently be placed on tree roots for greater safety, blazing tree for witness.

Cross-Sectioning.—All cross-sections should be entered in the cross-section book as taken. Even if the cross-sectioning cannot be carried continuously across a residency, the entries should be made continuous as though it were, leaving two or more blank leaves at the end of each mile to be used for a summary. Each piece of cross-sectioning should be carefully indexed in the cross-section book, station to station.

Vertical curves should be calculated, before the cross-sectioning is done, for all grade intersections, and in sags, the rate should not exceed 0.10 foot per station. On summits in cuts the rate should be sharper to facilitate drainage. On all vertical curves the grade elevation of each full station, and 50 feet should be entered on the profile as well as in the level and cross-section book.

Cross-sections should be taken and slopes set at every point where a difference of elevation of center line of the two sections exceeds 2 feet, and always every fifty feet, treating half stations as though they were full ones. In marking stakes, have the station number on the face of each center stake and the cut or fill on the back. On slope stakes have the cut and fill on the face and station number on the back. Have plus stations marked with the last figure of the preceding station, with the +, thus: for station 165 +50, mark 5 +50.

Take cross-sections and set grades where the shallow side of a cut runs to grade and where the shallow side of a fill does the same. It is usually sufficient to note the plusses where the deep sides of a cut or a fill come to grade, but the author always follows the practice of setting grades.

Where it is expected to strike rock or its equivalent, the preliminary cross-sectioning may be made at a slope of ½ to 1, which will in part compensate for the irregular or compound sections that develop on construction.

All embankments at bridge openings should be staked out 2 feet wider than specifications and tapering back to the standard in 50 feet, and as these banks are more exposed to wash, they should be carried out wedge-shaped instead of with the usual rounded corners. This gives footing material for support of the outside corners of the roadbed.

Exceptionally high banks should have the allowance for shrinkage made in width when cross-sectioning, which will give a good footing for additional material placed in bringing up to a true grade after settlement has taken place and the road is in operation. A number of western roads put all shrinkage on in width when staking out the work and only bring dump to the true profile grade, claiming that they have a better bed after settlement and sufficient supporting room to raise to true grade with train service and in ballast.

All isolated masses of rock which occur between stakes, but not included in regular notes, should be separately noted and added to the sum total of the yardage.

Sections should be taken at each mile post for convenience in making estimates.

Records.—The engineer should keep a transit book, level book, field cross-section book, bridge book, pile record book, and diary, for a field entry of notes on paper or a memorandum for future entrance in the record books should never be practiced nor permitted by an assistant. Taking a simple record of notes in memory and failing to record same has probably brought more otherwise good engineers into disrepute than any other one thing. I once heard a chief engineer say very forcibly that a large majority of his men would become good engineers only when they had some one to cut off their heads and send them to the office files.

A title should be written on the fly leaf of each book giving the residency number, resident's name and address, with a brief statement of what the book is used for. Each page must be numbered and dated for each day's entry and indexed in front of book for each separate piece of work.

"Nothing new under the sun" can be said about the methods of taking notes, but it is a subject which has been sadly neglected and the author gives with apologies a method which he has arrived at through the fog of many experiences:

Left Hand Page.							Right Hand Page.		
Sta.	Elev.	Grade	Areas		Cu. Yds.		Cross Sections.		
			Cut	Fill	Cut	Fill	L.	C.	R.

In the diary should be kept a careful and conscientious record of the work done on that date by themselves and parties, and the location, amount and nature of the work done by various contractors. It frequently happens that a controversy may arise between the contractors and company concerning the amount of extra work, delays, hindrances, etc., which came up during the progress of the construction, and the object of these diaries is to have at hand a record of these points, which at any time in the future may be consulted and from which the justice of the claims may be determined.

Particular care should be exercised in keeping a careful record where any cut has in it a questionable material that might claim classification. In such an instance, the diary should state plainly at what times the cut was inspected, how frequently during the day, what force was at work, what progress was being made, what special difficulties encountered and the different locations and amounts of any material considered by the engineer as entitled to classification under the specifications. Particular attention should be given to the number, appearance and condition of the plow stock, as this is a common point of determination between classified material and earth. The diary should also show a copy of all instructions given to contractors verbally, and any other items pertinent to a record of the work, and a comprehensive estimate of same when completed, bearing in mind that this is a most important part of the final record.

The diary should also embrace a careful report of the weather and ground conditions, as this is frequently a factor in claims for an extension of time by the contractor. Also, in this connection, the engineer should go over the ground during or immediately after any unusual or record-breaking storms, and note carefully the amount of rainfall reaching the openings in his track, damage done, etc., etc., to determine, if possible, any necessary changes in the size of his bridge openings. A careful inspection on the ground is worth more than the evidence of a number of men, years afterwards, who did not have a particular reason for noting the extreme heights of floods, etc.

Clearing and Grubbing.—Clearing must not be piled off the right of way without first securing consent from the owner in writing, which must be forwarded to the chief engineer for his files; nor within the reach of high water which might float it back into the openings, always bearing in mind that in flood districts there is a current both ways.

In clearing, make allowance for telegraph lines, which are usually 45 feet from the center line. Dead or leaning trees outside the right of way, which if blown would wreck the wires, should be cut, and damages, if any, allowed to the owner.

Grub holes under the embankment, made by blasting, should be carefully filled and tamped, and the use of powder for "shooting stumps" under embankments must be restricted and discouraged, grubbing being much preferable.

While the cross-sections are being taken, the location and height of stumps to be grubbed should be noted and the location fixed by measurement and sketch, so that they may be sounded for later on, and if covered by the contractor, ordered removed before acceptance.

The specifications as to height of stumps and the burning or removal of grubs, should be rigidly inforced.

Roadbed Excavations.—The engineer will give centers through the excavations as the work progresses in order to insure the contractor's excavating to the required slope, and he will not allow ploughing to be done nearer than one foot to the slope. All slopes must be cleaned down and dressed as the work progresses, if the material will permit.

Slope boards must be used in this work and will be furnished by the company for the use of the contractor, and will be returned to the engineer as soon as the work is completed.

If, as the work progresses, the character of the material changes so as to require a different slope or roadbed, the engineer must re-cross-section the work without delay and take sufficient measurements to enable him to calculate accurately the material excavated.

When excavation is in excess of embankment within the haul limits, the embankments should be proportionally widened to take the material, if, in the judgment of the engineer, the increase in width is not exceeded in value by the price of over-haul. It should be thoroughly understood by the engineer that all material may be hauled at his discretion up to the point where overhaul exceeds the price of excavation.

In cases where banks are so low as to make haul impossible within the price, material may be wasted under due precautions to place it in such a way that it may not be washed back into the cut. Wasting material is objectionable in many ways and will only be resorted to when it cannot be avoided, and in such cases the banks must be left in regular and sightly shape, not nearer than 15 feet to the slope stakes and never permitted at the mouth of cuts. Line the back of waste banks, leaving a liberal fence berm.

Whenever embankments are in excess, cuts within the limits of free haul and at the discretion of the engineer for a reasonable distance beyond should be widened for the material and provision made therefor in cross-sectioning.

All change channel work and ditching shall be staked out in advance, and liberally, so that the contractor will have no excuse for filling everything in sight from borrow.

It costs the contractor an additional price to widen a cut or ditch after it has once been excavated, and as it is to your interest as well as his to see that he makes as large a profit as possible within the requirements of his contract, you should never by your carelessness entail upon him this additional expense.

At passing tracks and switch stands, both cut and fills should have an additional width of 3 feet for distances of 50 feet toward the station and 200 feet away from it, to enable the brakeman to overtake the train after throwing the switch.

While the work of finishing is being done the engineer should see that all rock cuts or cuts having boulders in the bottom have been taken out one foot below sub-grade and that the cut is full width on bottom to allow for a good ditch. After the cut is taken out, the roadbed should be filled in to grade with the best material at hand.

The engineer may require the contractor to place in suitable piles and at places he may direct any material suitable for riprap, slope, wall, foundations, etc. In making these piles, place them at 90 degrees to the track and leave runways of 4 feet width between piles to facilitate rapid loading by work train crews later on. Contractor should be allowed a suitable amount for such sorting and piling.

The use of large quantities of powder in pot holes, seams, shaft or drift shots, may be restricted within the judgment of the engineer, in order to protect the slopes or the earth banks on compound sections. In an ordinary cut, of say 6 feet of earth over 8 feet of rock, the centers should be fired first and the material mucked out and then the cut widened by light side shots to avoid shattering slopes.

Surface and Drainage Ditches.—In few matters is there more of an opportunity for an engineer to exercise good judgment in construction than in the question of drainage, including the disposal of surface water above and in cuts, above embankments on side-hill work, and the straightening and possible changing of channels in streams. A very slight change in profile of a line will often create or eliminate a vast amount of expense in the maintenance later on.

Liberal surface ditches will be staked out on the high side of all cuts and excavated before the work of excavation of the roadbed has been more than well started.

The material excavated therefrom will be placed in a continuous bank or levee between the ditch and cut, leaving a 3-foot berm between the ditch and bank, thus adding to the capacity and value of the ditch.

No surface ditch should be less than 2 feet wide on the bottom or less than 1½ feet deep.

All ditches should be carried to a borrow pit or water course, or turned away from the embankment below the mouth of cut.

Where embankments are made from excavation and there is no borrow pit, berm ditches will be excavated and made of ample dimensions for the requirements of the location. All ditches must be staked out, and in general the material excavated from them placed in the embankment. In change channels for turning streams, care must be taken to make embankments across the old channel of sufficient width to withstand the action of the current. In such cases, the width of the embankment should usually be not less than 20 feet on top, with a slope of two to one, bearing in mind that it is cheaper to build a dyke too strong than to have it washed out and be forced to replace it. In turning rapid turbulent streams, take especial care to prevent the new embankments from being washed away before they are high and strong enough to withstand the current.

Embankments.—The clause in the ordinary specifications which requires the embankments to be built out to the slopes from the base up, so that the whole will settle compactly, must be rigidly enforced. The contractor will, if left to himself, carry up his centers and then widen by dumping over the sides in order to make a neat-looking job, and if paid by embankment measurement, will figure that he puts in less yardage in that manner, which is true; but he is paid to bring his dump to a true prism, and if kept out to slopes from base up, will have no difficulty with concave slopes or "sloughing off" from the shoulders.

The best material must be placed under the center of the roadbed and the poorest under the slopes, using care with material liable to a large shrinkage, such as sod, frost clods, etc., to have them no farther in from the slopes than they are below grade. See that sod and surface material from cuts are not placed in the shallow part of the fills, but carried farther along where the bank is high.

When necessary to work in freezing weather, see that the material is kept constantly ploughed to minimize the freezing, and when wheel scrapers are used on high banks, see that the runways are carried up the full width of banks in order to get uniform compacting by the travel.

The shrinkage varies greatly with different authorities and also the method of applying the same to embankments. A safe plan is to widen the banks from slope stakes up and then correct the grade line, after settlement, with ballast or otherwise. The average shrinkage used on most roads is 5 per cent. for scraper work, 7 per cent for wagon work, and 10 per cent. on casting and grader work without wagons.

The use of grading machines, elevating directly to dump, may be allowed when the layers are limited to not more than 8 inches in thickness before compacting. Each layer must then be compacted by a narrow or heavy roller or both, as may be necessary in the judgment of the engineer.

When fills are less than two feet in height, the sod from the top of the borrow pit or cut to a depth of not less than 3 inches should be wasted if a machine is used.

Riprap.—When embankment must of necessity be riprapped to protect it from the action of water, it should be built at a slope not greater than two to one, and if built steeper, the riprap should be placed with its exterior face at that slope and be well backed for safety. In case the base of the riprap rests on rock, a steeper slope is permissible, but seldom less than 1½ to one.

The riprap stones should be placed with the larger ones at the bottom and laid by hand with considerable care to avoid large openings. The stones should measure 1 cubic foot at least and at the ends should be turned into the bank for a couple of feet to avoid undermining or washing out.

Borrow Pits.—No borrowing of material will be permitted on the station grounds without express permission from the engineer and no pits will be made where they might cause injury to the embankment. Where necessary, they will be made on the outside edge of the right of way and not excavated below the bottom of openings through which they are to drain, and the contractor must be instructed how to excavate them so that they will drain themselves for their entire length. If necessary, grades should be run for this.

Borrow pits for light fills should be narrow and deep to diminish the percentage of sod in the fills. Commence all pits at least 3 feet farther from the bank than the berm specified, because the scrapers will drag off the corners and the contractors' tendency is to cut the berm down at all times.

The quantities to be borrowed are arrived at from the plotted haul and the contractors are to be instructed how much and when to borrow so that the borrow will not be exclusive, leaving the cuts to be wasted.

Berms of the following width should be left between the slope stakes and borrow pits:

Banks under 3 feet....................	6 feet berm
Banks 3 feet to 10 feet..................	8 feet berm
Banks over 10 feet....................	10 feet berm

Crossings.—In locating crossings, consult the right of way deeds and comply with the stipulations contained therein.

Grades on crossings should not exceed 6 per cent. with 20 feet of level grade on each side of center line of track. The usual width of a farm crossing is from 12 to 20 feet and of a highway crossing from 20 to 36 feet on different roads, with the usual roadbed slopes.

The engineer should endeavor to secure, within reasonable expense, under or overhead crossings. Bridges and culverts can usually be utilized for farm crossings at least, with but small outlay.

Finishing.—All grading will be finished to the standard roadbed sections and slopes should be dressed to true prisms, both in cut and fill, no concave slopes in fills or cuts being permitted.

In finishing embankment the author has made a practice of setting shoulder stakes at each station and center hubs at each +50 on tangents, and two stakes on curves, one on each side at extreme width of cut at stations and plusses. With some contractors he has found it necessary to set crown stakes for the roadbed in cuts also.

Before accepting, the grades over finished work should be checked and attention paid to the ditches to see that they have proper width and depth. Any method of finishing that will disturb the grade stakes will not be permitted.

Where the road is to be ballasted, in order to facilitate drainage, the roadbed at sub-grades should be crowned both on tangents and curves by raising the center 4 inches above the sides, making due allowance for ballast in establishing grade elevations.

Super-Elevation of Curves.—On all curves the roadbed is to be finished to conform to a super-elevation equal to 2 per cent. of the width of the roadbed for each degree in the index of the curve. The outer edge of the roadbed will be raised above the grade at the center line half the super-elevation and the inner edge of the roadbed will be depressed below the grade at the center line half of the super-elevation, the center line remaining in conformity with the profile grade, plus shrinkage. Thus: for a 16-foot roadbed on a 4 degree curve, the super-elevation would equal 1.28 feet, or 0.64 foot above the grade of the center for outer edge and 0.64 foot below the grade of the center for inner edge.

Curves having bridges within their lengths should be treated in the same manner as at other points, the grade line of the bridge being adjusted in accordance with the above rule.

The distance out in both cases will be set at a point corresponding with the width of roadbed desired, which in general will be 16 feet on embankments and 8 feet each side of the center line. On sharp curves proper correction should be made in the slope stakes due to the super-elevation. It is desired that embankments shall be full and strong on the outside of all curves.

(To be continued.)

The Philadelphia Fire-Protection Pumping Station.

Within the past year the Bureau of Water of the City of Philadelphia, under the direction of Mr. F. L. Hand, chief of the bureau, has completed a system of high-pressure salt-water fire mains. For a time water was pumped into these mains, in the case of fire in the district protected, by fire boats which could connect at three places on the river front. This method was not considered wholly satisfactory, and so a pumping station was designed for this special service. The pipe system was briefly described in this journal June 14, 1902.

The pump installation, recently completed, is located on the Delaware River front, at the corner of Race Street and Delaware Avenue. The district protected is bounded by Broad, Walnut and Race streets and the Delaware River, and contains many high office buildings. The pumping station, a building 72 by 140 feet, will contain ten 11½x12-inch vertical, direct-acting Deane triplex pumps, each capable of delivering 1,200 gallons per minute at 40 revolutions, against a pressure of 300 pounds per square inch, and two 6¼x12-inch pumps of the same type of 350 gallons capacity per minute. These pumps are to work together or singly, as may be desired, and all will discharge into a common 20-inch main. The water supply for the pumps will be taken directly from the Delaware River through a 36-inch suction main. Only seven of the larger pumps are being installed at present, each of which will be driven by a 280-horse-power Westinghouse three-cylinder single-acting gas engine; the small pumps will have engines of the same type of 125-horse-power, direct-connected through friction clutches, which will also drive electric ignition generators of 7.5 kilowatts each, and the air compressors supplying air at 200 pounds pressure for starting the main engines. There are three sources of current for ignition, connections with the city lighting mains and a storage battery being provided in addition to the ignition generators. The lighting current is reduced from 220 to 110 volts by a rotary transformer. Cooling water for the gas engine cylinders may be taken from two different city water mains and from the fire mains. A gas pressure regulator on the supply pipe of each engine maintains the pressure constant.

Triplex pumps have been selected because of the even flow of the discharge, producing practically constant pressure on the discharge mains and making a very even load through all parts of the gas engine cycle. The crank-shafts are driven from the engine shafts through single-reduction gears. The fact that the pumps are of the vertical type makes it easy to connect them directly to the engines and also results in a considerable saving in space. Each pump is fitted with a by-pass valve and a relief valve, the manner of using these valves being well described in the following clause from the specifications: "It is proposed to maintain about 60 pounds pressure on the fire mains from the city reservoir. The pumps will be started under these conditions with the by-pass open, and any surplus of water pumped will be discharged through the relief valve into the suction main. When the engine is under way the by-pass will be closed, and when the water is used as fast as this unit will deliver it, its relief valve will close. In the meantime a second unit will be started and handled in the same way and so on until the full plant is in operation."

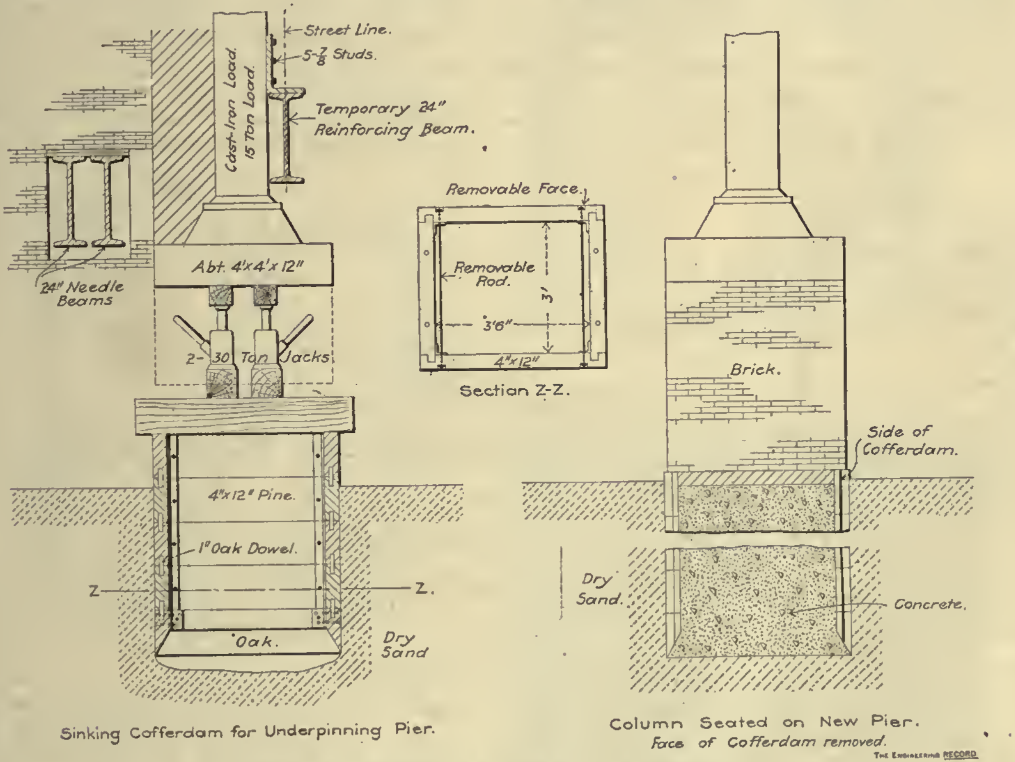
The pressure in the fire mains is controlled automatically by an electric motor acting on a valve. It may be held steadily at any point under 300 pounds, while a spring relief valve prevents its from rising above. The water ends of the pumps are divided into sections, that is, each cylinder and valve chest is a separate casting and can easily be removed without disturbing the other parts. The pumps have large valve areas and are capable of a much higher speed and greater pressure than are called for in the specification. The valves are of hard rubber, especially suited for this work.

The machines were designed for fire service by the Deane Steam Pump Company, of Holyoke, Mass., and are brass fitted throughout in order that they may be able to start after long periods of idleness. All moving parts, such as bearings, connecting rods, crank-pin boxes and cross-head shoes, are adjustable for wear. The crank-shafts and connecting rods are made of forged compressed steel, have large factors of safety and are superior to the steel castings sometimes used. The pinions are of steel, and the gears are steel castings, all carefully cut by machine and running with little noise. The pumps are heavy in every particularly and insure that every requirement on the pumping end of the equipment will be fully met.

The mains supplied by this pumping station are 9 miles long and 8, 12 and 16 inches in diameter. They are of extra thickness and all fittings, including fire plugs, are of special design. The total weight of the pipe is 6,500,000 pounds, and of the fittings, 850,000 pounds, costing altogether $355,000. The pump house cost $250,000, the large units, $22,000 each, and the small units $8,000. The station replaces with advantage more than 40 fire engines, and as a result of its installation the rate of insurance will be reduced 25 cents per $100. The selection of gas engines for motive power is novel, but is believed to be justified in view of the perfection of the modern gas engine as regards reliability and freedom from break-down. The advantages are economy during periods of idleness, as compared with steam plants, and the ability to start up immediately, at full power.

Jacking Down Open Cribs for Underpinning.

The erection of the steel cage office building at the corner of William and Fulton streets, New York, and the excavation of its cellar below the footings of the adjacent buildings necessitated the underpinning of the walls and columns on both sides of it. The building at No. 102 Fulton Street is seven stories high, with a 3-foot wall, which was estimated to have a total load of 13 tons per linear foot. The wall was supported on 24-inch I-beam needles, and the rubble footing was removed, a trench excavated to the bottom of the new cellar, the new footing built and the lower part of the wall replaced in the usual manner. At the street corner the side wall terminated in a vertical plane about 4 feet back of the street line, and in the face of the building there is a rectangular cast-iron column at the intersection of the side and front walls. This column was seated on a cast-iron shoe and a granite pedestal about 12 inches thick and 4 feet square. That portion of the side wall adjacent to the column which was supported on the pedestal is in the same plane as the remainder of the side wall, but has no bond with it. These conditions and the fact that neither trenching nor timbering was considered practicable under the column made the problem of underpinning it a difficult one. It was finally solved by an ingenious application of the Breuchaud process, which embodied the novel feature of using an open timber crib.



Sinking Cofferdam for Underpinning Pier.

Section Z-Z.

Column Seated on New Pier. Face of Cofferdam removed.

Method of Sinking Open Cribs for Underpinning.

A heavy bracket made of a steel plate 26 inches long and 1¼ inches thick, bent at right angles, was secured to the street face of the column by five ⅞-inch stud-bolts. Its longitudinal face took bearing on the upper flange of a 24-inch I-beam needle parallel to the street line which was supported on a sill in the sidewalk vault and on cribbing in the excavation for the new building. The granite pedestal was removed, the concrete footing torn out and the excavation carried down a little lower to receive the bottom course of a timber crib or caisson 36 inches wide and 42 inches long inside. This course consisted of four 4x12-inch oak planks set edgewise, and having their lower sides beveled to a cutting edge. They were connected at the corners by short vertical angles and had 1-inch tie-rods with countersunk heads in the direction transverse to the lot line. The two sides parallel with the lot line had mortised joints with the other two sides, and the frame thus formed was provided with vertical oak dowels 1 inch in diameter which projected from the upper edge to lock it to the succeeding course.

Timbers were set on the upper edges of the planks, and two 30-ton jacks seated in the middle of them reacted against the granite pedestal which was inserted between their tops and the base plate. A laborer with a shovel and scoop excavated the sand from the interior of this caisson as it was forced down by two other men operating the hydraulic jacks. When the jacks had made a full stroke, the pedestal was supported by cross pieces temporarily inserted under it and bearing on needle beams and sills. The jacks were then released, another course added to the caisson, the jacks replaced, the caisson forced down and excavation continued and so on, until the caisson was sunk with its cutting edge below the level of the excavation for the new building at a point just above ground water line. The caisson was sunk 15 feet in seven hours by three men. The sand was hoisted out by hand in a water bucket, and the operation was conducted without any inflow of the soil or undermining the neighboring wall.

When the caisson was sunk to place the bottom of the excavation was carefully leveled and the excavation filled with concrete rammed in 6-inch layers. The top of the caisson was covered by heavy flagstones set so as not to bear on the timber walls, and on them a brick pier was built up nearly to the height of the granite pedestal and capped with a cut granite block between which and the pedestal pairs of steel wedges were driven until the weight of the column was transferred from the needle beam to the new footing. After the excavation for the new cellar was completed, the nuts on the ends of the transverse rods through the courses of the caisson were removed, and the outside boards were taken off exposing the face of the concrete pier within which was continuous with the concrete footing under the side wall. This method of underpinning was also adopted with satisfactory results for the 85-foot wall of the Merchants and Traders Bank adjacent to the Singer Building at the corner of Prince Street and Broadway, New York.

The Singer Building has an L-shaped plan enclosing the two inner walls of the bank building. Its excavation was carried below the footing of the bank building so that it was necessary to first underpin the walls of the latter. The wall opposite Prince Street was about 24 inches thick at the base, and nine stories high, having an estimated total load of 15 tons per linear foot. Adjacent to it there is a row of vaults extending entirely across the basement of the bank building so that it was impossible for the interior to be occupied or obstructed by needle beams or excavation.

In order to underpin the wall wholly within its own area, a hole about 5 feet long and 2 feet high was first cut entirely through the wall at the center point, and an excavation was made there to a depth of 2 or 3 feet. In it was seated the lower course of a timber caisson about 4 feet long and 3 feet wide. It had a beveled oak cutting edge and corresponded in its construction with the caisson described for No. 102 Fulton Street.

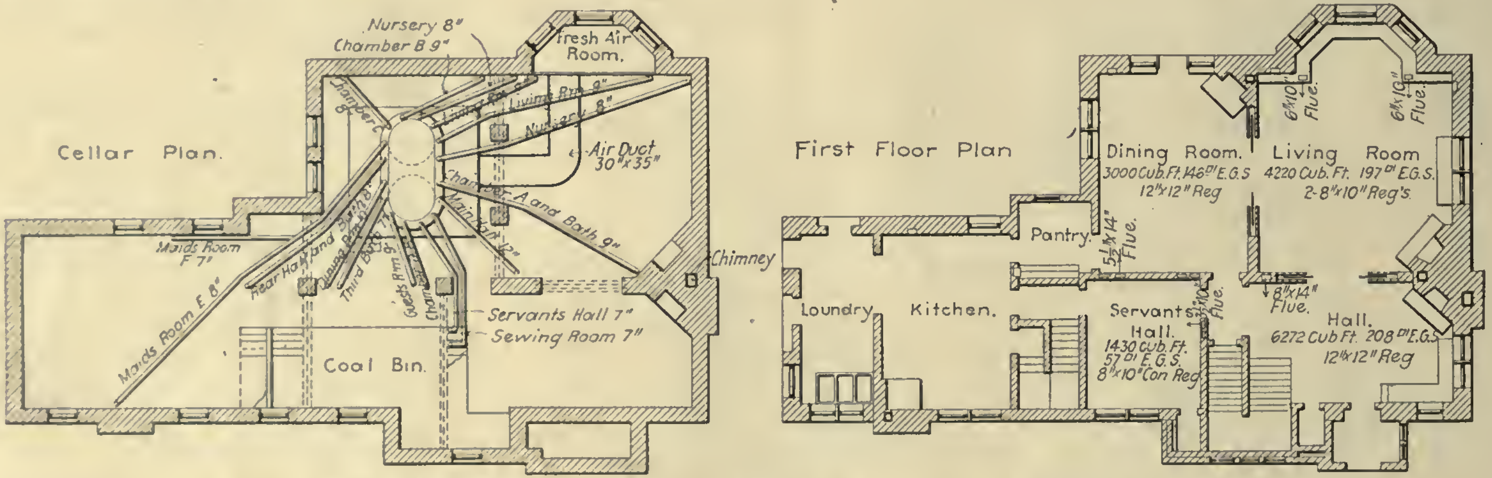
After the first course was set, the excavation inside was commenced, and it was lowered sufficiently to add the second course and place the jack screws reacting against bearing timbers on the under side of the wall above. The jacking and excavation was then continued, and as the caisson was sunk, fourteen more 12-inch courses were added. The caisson was sunk until the cutting edge reached the level of the caissons for the Singer Building, and then the excavation was continued 18 inches further and was extended 1 foot beyond the face of the caisson on the inside of the bank building, thus forming an eccentric footing.

The caisson was rammed full of concrete in 6-inch layers, and a brick wall was built on top to engage the old wall and the pressure transferred with wedges in the usual manner. After this caisson was completed, two more were sunk at points midway between it and the corners of the wall, and others were then successively sunk, always at the centers of the vacant spaces, until the whole wall was supported on nineteen caissons set close together and forming an almost continuous footing. The caissons were sunk by three men each, at a rate of about 2 feet per hour, and after the excavation was made for the Singer Building, the planks were removed from the exposed faces of the caissons, the bolts withdrawn and the ends of the side planks cut off so as to leave a smooth continuous wall under the bank building.

Mr. Ernest Flagg was the architect for the Singer Building, Dawson & Archer were the general contractors, and T. P. Galligan's Sons were the sub-contractors for the shoring and part of the underpinning. The underpinning was executed by the Foundation & Contracting Company under the direction of Superintendent L. L. Brown and Foreman W. S. Downing.

THE EXPANSION DUE TO TEMPERATURE of an alloy of iron with 36 per cent. of nickel is so small that it can be measured only with the aid of delicate instruments, although that of each metal is considerable.

A Battery Furnace Residence Heating System.



Plans of a Three-Story Residence Warmed by a Battery of Hot-Air Furnaces.

The installation of a residence heating system in which a pair of hot-air furnaces or heaters connected together were employed, was made the subject of a paper presented by the designer of the plant, Mr. C. E. Oldacre, of Philadelphia, before the American Society of Heating and Ventilating Engineers. An abstract of the paper is given in the succeeding paragraphs, and also an illustration of the operation of the apparatus.

The house is located at Jenkintown, Pa., near Philadelphia, on high ground, and facing the north. It is partly of stone and partly of framework. The total contents of the rooms to which heat is carried is 33,744 cubic feet; the area of exposed wall surfaces, 2,853 square feet; that of the glass surface, 731, and the total area of the equivalent glass surface, 1,537 square feet. The heaters are located in a pit having a clear height to the first floor joists of 8½ feet. The heaters have grates 21 inches in diameter and the heating surface of the two heaters is 300 square feet, or 150 square feet each. The total grate surface being about 5 square feet, the ratio of grate to heating surface is 1 to 60. The heaters are set 12 inches apart and are connected at the top to a common dome, or air chamber, that allows 18 inches clear space between its top and the top of the heater casings. For each heater there is an 8-inch smoke connection, uniting in a 10-inch galvanized-iron pipe which leads to a terra-cotta lined chimney 7½x11 inches inside.

The fresh air is brought through three windows on the west side of the cellar, aggregating in net area 1,000 square inches. The fresh-air chamber is tightly boarded off from the cellar and the air is conducted to the heaters through a 30x35-inch galvanized-iron duct. Near the heaters the duct is divided into two parts, each of which is above ground and spread out to the diameter of the heater casing or outside jacket or to a cross-section of 14x51 inches. Near the fresh-air chamber there is a cut-off damper, with an outside indicator, and this when shown shut still leaves an opening two-fifths the size of the main duct. This arrangement is to allow for cutting down too great an inrush of air during high winds and also at night when the fires may become low, and it prevents the duct being entirely closed off with a likelihood of damage to the heater and of interference with the working of the system. In the branch duct to each heater there is a tight damper as there are also in the individual smoke pipes. The tight dampers of the air duct and smoke-pipe of each heater are connected together by chains so that when the chain is operated to close the duct to either heater, it simultaneously closes the damper in the smoke-pipe. Should the chain break or become detached, the dampers automatically open, avoiding dangers from closing smoke-pipe or air duct. The purpose of the dampers is to allow the use of either heater independently, if so desired. Otherwise, if the air were allowed to pass through one of the heaters which had no fire in it, this air would reduce the temperature of the air coming into the warm-air chamber from the heater in operation.

The heater casings are galvanized iron, lined on the inside with corrugated asbestos. The top or dome is of the same material, and is lined with corrugated asbestos and an inner lining of tin plate. Here are 16 collars or outlets on the heater top for the connection of the heat pipes, nearly all of which are connected to the separate rooms. The collars are made flaring; that is, the bottom of the collar at the top of the heater, is 2 inches larger in diameter than the top where the pipe is attached. The pipes are of IX bright tin plate 4A grade, and are covered with corrugated asbestos, secured to the pipes by means of japanned metal bands. Whereever there is a change of direction in the pipes, easy bends are employed. Flues in partitions and walls are made of the same material as the cellar pipes, and are covered with asbestos sheathing paper, two thickness in partitions and four thickness in addition between the pipes and wall in outside walls. Over all the flues there is punched metal lathing on which the plastering is done.

Each outlet has a plain lattice register. Where the depth of the register box is such that a plain-face register would cut off part of the area of the flue, a convex-face register is used. The total area of all heat pipes, 16 in number, is 983 square inches. The equivalent glass surface, as already stated, is 1,537 square feet, this calculated on a basis that 4 square feet of the wall surface are equivalent in cooling action to 1 square foot of glass surface, and that, for the third-story rooms, 10 square feet of the ceiling are equivalent in this respect to 1 of glass. It will be seen that there are 34.3 cubic feet of air space for each square inch of area in the heat pipes, or 29 square inches in the heat pipes for every 1,000 cubic feet of contents. There are 1.56 square feet of equivalent glass surface for each square inch in the heat pipes and approximately 4 square feet of gross exposed wall surface, including the windows, for each square inch of heat-pipe area. The proportion of the space heated to the heating surface of the furnace is 112 to 1. In a study of the individual cases, for which the author presented a table, a wide variation is shown in relation of the area of heat pipes to the cubic contents and also in the relation to the equivalent glass surface, but this variation, he explained, is occasioned by the conditions of each case, such as the exposure, direction of the exposure, elevation, and length of the heat pipes and the surroundings of the heat flue. For example, the ratio of heat-pipe area in square inches to space heated in cubic feet, is 1 to 33 in the case of the living room on the first floor; 1 to 38 for the dining room; 1 to 55 for the hall, which has 6,272 cubic feet of contents through the three stories and register in the first floor only; and 1 to 38 for the servants' hall. In rear rooms on the second floor the ratios are 1 to 18 and 1 to 20. The ratio of heat-pipe areas to equivalent glass surface is for the rooms mentioned: 1 to 1.56; 1 to 1.87; 1 to 1.84; 1 to 1.5 and 1 to 1.2. For a bath room on the third floor the ratio on the basis of room contents is 1 to 10 and on the basis of equivalent glass surface, 1 to 0.6. In the latter there is, of course, an equivalent glass surface which was to cover transmission losses through the ceiling.

As an illustration of the distribution of heat the author gave a table of the temperatures observed in the different rooms and also of the temperature of the air at the registers. This was not presented as indicating a test, as the outdoor temperature was 18 degrees above zero. The temperatures throughout the house ranged from 75 to 84 with an average of 79. The room and register temperatures for the first floor rooms are as follows: Hall 80 and 180; living room, 80 and 172; dining room, 79 and 170; servants' hall, 79 and 174. From these figures The Engineering Record has made the following calculations. In the case of the living room there is an equivalent of 197 glass surface. As the temperature difference between room and outside is 62, the cooling action, at 1 British thermal unit per square foot of the equivalent glass surface per hour per degree difference, is 62×197=12,214 thermal units. If this is increased one-third to allow for its northwest location, the total cooling action may be taken as 16,300 thermal units per hour. This amount of heat is supplied by the incoming air which is cooled 92 degrees in giving up the heat. As one cubic foot of air loses 0.019 thermal unit in cooling one degree, it will lose 1.75 units in cooling 92 degrees and to supply 16,300 units in one hour, 9,300 cubic feet will be required in that time. This would correspond to a velocity of about 3 feet per second in the heat pipes and a change of air in the room at the rate of 2.2 times in an hour.

On the Siberian Railway heretofore certain students of the technical schools have been permitted to run locomotives as a part of their training, but orders forbidding this practice have recently been issued, thus debarring about one hundred students. These orders were called forth by the derailment of a butter train near Cheliabinsk while a student from the Tomsk Technological Institute was managing the locomotive.

Illinois Engineers and Illinois Roads.

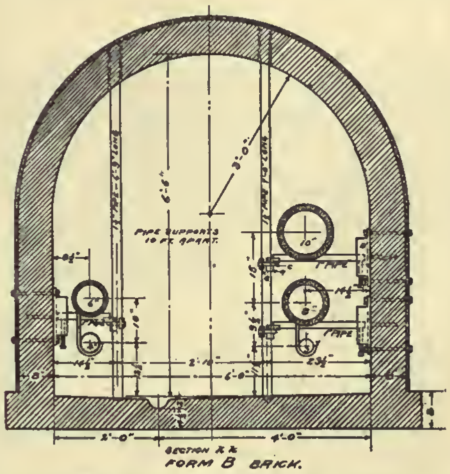
Abstract of a paper read by Prof. I. O. Baker before the Illinois Society of Engineers and Surveyors.

Engineers frequently complain that in emoluments and in public esteem the engineering profession does not stand as high as it deserves, either in comparison with other professions or on account of the importance of the interests involved. There is doubtless some justification for this contention, yet the reason for the lack of appreciation of engineers by the public is not far to seek. The work of the engineer is almost wholly with inanimate things, the world of dead matter and of force. The engineer devotes all or nearly all of his time to the materials, the laws and the forces of nature, and scarcely any time or thought to the life of the world, to its commercial, political, intellectual and social activities. Natural law, dead matter and lifeless force make up his working world; and in these alone many engineers live and move and have their professional being, and they have scarcely any conception of any other world. The social and the political problems of the community in which they live seem not to concern them. They do their work largely apart and separate from other men, and particularly from those men who are making and molding public opinion, and who are giving time and thought to the social and political problems of the community. These engineers give themselves so much to the contemplation of the material problems of their profession that they lose interest in the intellectual and social life of the world, and lack appreciation and enjoyment of literature and art; and consequently have but little in common with men and women whom they meet. The minds of such men are all shop, out of which only shop talk can be drawn. Such men are little more than animal tools and are liable to be something of a bore to their friends and a weariness to the flesh of the more liberal minded men of the other professions. Their influence upon the social and the intellectual life of the community is zero, and it is no wonder that those who mold and make public opinion do not accord these engineers a high place in their estimation, and it need be no surprise that the returns for professional labors are too much like that received by other ciphers in society and too little like that obtained by those who make and mold public opinion.

Just now, however, there is a distinct call to the engineers of the State to help in finding the best solution of the good roads problem. The Legislature at its last session authorized the Governor to appoint a Commission to study the road question, and report its conclusions to the next Legislature. The Commission has been appointed and its report is sure to bring the road subject up for active consideration. It is not too much to say that the civil engineers of the State, particularly the members of this society, scattered in the several communities, should contribute of their knowledge to the solution of this problem. In one phase the road question has to do with the materials and the forces of nature, and hence is in the field of the engineer's professional activity. In another phase, the road question is quantitative rather than qualitative, and since the engineer in his professional work is accustomed to deal wholly with quantitative questions, he should be particularly fitted to help solve the road problem. The engineer is especially qualified by his professional training to consider questions as to the amount of the present traffic and its cost, the probable future traffic and its cost, the cost of maintenance of the present and of the proposed road, the materials for the road surface, and the details of the method of construction.

But the good roads problem is usually much more than a question of materials and the methods of using them. Matters relating to efficient road administration, and to the equitable adjustment of the expense of any proposed improvement between the lowest and the various higher governmental units, and a proper distribution of the expense between the present and the future, will require the wisest statesmanship, the most careful consideration of conflicting interests, and a recognition of the power of established practice. The engineer who has been trained to weigh causes and foresee results should be able to throw some light upon this part of the good roads problem.

The economics of the good road problem is not a mere academic question, but one vibrant with interest to the whole State. If you believe with some that the people of the State are losing vast sums through poor wagon roads, then you should lend a hand to stop this waste; and if you believe with others that any attempt to spend considerable sums in road improvement would be a public calamity, then you should do all in your power to prevent such useless expenditure. This question has been before the public for about a decade, but it is a curious fact that the contentions of either side have never been seriously considered by the other. The disputants have faced in opposite directions, and each has addressed only those who held his own views, and consequently little or no progress has been made toward the solution of the problem—unless it be that the disputants have gotten farther apart. But this condition of affairs is likely to come to an end, for the report of the State Good Roads Commission will bring the matter up in the next Legislature, and an attempt will likely be made to embody some view of road reform in legal enactment. Within a year the discussion of the good road question is likely to take on a new aspect in this State, and engineers should be ready to discuss the subject with intelligence and considerateness. The discussion should proceed with more light and less heat than has been common in the past.



Cross-Section of the Pipe Tunnel.

Conduit for Steam Pipes.

Purdue University Central Heating and Power Station.

Abstract of a paper read by J. D. Hoffman, Associate Professor of Engineering Design, Purdue University, Lafayette, Ind., at the meeting of the Indiana Engineering Society.

At Purdue University there has been installed a complete centralized plant to provide heat and light for the various buildings, thirteen in number, located at distances varying from 125 to 1,200 feet from the power-house site, and also a central generating system for these buildings, using steam and electricity for power or experimental purposes. In selecting the site for the building, the probable growth of the university was taken into account, so as to have the supply eventually about the center of the field of demand. Dean W. F. M. Goss, of the engineering department, is the designer and superintended the erection of the entire plant.

The pipe lines to the several buildings are carried first through a large subway or tunnel, and then in conduits. One conduit, leading from the tunnel, the east one, is double and carries two flow mains and one return main. One main is a high-pressure main carrying steam as high as 250 pounds pressure to supply the various power and experimental engines, the other and larger main carries the low-pressure and exhaust steam from all the engines to the respective buildings along this branch for heating purposes. The return main carries all the condensation from the various buildings using heat and power back to a receiver located in a pit in the power-house. The pipes are graded so the entire return water will flow to the power-house by gravity. The present plans provide for 40 to 45 pounds pressure in one case for heating, with pressure reducing valves at each building. Those buildings connecting with the exhaust main will heat from steam at a pressure slightly above that of the atmosphere.

The accompanying drawing shows a section of the tunnel near the power-house. The pipes are supported on rollers of 1-inch pipe, being held at one end by a cup-shaped casting and at the other by a set screw which provides for vertical adjustment without restricting the turning of the roller. The bottom of the tunnel is cemented and thoroughly drained. The photograph shows details of the conduit for the single and double lines. Manholes are placed at important points along the line.

All main lines of piping have flanged fittings throughout so that in case of accident any section can be removed for repairs on short notice. No expansion joints are used, all expansion being provided for by offsets. All corners are fitted with pipes of a 90-degree long radius bend instead of the ordinary elbow joint. Anchors are placed at proper intervals to make the expansion suitable at the different bends. All pipes are protected with magnesia sectional covering and the conduits enclosed with halved tiles cemented in place.

The boiler plant consists of two Stirling units of 500-horse-power each, with the foundation prepared for the installation of a third unit of the same size at some later date. These boilers are connected by bent pipes of large radius turns to suitable steam headers, so valved and fitted that they may be used independently or combined. The firing is accomplished by means of the Roney mechanical stoker and is supplied with coal through down spouts from a coal storage bin. The ashes fall in pits located along the line of a bucket conveyor, and when occasion demands, are dumped into the conveyor and elevated to an ash bin located at one end of the building and at an elevation the same as that of the upper coal bin. From this bin the ashes can be spouted to a car or to wagons. The receiving hopper for the coal is located on one side of the building in the line of the railroad. The coal from this hopper is caught by a cross-conveyor and carried to the crusher directly over the lower strand of the bucket-conveyor. The coal when crushed falls into the bucket-conveyor, is elevated to the roof line and is dumped into the coal bin mentioned, which is upper of two coal bins. From this upper bin filling spouts drop, as stated, to the stokers. When the upper bin is filled a sliding gate is opened and the coal falls to the lower or main storage bin. The bottom of the main storage bin is built hopper fashion with spouts properly valved, leading to the lower strand of the bucket-conveyor. When coal is scarce in the upper bin, the coal from the lower bin is spouted to the bucket-conveyor and carried to the upper bin for use. The convenience with which the coal can be moved is expected to prove of great value in case of the heating of the coal in the large bin. By continuous handling of the coal it would be given a chance to become cooled. If in an emergency it becomes necessary to remove the coal from the building, it can be dumped into the ash bin, and from there spouted to the cars. The power-house is 60x130 feet, with a stack 9 feet free diameter and 150 feet high.

The Tenth Anniversary of the American Society of Heating and Ventilating Engineers.

(Continued from page 115.)

In the account last week of the tenth anniversary meeting of the American Society of Heating and Ventilating Engineers the proceedings were carried through the first session of the third day. The next session was the concluding one of the convention and two papers were presented, a number of topical discussions taken up and the new board of officers installed.

The two papers were those of Prof. Carpenter on the necessity of moisture in heated houses, reprinted in last week's issue, and of Mr. C. E. Oldacre on a battery furnace system of heating a residence, reviewed elsewhere in this impression. The two papers were discussed together. Prof. Carpenter called attention to a statement in Mr. Loveland's study, forming the basis of his contribution, that with an inside temperature of 70 degrees and relative humidity of 30 per cent., considerable condensation on the windows took place, which fact Prof. Carpenter felt indicated that 30 per cent. was about the limit of the humidity allowable within a house. Mr. Oldacre believed that the water pan is really a detriment to a hot-air furnace system, regarding it as a means of collecting and emitting dust, besides being a cause for the burning out and cracking of furnace fire pots, due partly to the local obstruction it interposes to the proper flow of air. He stated that in a room of some 12,000 cubic feet, maintained at a temperature of 68 degrees, the relative humidity was raised only 5 per cent. by the evaporation of 8½ gallons a day.

Among the topics for discussion some reference was made to the dependance on records of temperature and humidity in figuring the requirements for district heating systems. Prof. Kinealy said that according to Mr. W. H. Bryan the temperature should be taken at about 30 degrees less than the average. As to the relative superiority of iron or steel pipes in heating systems, it was thought that steel pipes had not been used long enough to tell. One member said that wrought iron was much to be preferred in connection with furnace domes.

The following committee appointments were announced: Compulsory Legislation, C. B. J. Snyder; Henry Adams; W. C. Vrooman; T. J. Waters; B. H. Carpenter. Standards—J. H. Kinealy; H. D. Crane; James Mackay; J. J. Blackmore; Wm. G. Snow. Tests—R. C. Carpenter; Wm. Kent; George Mehring; A. A. Cary; B. F. Stangland. The attendance at the convention was the largest in its history by 40 or 50 per cent., and the society is to be congratulated on the quality of its work, especially during late years, as evidenced in the historical papers presented. At the dinner Wednesday night a substantial token of the appreciation of Mr. W. M. Mackay's work in behalf of the society was given to him by the members in the shape of a silver loving cup.

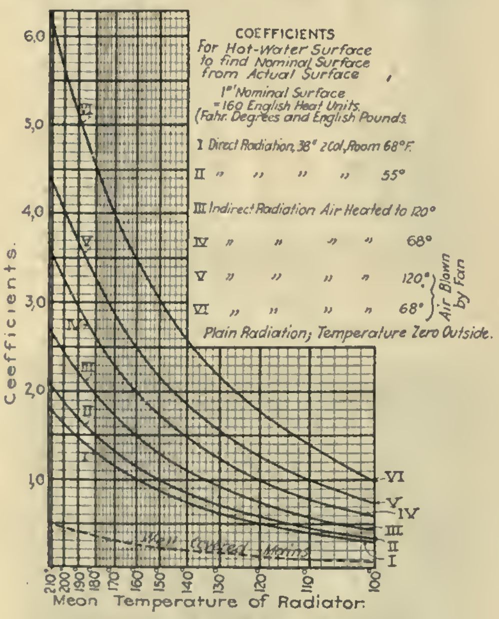


Chart for Hot-Water Radiation.

In connection with the paper presented by Capt. Reck, of Copenhagen, on the hot-water heating installation in an institution in that city, attention is called to the accompanying chart. The reading of the paper was referred to in last week's report. In his calculations for hot-water heating surface, he has adopted a standard of radiation or nominal square foot, which is a square foot of the ordinary pattern of two-column cast-iron radiator, 38 inches high, heated to a temperature of 160 degrees Fahrenheit, and placed as direct radiation in a room where the temperature is 68 degrees. He has found that a square foot of heating surface under these circumstances will emit nearly 160 British thermal units per hour. It will be noted that in this standard there is only one round number to be remembered, the temperature of the radiator and the number of heating units emitted, being 160 in each case.

The horizontal distances between each ten degrees at the bottom of the diagram are in inverse proportion to the heat emitted per square foot by the radiators. For instance, the distance between 130 and 120 degrees is double that between 170 and 160, because between 130 and 120 the radiator will, he stated, only emit one-half the heat that is emitted between 170 and 160. Again, if the water in a radiator of the type represented by curve I will go into the radiator at a temperature of 170 degrees and leave it at a temperature of 120, then, as the number 140 is found about at the mid point between 170 and 120, the mean temperature of the radiator is taken at 140° and its heat-emitting power will be about 0.73 of a nominal square foot, this number being the coefficient corresponding to the figure 140 for the curve in question. If 145 had been taken as the mean, 0.8 would have been the coefficient, but under this assumption the radiator would, according to the author, have been over-rated. The real mean temperature of a hot-water radiator must generally be somewhat lower than the arithmetical mean between the temperatures of inflow and outflow because the water cools more rapidly the higher its temperature.

The building, for which the heating installation was described, contains in five floors 100 two-room suites occupied mainly by aged people. All told, the contents of the room heated are nearly 300,000 cubic feet and they are heated by hot-water from two low-pressure steam boilers, each with 190 square feet of heating surface. The author stated that a temperature of 68 degrees can be maintained in the rooms with an outside temperature of 4 degrees below zero. The total of radiation amounts to 6,210 nominal square feet, equivalent to a transmission of 1,000,000 British thermal units per hour. The service is all supplied from a 3½-inch main rising from the reheater to the circulator and the expansion tank, in accordance with the system described in the issue of January 16. Each supply riser from the main carries ten to twelve radiators; most of these supply pipes are but ¾ inch in diameter and carry 300 or more nominal square feet of radiation or about 50,000 thermal units. As explanatory of the efficiency of the circulator the author stated that the attendant can get the radiators to a temperature of 180 degrees during the morning in less than an hour.

The Steam Consumption in a central station where both electric current and steam heating are supplied was discussed by Mr. Fred. B. Hofft, of the Merchants' Heat & Light Company, of Indianapolis, before the Indiana Engineering Society. A comparison was made first with the station run condensing and then when supplying exhaust for heating. Assuming the average electric load for 24 hours as 750 kilowatts, the engines were charged with consuming 18 pounds of steam per horse-power per hour, the condenser pumps with 40 horse-power at 80 pounds per horse-power hour; the cooling-tower fan with 20 horse-power in an electric motor at a steam value of 21 pounds per horse-power hour; the boiler-feed pumps with 15 horse-power at 80 pounds of steam per horse-power hour, or a total for 24 hours of 538,080 pounds. When the heating season occurs, with the average of 29 degrees Fahr. in the outside atmosphere, the use of the 200,000 square feet of radiation was said to require power-house pressure of 3½ pounds. The steam engine water rate was increased on this account to 26 pounds; the power for the boiler-feed pumps to 20 horse-power; a deep-well pump to furnish the additional water was charged with 5 electrical horse-power at 21 pounds of steam per horse-power hour; and 69,000 pounds of live steam was added to take care of 17,000 square feet of radiation, as the exhaust steam available would only supply 183,000 square feet; making a total of 729,720 pounds of steam in 24 hours when the plant is run non-condensing for general heating purposes. The heat consumed in feed-water heating was also considered. The difference between the heat represented in heating the former quantity of water from 90 to 210 degrees and that in heating the latter quantity from 50 to 210 degrees is 52,585,000 thermal units, which is equivalent to about 40,000 pounds of steam to be charged to the steam-heating period, making a total of 769,720, or a difference between the two cases of 231,640 pounds of steam for 24 hours.

Dr. Charles B. Dudley, President American Society for Testing Materials.

Charles B. Dudley was born at Oxford, Chenango County, N. Y., on July 14, 1842, of New England parentage. His early years were spent in attending the village school and later the academy, in the fall and winter, and in working on a farm in summer. In 1862 he enlisted as a private soldier in the 114th New York Volunteers, and spent the greater part of the next three years in the War of the Rebellion. He was in seven battles, and was finally severely wounded in the battle of Opequan Creek in September, 1864. The studious habits which may be said to have characterized Doctor Dudley's whole life, manifested themselves even during his army service. During one winter, while the army was in winter quarters at Franklin, he had his Latin grammar and reader sent to him, and devoted many hours of his camp leisure that winter to a study of that language. Returning from the war in 1865, he resumed his studies and graduated from Yale College in 1871. The next year was spent in newspaper work in New Haven, obtaining means to prosecute further studies, and to pay off obligations already incurred during the previous four years. In the fall of 1872, he entered the Sheffield Scientific School and graduated in 1874, with the degree of Ph.D., having spent the two years largely in chemical study. The next college year was spent as assistant to Dr. George F. Barker, Professor of Physics, at the University of Pennsylvania. In September, 1875, Dr. Dudley accepted the position of teacher of the sciences in Riverview Military Academy at Poughkeepsie, which position he retained only about a month, as on November 10 of the same year be was invited to accept the position of chemist of the Pennsylvania Railroad Company at Altoona, which position he still holds.

It will be noted that by far the largest portion of Dr. Dudley's active life has been spent at Altoona. When he began his work there, no railroad had a chemist as a regular employe, although many of them had occasional chemical work done. At that time the whole subject of the relation between scientific knowledge and its practical use by railroads was in a very chaotic state. There were very few, if any, specifications. The study of the valuable properties of metals and other materials used in construction may fairly be said to have been in its infancy. Engineers, both civil and mechanical, were largely dependent on the makers of commercial products for their knowledge as to the fitness of these products for the purpose desired; also there was an almost absolute absence of positive knowledge as to whether the thousand and one different articles used by railroads, either in construction or in the supplies that are consumed from day to day, were really what they professed to be. Furthermore, the study of materials from the standpoint of the service had only just begun. The study of materials from the standpoint of the maker, that is how to manufacture a given product successfully, had made much more progress; but whether that product so manufactured would give the best results in actual service was largely an unknown field. This distinction as to whether a product that can be successfully made from the manufacturing standpoint will give the best results in service, is believed to be a real and a valid one, and one that is far too often overlooked. Finally the question as to whether there is any room in a railroad organization for an employe or employes who should devote themselves to the study of materials from the standpoint of the consumer, who should investigate methods and practices, both of construction and operation, that happen to be in daily use, with the view of their improvement, and who should keep in touch with the progress of scientific knowledge, with the view of applying to railroad operation such portions as may be fit, was at that time an entirely unsolved problem. To Mr. Theo. N. Ely, formerly superintendent of motive power, and at present chief of motive power of the Pennsylvania Railroad Company, is due the credit for the conception and the belief that there was room in a railroad organization for an Experimental Department, devoted to the work outlined above, and the securing of a chemist was one of the important steps in the development of his idea.

Dr. Charles B. Dudley.

Of the work done by Dr. Dudley during the little over twenty-eight years of his life in Altoona, perhaps that which has attracted the most widespread public attention was the study of steel rails made in the early eighties. The thought which led to and actuated that study throughout was: "What does the actual service of the rails in the track teach us in regard to the kind or quality of steel that will give best service?" The plan of the investigation consisted in taking from the track about a hundred rails whose history was known, approximately one-half of which had given inferior service and the other half better service, and subject these rails to both physical test and chemical analysis. Microscopic examination of steel had not at that time come into prominence. The results of the study seemed to point very clearly to the conclusion that mild or softer steel gave not only a safer rail, but also one that suffered less loss of metal by wear than harder steel. The results were so contrary to the commonly received views on the subject, and were so antagonistic to the interests of the rail manufacturers, since harder steel rails are easier made, that they were received with incredulity. The studies were published in a series of papers in the "Proceedings" of the American Institute of Mining Engineers, and led to a most animated discussion. They were also published either in full or in copious abstract in various engineering and metallurgical papers in this country and England, and were translated and printed in a number of papers on the Continent of Europe. Although the main contention of this study of steel from the standpoint of the user has to this day not been generally accepted, it is perhaps not too much to say that the influence of this investigation on the metallurgical world has been both deep and lasting. By it the steel maker, as perhaps never before, was given a view of his product from the standpoint of the user, and in no uncertain manner was called upon to study steel not alone with an eye to output, but also with an eye to the subsequent demands which the service would make upon it. It may not be amiss to add that many metallurgists have expressed appreciation and acknowledgment of their indebtedness to this investigation for new ideas and stimulus in their study of steel.

Another and very important line of work in connection with the laboratory of the Pennsylvania Railroad at Altoona during these twenty-eight years has been the making of specifications for materials. This is perhaps the most exacting and time consuming work that has been undertaken. No specification has been made without a more or less exhaustive study of the conditions under which the material does its work, and these studies have not infrequently required two or three years or even longer, before a specification would be forthcoming. There are now some 48 specifications for different materials in use on the Pennsylvania Railroad, of which a part are purely physical, a part purely chemical, and a part jointly chemical and physical. Dr. Dudley can hardly be held responsible for all the specifications, but is responsible for the chemical part, and by way of consultation and suggestion, has helped with the others. The field for the making of specifications is far from being completely worked over as yet, and new ones are continually being made, as fast as information can be accumulated. But this making of specifications is only half the problem. The specifications tell what is wanted, but is the material wanted actually furnished? To answer this question involves tests of samples from shipments, as they are received, and it is a part of the scheme of the Pennsylvania Railroad Company, in connection with its Experimental and Testing Departments, to allow no bill to be paid until the material covered by it has either been inspected by a competent person, or been tested either physically or chemically, as the case may be. This scheme so far as the chemical part is concerned involves a thoroughly equipped Laboratory, with a total force at the present time of eighteen persons, of whom twelve are regularly educated chemists. One of the force is likewise a regularly graduated bacteriologist, who has studied in Europe and who is occupied in the examination of water supplies, experiments on disinfection, and in making bacteriological tests for diagnosis in connection with the Relief Fund. The total number of tests and chemical determinations made in the Laboratory in connection with shipments of materials, amounts to about 60,000 per year.

In this connection, several years ago when the number of specifications had reached some thirty or more, it was thought that if the reasons why, for the various requirements were put in print, it might serve some valuable purpose in making the specifications better understood by those desiring to furnish materials. This led to a series of articles, twenty-five in number, in the "American Engineer and Railroad Journal," under the title of "Chemistry Applied to Railroads." Also under the same title, a second series of thirty-one articles was published in the same journal, embracing the chemical methods involved in the examination of commercial products bought under specifications. These articles have attracted considerable attention, and although the series was started more than fourteen years ago, it is even now not rare for copies of the various papers to be asked for. It is the intention ultimately to bring the two series up to date, and issue them in book form.

As illustrating the influence of an Experimental Department on the constructions and practices actually in daily use on railroads, the studies under the supervision of the Laboratory on the ventilation of passenger cars may be mentioned. These studies embraced a period of some three or four years, and resulted in the development of what is believed to be a very satisfactory system of car ventilation. When the studies were first undertaken, the ordinary passenger car either had no ventilation at all or at the best supplied to the passengers from six to ten thousand cubic feet of fresh air per hour. With the system as developed, sixty thousand cubic feet per hour are supplied, or one thousand cubic feet per passenger, and this air is warmed to seventy degrees in the most severe weather.

Space does not suffice to describe special investigations or further studies leading to modifications of practices, but it may not be amiss to mention that these investigations and studies embrace such subjects as car lighting, steam heating of cars, studies on disinfectants, resulting in the manufacture of a standard disinfectant by the Laboratory, studies on cast-iron for car wheels, and for other important uses, studies on paints, studies and long-continued tests on bearing metals, analyses of coals, examination of water supplies both for boiler use and for drinking, and quite an exhaustive study of explosives, resulting in the formulation of rules governing the transportation of these and other hazardous materials.

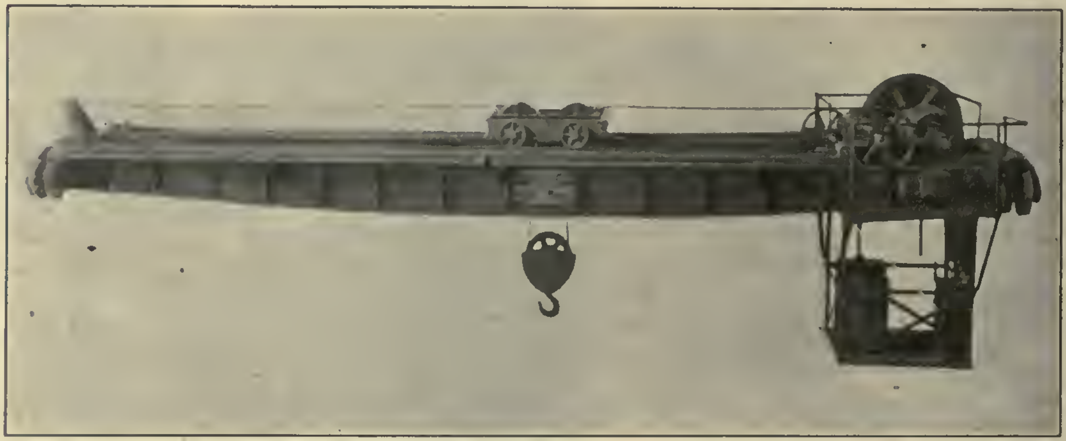
Dr. Dudley has twice been abroad on business for the company, once in 1886 to study oil-burning on locomotives in Russia, and again in 1900 as delegate to the International Railway Congress in Paris. He has been vice-president of the American Institute of Mining Engineers and twice president of the American Chemical Society. He is at present president of the American Society for Testing Materials. He is a member of the English, French and German chemical societies, of the Iron and Steel Institute of Great Britain, and of the Verein Deutscher Eisenhuttenleute. He is also a member of the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers of this country. He is a member of the Union League of Philadelphia, the Cosmos Club of Washington, and of the Engineers' Club of New York.

Apart from professional work, Dr. Dudley spends no small amount of time in connection with the Altoona Mechanics' Library, in which he is much interested. Under his supervision and with the fostering aid of the Pennsylvania Railroad Company, this Library, which contains now over 35,000 volumes, is accumulating a collection of technical books, and bound scientific periodicals, which many a more pretentious library might be proud to own.

A Special Pipe Foundry Crane.

The Montreal Pipe Foundry Company has recently received from the Northern Engineering Works, of Detroit, the special crane shown in the accompanying illustration. It was designed for work over a pit in a pipe foundry, a location particularly trying for an electric crane of the usual construction, with the hoisting mechanism on the trolley. In this new type tho hoisting and traversing apparatus, with the motors driving it, is located at one end of the bridge away from the dust and heat of the pouring pit.

The design illustrated also permits the load to be lowered rapidly when desired, under the control of a large band brake operated by the man in the cab, a particularly desirable feature in handling core barrels and flasks in pipe foundries. A lowering brake operated by the hoisting motor is also provided, and there is a powerful electric solenoid brake to stop the motor when the current is off. This last brake has sufficient power to hold the full load independently of the others.



Special Crane in the Works of the Montreal Pipe Foundry Company.

The construction has been made of the heaviest character in order to meet the severe conditions of pipe foundry service. The principal gears and pinions are of steel with cut teeth, the truck and trolley wheels are also of steel, and all drums and sheaves have unusually large diameters. Special attention was paid to selecting motors of ample power for the work and to protecting them from the dust.

The Hennepin Canal.

A paper read before the Illinois Society of Engineers and Surveyors.

This canal, officially known as the Illinois and Mississippi Canal, is intended to be a link in a waterway from Lake Michigan at Chicago to a point on the Mississippi River at the mouth of Rock River four miles below the city of Rock Island, Ill. It is being built by the United States, and is under the general charge of Captain C. S. Riche, Corps of Engineers, U. S. Army. The feeder line and western section are under the local charge of L. L. Wheeler, U. S. assistant engineer, and the eastern section is under the local charge of J. C. Long, U. S. assistant engineer.

The canal begins at the great bend of the Illinois River, 1¾ miles above the town of Hennepin, Ill., proceeds thence 62 miles via Bureau Creek valley and over the summit to Rock River at the mouth of Green River, near Colona, Ill., thence by slack water down Rock River 8½ miles, thence by canal around the lower rapids of Rock River 4½ miles to the Mississippi River, making a total distance from the Illinois to the Mississippi River of 75 miles, and 193¼ miles from Chicago to the Mississippi River.

The canal is 80 feet wide at the water surface, 7 feet deep, with lock chambers 2,170 feet in length and 35 feet in width, capable of passing barges of 600 tons burden.

The summit level is about 11 miles in length, and the distance from its eastern end to the Illinois River is 18.4 miles, with a difference of level of 196.4 feet, which is overcome by 21 locks. The distance from the western end of the summit level to the Mississippi River is 45.6 miles and the difference in level is 100 feet, overcome by 11 locks. The summit level is fed by a navigable feeder, which is of the same size as the main canal and 29 miles long, beginning at Sterling, Ill., where water for the feeder is obtained by damming Rock River.

A lock is located at the head of the feeder as a guard lock and also to enable boats to pass from the feeder into the river and back at different stages of the water in the river. The dam located here also creates slack water in Rock River, enabling boats to navigate it as far as Dixon, Ill., giving to that place as well as to Sterling water connection with the canal.

Work was begun on the canal in July, 1892, on the Mississippi near the mouth of Rock River, and the 4½ miles of canal around the lower rapids of Rock River, with slack water in the river above, were completed and formally opened to navigation on April 17, 1895, and since that time have been largely used by coal boats from the mines on Rock River. The feeder and the rest of the canal are still under construction and are about 75 per cent. completed. The original estimate of the cost of the whole improvement was in round numbers $7,000,000, but owing to various causes the work will cost something more.

The masonry in the large number of structures, such as locks, arch culverts, abutments and piers of railway, highway and aqueduct bridges, has all been constructed of concrete and has demonstrated its superiority over ordinary stone masonry in stability, economy of construction and rapidity of execution. The walls of 21 locks on the eastern section, containing on the average 2,500 cubic yards of concrete masonry each, were built in an average of ten days time each, working three shifts of 8 hours per day.

I stated before that this canal was a link in a waterway from Chicago to the Mississippi River near Rock Island. Another link is the Illinois and Michigan canal, belonging to the

State of Illinois, extending from Chicago River about 5 miles above its mouth to La Salle. It is 96 miles long, 60 feet wide at the water surface, 36 feet wide at the bottom in earth excavation, and 48 feet in rock, with locks 110 feet long and 18 feet wide, having 6 feet of water over mitre sills. It is navigable by boats 97 feet long, 17 feet 6 inches wide and 5 feet draft. It will be seen from these dimensions that the Hennepin canal cannot reach its usefulness until the State canal is enlarged, which I suppose will be done by the United States after the Hennepin canal is complete two years hence, by agreement with the State of Illinois.

Concrete Building Blocks.

Used a few years ago principally in large masses in foundations and similar parts of structures in which occasional departures from uniformity of quality were not serious, the application of hydraulic cements to building construction has advanced within recent years to a very considerable degree of refinement, demanding careful and reliable workmanship and intelligent design and supervision. This development has proceeded along two distinct paths, one leading to the great variety of systems of concrete-steel or reinforced concrete construction, and the other to the numerous types of concrete blocks. In the concrete-steel systems the structures are usually formed wholly in place in wooden moulds and are more or less monolithic; but by the latter method blocks of a variety of shapes are made in moulds, with or without pressure, and allowed to harden before being placed in the building similarly to bricks or stones. Each method of construction has its own field, but these overlap somewhat.

Among the more recently perfected systems of concrete building blocks is one in which solid blocks of ingeniously devised shapes are used for building hollow well-bonded walls. Excepting window and door jambs and sills, and similar pieces, no block extends through the wall. Each regular wall block consists of a face slab and three short webs, projecting from each end and the middle of the slab part way through the wall. These webs are of different lengths, so proportioned as to break joints well and secure a strong bond. To increase the thickness of the wall these webs are increased in length. This shape permits the blocks to be formed without cores in steel-lined wooden moulds and subjected immediately to pressures of 35 to 40 tons, by means of a press, thus thoroughly compacting the concrete so as to make it very dense and allow the immediate removal of the moulds, excepting the part against which the face of the block is formed. Wet concrete composed of one part Portland cement and six to eight parts sand and gravel or crushed stone, of one-inch maximum size, is shoveled into the mould, set face side up, and struck off level, when the face plate is put on and the mould sent to press. If a special surface is to be given the block, the concrete is removed to a depth of one-quarter inch below the top of the mould and the face mortar put in. Rock-face, chiseled stone or other finishes, of any desired color, can be given to the blocks by the use of proper face plates. After the removal of the moulds the blocks are left on the face plates for 36 to 48 hours and stored on racks; then the blocks are taken off the face plates and stacked in the storehouse or yard and sprinkled frequently until thoroughly hardened. The blocks are not exposed to freezing temperatures until at least five days old.

Each block is made in one solid piece, but two blocks are required for the thickness of the wall. The blocks are set to break joints both through the wall and vertically, thus securing a strong bond while forming continuous hollow spaces which constitute about 52 per cent. of the volume of the wall and greatly reduce the weight. Blocks are usually made 12 inches high and 24 or 32 inches long, of a size to be handled easily by one man. Besides being fireproof and impervious to heat and vermin, it is claimed that walls of this construction are especially proof against moisture and soot owing to the density secured by the great pressure. By using suitable moulds blocks of any special shapes can be made for architectural features. The cost is very much less than that of brick or stone and in many cases closely approximates that of good frame construction. Buildings of this type have now stood the test of several years. The illustration shows the 66½x200-foot three-story office building recently erected for the National Electric Company, of Milwaukee, Wis., the 12-inch outside walls, the partitions and the ornamental features being wholly of this type of blocks.

An Office Building of Pressed Concrete Blocks.

For manufacturing the blocks, power and hand presses of large capacity and standard moulds have been designed. The hollow spaces, or flues, in the walls can be used for ventilation purposes, and as ducts for pipes and wires. If at any place a solid pier be required, it is only necessary to fill the spaces with concrete. Cracks due to temperature changes and to the setting of the cement are avoided by the use of blocks. The system is controlled by the American Hydraulic Stone Company, of Denver, Colo.

THE BOILER PLANT of the Manchester, Eng., Electricity Works contains eleven Babcock & Wilcox boilers, each of 5,140 square feet heating surface, capable of evaporating 18,000 pounds hourly at 160 pounds pressure. They have superheaters raising the steam temperature about 90 degrees Fahr.

High Pressure Gas Distribution by Gas Power.

A gas power installation of unusual interest is now under construction by the Laclede Gas Light Company, of St. Louis, Mo. The system has for its object the more efficient distribution of gas over larger areas than may be economically covered by the simple method of running large low pressure mains from centrally located gas works. The system under construction is intended to supply the entire city of St. Louis, embracing an area of approximately 65 square miles.

It is evident that in order to serve the outlying districts of such an area, one of three methods must be employed: First, a large low-pressure feeder from the central holder to the center of the district to be covered; second, medium-size feeders from the main holder to the auxiliary holder in the center of the district; and third, a high-pressure feeder to the distributing center, using pressure-reducing valves at this point for obtaining proper pressure upon the service lines. The enormous expense for construction entailed by the first two methods has practically prohibited their use in St. Louis, and the high-pressure system is being installed. With this system, the size of feeder pipes is greatly reduced and the necessity of auxiliary district holders is entirely done away with.

For serving suburban communities, lying far beyond the city limits, this method may be extended and the pressure of the gas raised to any desirable extent for transmission through small pipes, this pressure being reduced at the suburban distribution center by pressure regulators, as in the medium-pressure system above mentioned. This gas distribution system as a whole presents a striking similarity to the ordinary alternating current distribution system with primary high-pressure feeders, reducing transformers and secondary low-pressure distributing lines, the theory of high-pressure transmission being in both cases identical.

The pressures to be employed in the system under construction at St. Louis are approximately 5 pounds per square inch for the medium-pressure feeders and from 20 to 80 pounds per square inch for the high-pressure suburban feeders. On account of the use of cast-iron mains, the 5 pound limit was chosen for the medium-pressure system, but for the high-pressure system iron pipe with screwed fittings will be used. With this construction any desirable pressure may be carried with entire safety and the radius of distribution extended to 100 miles if necessary.

In the medium-pressure system, the gas pressure will be supplied by a blowing unit, consisting of a Connersville blower direct-driven by a 300 horse-power Westinghouse horizontal gas engine. The engine is of the type recently brought out for high-power work and embodies a number of new features which distinguish the construction of the horizontal type. It has two double-acting cylinders 16½ inches in diameter, and a 24-inch stroke, the cylinders being arranged in tandem with a single crank. The engine uses for fuel the ordinary illuminating gas such as is distributed to customers, and draws its supply directly from the gas main. The engine operates on the four-stroke cycle and the method of governing secures a constant quality of explosive mixture at all loads, the quantity of the mixture being proportioned by the governor to the load on the engine. Electric ignition is employed.

In this particular installation the engine is controlled by an automatic pressure governor which adjusts the speed of the unit in direct proportion to the demand for gas, the speed thus being in inverse proportion to the pressure in the distribution main. So sensitive is this control that the variation in pressure will not exceed 8 ounces for a 50 per cent. range in gas output. The regular centrifugal speed governor is, however, also used in order to prevent, under any conditions, the engine running at excessive speed.

The St. Louis installation is one of the first of its kind in the illuminating gas field and presents many interesting features. The system has, however, long been in successful use in the distribution of natural gas over large districts adjacent to natural gas fields. The St. Louis work is in charge of Mr. W. A. Baehr, engineer of the Laclede Gas Light Company.

The Municipal Testing Laboratory of the City of Indianapolis.

A paper by Walter Buehler, Assistant Engineer, Indianapolis, read at the annual meeting of the Indiana Engineering Society.

The municipal testing laboratory of Indianapolis came into existence in the fall of 1902. Prior to that time there was absolutely no systematic testing of any of the material used in work done under the supervision of the city civil engineer. There were tests made of cement, asphalt and oils, but as no record was kept of such tests, they are, of course, valueless at this time. First, apparatus for the physical and chemical examination of cement was purchased and later apparatus for the chemical examination of creosote oils, asphalt, and for the examination of the candle power of the artificial gas. In making tests since the laboratory has been in existence, the writer has had in mind the importance of a systematic method of keeping the records, and in the testing of cement, the value of uniformity of manipulation.

The specifications adopted by the Board of Public Works are taken as a basis for the acceptance or rejection of the cement. The samples of cement are taken from the work in strong paper bags, each having a number which corresponds to one on a tag filled out by the inspector collecting the sample. This tag with all necessary data pertaining to the sample, such as: "Date when collected," "Where obtained," meaning the exact location on any street; "The agent for the cement," "Contractor doing the work," and "The name of the man collecting the sample," is placed on file in the laboratory, and afterwards copied with the results of the tests into a book printed expressly for that purpose.

The following tests were made of each sample: Fineness, tensile strength, time of initial and final set, soundness, specific gravity, and, when thought necessary, a chemical examination. In determining the fineness, one hundred grams of cement are passed successively through a one hundred, an eighty, and a fifty-mesh sieve. The sieve is shaken by hand for ten minutes; the screenings are then weighed, and the sieve is shaken again for one minute and the second screenings weighed; if this weight be more than one-tenth of a gram, the sieve is shaken again, and so on till after shaking one minute, less than one-tenth of a gram passes through. The combined weight of the screenings is taken as the amount passing through that particular sieve.

Having first determined the proper percentage of water for the neat tests, by adding a small portion of water from a graduate till a stiff plastic paste is obtained which will, when moulded into a ball, withstand a fall of 20 inches without cracking, twenty ounces of the cement are weighed out and placed upon the mixing table, into which the proper percentage of clean water is poured and the whole thoroughly kneaded to the proper consistency with the hands. It is then put into the moulds in three layers, each layer rammed thirty times with a brass rod ¾ inch in diameter weighing one pound. The briquettes are then numbered and covered with a damp cloth for twenty-four hours, at the end of which time they are removed from the molds and placed on edge in galvanized-iron pans, submerged in a large tank of constantly changing water. Briquettes are broken at regular periods of twenty-four hours, seven days, twenty-eight days and two months. The sand used in three to one and two to one tests is Ottawa sea sand passing a twenty sieve and retained on a thirty.

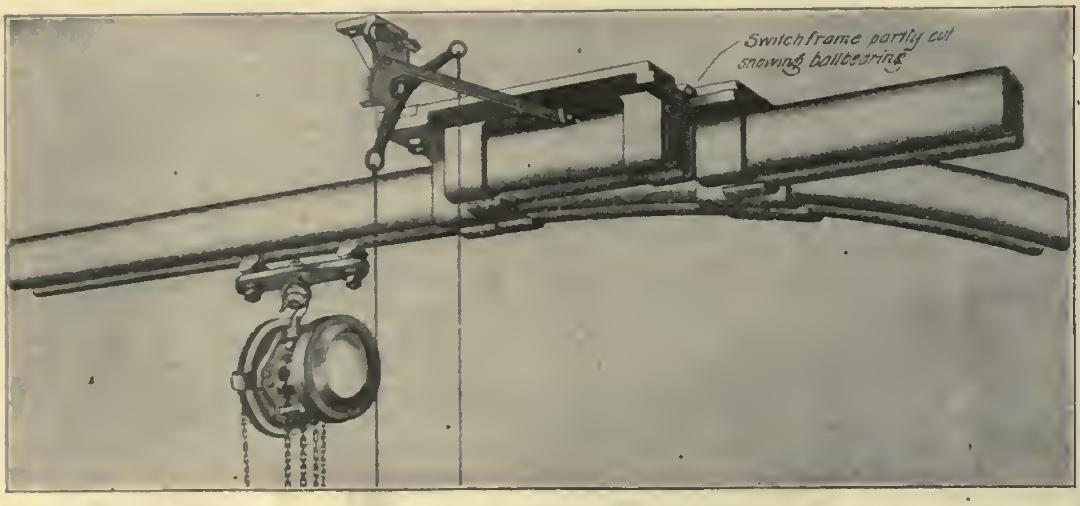
For determining the time of set, the laboratory is provided with Gilmore needles. The 1/12-inch wire weighted to a quarter of a pound is used for the initial set, the 1/24-inch needle weighted to one pound is used for the final set. In testing for soundness, the hot test, the air test and the water test are used. In the hot test a pat ½ inch thick and 3 inches in diameter is exposed to steam for six hours, and hot water for eighteen hours. When practical this hot water test is made at the end of the twenty-eight day test. The air and water test are made on pats which are exposed to air and water for twenty-eight days and studied at regular intervals. The specific gravity is determined by means of a Candelot specific gravity box. All cements are from time to time subjected to a chemical analysis, for which purpose the laboratory has been equipped in every detail. Mr. James B. Nelson gave the laboratory its start by expending $400 for apparatus, and Mr. B. J. T. Jeup, when appointed city engineer upon Mr. Nelson's resignation, furthered the equipment of the laboratory.

A Ball-Bearing Overhead Track Switch.

The switches of overhead tracks in industrial establishments are subject to such severe usage in case they do not work easily that the New Jersey Foundry & Machine Company, New York, has supplied all such switches with ball bearings. The type of bearing used with I-beams and hollow tracks is shown in the accompanying illustration, while a different pattern is employed with flat or bar track.

The switch consists of a frame bolted to the overhead supports and a steel plate moving within the frame. This plate carries the sections of track forming the switch and is not only supported by hardened steel balls but is guided by them. The balls run in V-shaped grooves in the frame below and at the ends of the plate. The latter is connected by a rod with a controller, which is moved by ropes from the ends of a rocking arm. A simple device is provided to hold the plate in any of the desired switch positions. The vertical distance required for the switch above the top of the track is only 2 inches.

For places where the intersections of the tracks is too sharp for such switches, a ball-bearing turntable has been designed along somewhat similar lines.

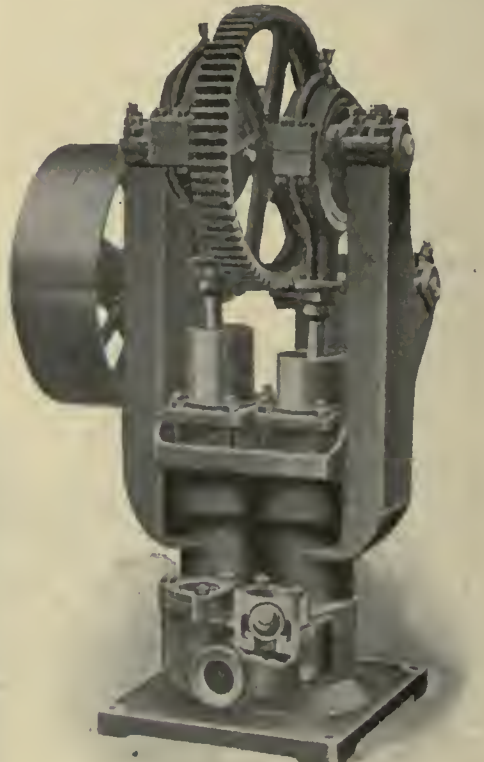


A Ball-Bearing Overhead Track Switch.

The Davis Duplex Stuff Pumps.

The duplex power pumps made by I. B. Davis & Son, Hartford, Conn., has recently been modified, as shown in the illustration, to enable them to run successfully in pulp mills, chemical works and similar industrial establishments where the fluid to be handled will clog or wear ordinary pumps. The valves are hollow composition balls made by special machinery, and are so well balanced as to turn constantly and thus prevent wear in any one spot. The plungers are also made of composition and the cylinders and glands are lined with it, although other materials can be substituted for composition if desired.

In its general features the pump retains the characteristics of the makers' standard duplex type. The uprights are of the box pattern, the plungers are outside packed, and the shafts run



The Davis Duplex Pump.

in adjustable babbitted boxes. The gears are molded from machine-cut iron patterns. There is a deep pan around the glands, with a pipe hole suitably tapped to drain it. The pumps are made in five sizes, with capacities of 125 to 13,500 gallons an hour.

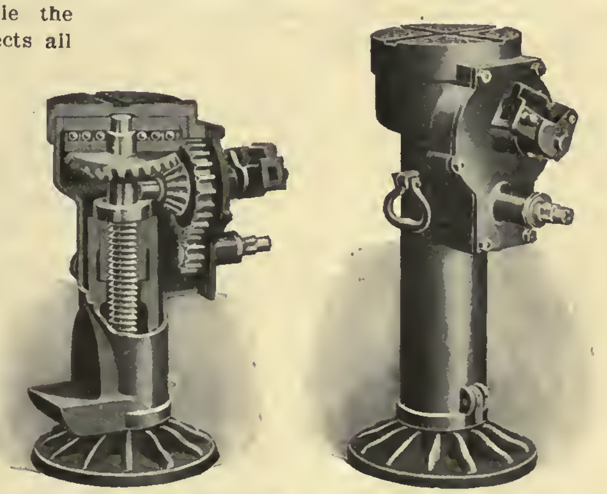
A Small Air Drill.

About a year ago the Rand Drill Company brought out the small piston air drill shown in the accompanying cut. It embodied the general features of design of the other Imperial tools and would drill a ⅞-inch hole when supplied with 18 cubic feet of air per minute. A few weeks ago a number of important improvements were made in the machine, increasing its weight about 9 pounds by raising its capacity to a hole 1¼ inches in diameter.

A New Type of Ball-Bearing Jack for Heavy Service.

A new type of ball-bearing jack has been brought out by Mr. A. O. Norton, 286 Congress Street, Boston, Mass., which is designed for specially heavy service and has a capacity of 70 tons. This jack is double geared, and is provided with a foot lift. The friction on the end of the screw is reduced 40 per cent. by means of hardened steel balls running between polished steel plates of the same degree of hardness, which prevents cutting. The screw runs through a phosphor-bronze nut into an oil chamber, and is self-lubricating, while the outer shell or sleeve of the jack protects all the working parts from grit and rust. A large shipment of these jacks has just been made to Holland.

A Small Air Drill.



Ball-Bearing Jack for Heavy Service.

Letters to the Editor.

THE UNION ENGINEERING BUILDING.

Sir: I send you herewith copy of letter sent by me to the Board of Direction of the American Society of Civil Engineers, June 19, 1903, also diagram illustrating the intent of the letter.

Considering the action of the Society taken January 20, 1904, it would appear that no consideration whatever has been given by the societies to an arrangement of the new building which would preserve the major part of the ownership and affairs of each as intact as today. If such consideration has been given, it has not been made public.

It does not seem that the fundamental ideas necessary for the acceptance of this gift have been worked out to proper termination by method suggested. It would be entirely feasible to participate in an honorable way in the gift proposed by Mr. Carnegie without in any manner injuring the individual or future progress of any of the societies or the Engineers' Club. It is to be hoped before this subject is dropped by adverse vote, or even if it is dropped by adverse vote, that it may receive further consideration and be brought to a reasonable conclusion.

If you see your way clear, I would be glad to have you publish this correspondence.

Yours very truly, GEO. B. FRANCIS.

New York, Jan. 21, 1904.

Mr. Francis' letter to the Board of Directors reads as follows:

"The following suggestions were not made by the undersigned at the annual convention of the society in Ashville, for the reason that it seemed better to place them before the Board of Direction in the form of a letter, than to take up the time of the convention.

"Regarding the proposed engineering building, it would appear to me that the Am. Soc. C. E. should take such course as will maintain every interest of the society as nearly intact as possible, namely, its ownership of land, buildings, library, etc. To this end it is suggested that it is wholly feasible to join in a general engineering building structure (providing land and also acquiescence on the part of Mr. Carnegie may be obtained), without in any great degree changing from definite ownership as seems proposed. This can be done first, by having each of the societies own the fee in the land which it is proposed they shall occupy; second, having a general building, divided vertically and so designed that each part devoted to each society may also be its property upon the land which it owns, and yet be a part of an architectural whole.

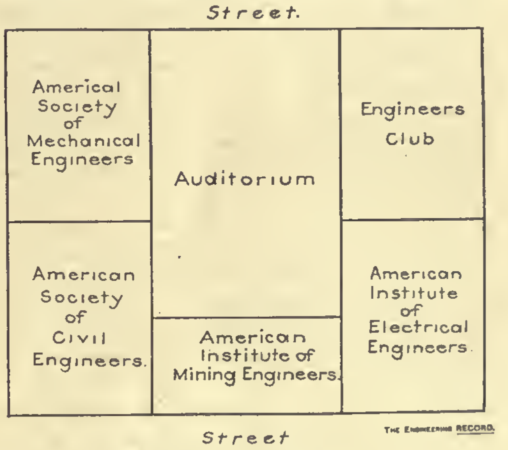
"It may not be possible for this to be done on the piece of land already selected, but it does not seem to me the project is so far advanced that a new piece of land for such ownership cannot be obtained, upon which such a structure can be properly designed.

"The joint ownership and operation can then be restricted to a proper arrangement of rooms for auditorium purposes and for heating and perhaps lighting. Such a scheme properly carried out would bring the societies together into an engineering building, give all the benefits of contact of one society with another and leave each society wholly free as regards the major part of its property and the management of the same.

"In this connection the action of one society could not seriously affect or involve the affairs of another society. In such a building as a whole, the division walls could be so arranged that all private purposes, aside from joint auditorium and heating, would be carried out in as individual a manner as at present. This would also permit of one society owning more property than another, if it so chose to do: for instance, the Am. Soc. C. E. might own a larger ground area and building than the Society of Mining Engineers. Neither would this involve the affairs of technical societies with those of the Engineers' Club, while they could all be together in one locality as a joint engineering headquarters, which appears to be the meaning and intent of Mr. Carnegie's gift."

Sir:—We had a talk last June regarding the Carnegie gift to Engineering. I am in hopes that the views which you expressed at that time were based upon conditions which have been removed. The gentlemen representing the other societies have met with Mr. Noble and his colleagues from the American Society of Civil Engineers from time to time and have earnestly endeavored to so shape the plans both of building and of organization in such a way as to remove the objections urged by some of the members of the A. S. C. E. Mr. Noble has assured us that so far as he can see every point has been satisfactorily covered and he did not see anything further that our committee could do to put the matter in better shape. I have thought it out of my province to enter into the affairs of the A. S. C. E. and have carefully refrained from "electioneering." The turn which matters have just taken, however, leads me to write this letter to you.

The magnificent postscript to Mr. Carnegie's original letter which he added on Monday of this week makes one and one-half million dollars available for the present enterprise provided all of the societies join together and cooperate. The vote of a member of the A. S. C. E. is therefore no longer one which concerns his society alone, but is one which concerns every American engineer. Not only does it concern the individual engineer, but it has a much higher significance. I am just now full of large ideals. I have just read Mr. George S. Morison's book "The New Epoch," in which the advent of the engineer is shown to have introduced a new epoch in the advance of civilization comparable to that of the introduction of iron or of a written language. A gentleman, not a member of my own society, who is deeply interested in the matter writes me as follows:


Street.
Americal Society of Mechanical Engineers
Auditorium
Engineers Club
American Society of Civil Engineers.
American Institute of Mining Engineers.
American Institute of Electrical Engineers.
Street
THE ENGINEERING RECORD.

Mr. Francis's Diagram.

"A failure to obtain union would be serious indeed. Instead of giving the world an example of American breadth, brotherhood, union of science in every department—co-operating and hence strengthening our country in its triumphal march of industrialism versus militarism—we should reveal the very reverse, a narrow exclusive standing part. The charm would be gone."

I realize that it is difficult for me to fully appreciate the other side when I am so strongly devoted to this great enterprise. I trust that the conditions have so changed and the broader aspect of the matter is now brought into such prominence that there should be from the engineering press no longer even a single discordant note.

Very sincerely yours, Chas. F. Scott.
Pittsburg, Jan. 22.

Crusher Screenings for Concrete.

Sir: From time to time recently I have noticed in your paper and others that the question of using crusher dust instead of sand for masonry was receiving considerable attention. During recent years it has been difficult to get a satisfactory sand here and the writer has substituted crusher dust for concrete work. Sand is still used on brick work for the reason that up to the present time dust has not been put upon the market in suitable condition for use in laying brick.

Before making the change mentioned a few tests were made to ascertain just what might be expected from the crushed stone dust in comparison with the sand and a copy of these tests is inclosed. This does not pretend to be an exhaustive study of the subject but simply a very superficial examination of one particular sample of stone dust, sand and cement. There are, however, several interesting things shown by the few tests made and if they should be verified they would show why certain results are obtained and perhaps clear up the question of the use of crusher dust.

In the first place from the mechanical analysis it will be seen that the sand is much more uniform than the dust, their coefficients of uniformity being 3.1 and 16.7 respectively. As a rule the most uneven material gave the highest tests and the decrease in strength was gradual in the samples of dust as the material became more uniform. It is also noticeable that the sand and dust (passing the No. 20 and held on No. 40) gave fairly comparable results at the end of one week with those of the mixtures of different sizes of dust, but that at the end of the first month the mixed sizes were far ahead.

It should be noted that the dust passing the No. 60 screen was not too fine for practical use in brick work and plastering, although it contained much very fine dust.

In these tests not less than two nor more than three briquettes were broken for each test reported.

From the last two columns in the table it would appear that there was no particular virtue in the crushed stone which the sand did not have, but rather that the difference in the various tests was due almost wholly to the coefficient of uniformity.

Yours truly, Harrison P. Eddy.
Worcester, Jan. 21.

Who is Slurring the Am. Soc. C. E.?

Sir:—In the closing paragraphs of a leading article in The Engineering Record of January 23, entitled "The Meeting of the American Society of Civil Engineers," was it your intention to put a greater slur upon the Society than any that has been published elsewhere? The drift of your remarks I understand to be that "a building with suitable accommodations for all the constituent societies can be planned on the land selected," that "the deliberations of the society were continued in the slow, careful manner which Mr. Carnegie himself has approved" and which "has been warmly commended by many of the leading men of the other organizations," but that "the American Society of Civil Engineers will not enter the project." Though I question the last statement and have reason for questioning it, I pass over that to complain of your imputation of a motive to the society. You do not say that you expect the society to be guided by its deliberate and careful consideration (which I expect, whether its decision be one way or the other). What you imply is that the society is going to act out of spite, because "various journals have called the members of the society names," and as a "result" of "unwarranted, unjust criticisms," although "the members of the electrical, mining and mechanical societies have no such opinions."

Yours truly, Fred. Brooks.
Boston, Jan. 24.

[The above letter, the heading of which was selected by the writer, is fairly typical of a class of communications on the subject of the union engineering building. They pretend to see in any statement contrary to their opinions a vindictiveness or personal feeling which does not exist. The Engineering Record has counseled two things in this matter. One was mature consideration on the part of the American Society of Civil Engineers before reaching a decision, and that has been the course followed, although a few members have urged haste. The second recommendation was the separation of the Engineers' Club, a local social organization, from the four national engineering societies. That has been done, although it was vigorously opposed by the same few members. The Engineering Record feels that the course it took, contrary to that of every other class journal, has been proved correct. The American Society of Civil Engineers is in such a peculiar position that some of its most influential members, also connected with other organizations mentioned in Mr. Carnegie's letter, are using all their influence to keep the society out of the project. Some of these men have been officers in other organizations concerned. It is no slur on the American Society of Civil Engineers to state that these men differ from Mr. Brooks and a comparatively few others, nor is it any slur on the society to state that the many abusive comments published against those who advised mature consideration of the project have led a great many members of the American Society of Civil Engineers to see no attraction in any association with people whom the authors of such ill-tempered criticisms pretend to represent. This project is not the first that has been injured by the unbalanced zeal of some of its advocates.]

Comparative Tests of Mortar Briquettes Made Up of Portland Cement with Sand and with Crusher Dust.

	Per Cent. Passing Sieve.							
Sieve	No. 4	No. 6	No. 10	No. 20	No. 40	No. 60	No. 100	Passing No. 20, held back on No. 40
Size in mm.	(4.470)	(2.420)	(1.345)	(.635)	(.295)	(.192)	(.106)	
Sand	100.00	99.28	95.17	82.35	38.03	23 33	5.83	44.33
Dust	98.79	82.41	56.20	36.06	23.01	20.68	12.58	13.05

Tensile Strength Tests.

			Crushed Stone Dust.						
Time in air.	Time in water.	Proportions of mixture.	Run of crusher.	Passing sieve No. 10.	Passing sieve No. 20.	Passing sieve No. 40.	Passing sieve No. 60.	Dust held back on No. 40 passing through No. 20.	Common sand.
16 h.	6 h.	2½-1	117	122	107	79	60	88	70
1 d.	1 d.	2½-1	192	164	142	103	104	151	112
1 d.	2 d.	2½-1	250	201	161	142	121	159	141
1 d.	3 d.	2½-1	281	263	193	211	197	213	143
1 d.	4 d.	2½-1	293	193	238	202	186	226	153
1 d.	5 d.	2½-1	298	289	187	222	166	216	201
1 d.	6 d.	2½-1	299	278	193	227	217	249	224
1 d.	27 d.	2½-1	467	493	392	346	384	293	278

Sand as coarse as can be obtained in market. Cobbles screened out.

The Asbestos Curtain at the Iroquois Theatre

Sir: The writer has just returned from Chicago, after making a careful examination of the stage at the Iroquois Theatre, and to dispel any doubts that may be entertained as to the fire-proof qualities of the asbestos curtain, which testimony before Coroner Traeger seems conclusively to show was not used, we beg to submit the following facts:

First. Large portions of the asbestos curtain were found lying across the stage extending from one side of the proscenium arch to the other. The curtain apparently hung suspended above the arch and remained there until the fire burned away its supports, when it dropped to the stage, falling almost underneath the point from which it was hung. It must have been heated to a very high temperature by the intense fire surrounding it, and as soon as it fell was deluged by water from the firemen's hose. This is shown conclusively from the fact that in order to recover portions of it, they had to be chopped out with a hatchet, as the whole mass was frozen solid. Even after such usage as this, which no mineral would stand without disintegration, the pieces of curtain imbedded part way through the mass, and which were protected while hot to some extent from the water, were found to have retained their tensile strength and pliability. This is an excellent proof of the quality and strength of the asbestos curtain. We have in our possession a piece of the asbestos curtain, brought back by the writer, which may be seen at our office in substantiation of our claims.

Second. The inquest has shown that when the fire started in the drops, the asbestos curtain was called for, but apparently a mistake was made and the act drop was lowered instead. This, of course, burned, and the public, through statements credited to prominent persons, was led to believe that the asbestos curtain burned. Superficial examinations show that pieces of burlap-backed screen had been picked up, and, as they were painted with a mineral composition, hasty conclusions were drawn that these were pieces of the asbestos curtain. Meanwhile, the asbestos curtain was covered with debris and was being trampled under foot by the curious.

Three. There is little doubt that had the asbestos curtain been lowered, it would have acted as a damper, preventing the great draught of air from the auditorium from forcing the flames up, through and among the drops, and would have thus temporarily held back and partially checked their spread. The audience, no doubt, had faith in the asbestos curtain, for testimony shows that they kept their seats until they saw a burning curtain lowered; and the awful panic followed. There is no doubt but that the sight of what they supposed was the asbestos curtain in flames, brought terror with it.

Can we not draw the following conclusions?: Firstly, that the asbestos curtain was of a high grade asbestos material and thoroughly substantial. Secondly, that the asbestos curtain was not lowered. Thirdly, that had it been lowered immediately, the progress of the fire would have been temporarily checked. Fourthly, that had it been lowered, the audience would have felt secure, a panic would have been averted, and the patrons would have left the theatre without confusion. Fifthly, that it is safe to say 587 lives would not have been lost.

Yours respectfully, C. W. Trainer Mfg. Co.
Boston, Jan. 19, 1904.

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Mathematics in Engineering Schools.

It will probably be generally admitted that the mathematical treatment of large groups of subjects lies at the foundation of a great portion of engineering design and even of engineering construction. It is difficult to form even a mental conception of rational design work without some degree of mathematical treatment, while such matters as the proper planning of steel and masonry bridges, retaining walls, masonry dams and other similar structures, involve in some cases mathematical treatment of a high order. Advances made in the engineering treatment of nearly all such structures and in the broad fields of steam and electrical engineering during the past twenty or twenty-five years have largely, if not nearly all, been due to the judicious application of mathematics to the problems confronting the engineer in those branches of his work. In nearly all cases material progress has been either indicated or made possible by the results of theoretical investigations directed by good judgment, as in Professor Pupin's remarkable results in telephony, all of which were conclusively demonstrated by refined and elegant mathematical analysis prior to experimental realization. So every-day a matter as steel bridge work has also been developed to its present degree of excellence largely through the stimulating influence of mathematical treatment in the design of not only main members but also practically all details. In other words, mathematics has been the agent of practically all progress in rational engineering design.

The fact that advances in the production of materials and in machine shop methods and capacity have also been absolutely essential to phenomenal progress in engineering design and construction does not militate in any manner against the preceding observations, for those advances have either simply responded to the constantly extending demands of design, or, on the other hand, have made it possible to realize the ends which have been attainable only through mathematical investigation. The part played by the application of pure mathematics in practically every branch of engineering activity is constantly lost sight of under the absorbing and broader activities of the administration of large engineering works. If one goes back of achieved results into the draughting and computing rooms of any large structural or machinery establishment, it will be found at the present time that the most successful designs of either structures or machinery are based upon refined mathematical treatment of fundamental problems.

The method of instruction in mathematics in engineering schools attains, therefore, a degree of importance which has not even yet been adequately recognized except in comparatively few quarters. While most engineering instructors who have in one way or another come in contact with practical matters are more or less agreed upon certain general principles for the giving of instruction in the subject, there is still a wide divergence of opinion on many essential details and on some general principles. The old method in vogue forty or fifty years ago, when engineering instruction had scarcely even attained to its boyhood, was what may be called the method of abstract instruction. In this method "mathematics for the sake of mathematics" seemed to be the guiding motive in all instruction. Engineering students were expected to demonstrate in the class-room all kinds of mathematical formulas applicable to engineering work, but without regard to the actual application of those formulas. Daily mathematical exercises in the engineering school consisted almost entirely, if not quite so, of old style mathematical recitations in which the abstract demonstration was everything and the application to engineering problems practically nothing. Although this method was an intense drill on certain general mathematical principles, the results were sterile for useful purposes. The student who had finished his engineering course of study at that time was essentially immune to any useful application of his mathematical work. A natural result was the widely extended repulsion of feeling, lasting even to the present time, toward mathematical treatment of engineering work; a repulsion without any rational foundation and which trenches materially on the true professional character of an engineer's practice.

The science of pure mathematics is absolutely nothing whatever beyond the precise and accurate treatment of problems, and one of the main purposes of rational mathematical instruction is to give facility in that kind of mental activity and to acquire the habit of accurate and logical thinking. The day has gone by when any instructor in any line of science whatever can properly pride himself on having accomplished nothing useful in either his mathematical or laboratory work, although that boast has many times been made in the great universities of the country. The human mind is so constituted that it works best, indeed it only really works at all, when it is engaged toward a definite purpose. Engineering students will acquire a more thorough and clear knowledge of mathematics when it is taught in connection with its application to engineering problems, and it is probably the only way in which ease and facility in the mathematical treatment of those problems can be attained. A small minority only of people are so constituted as to take a keen interest in purely abstract matters, but there are few indeed, and those few are not found among engineering students, who would not be inspired by mathematical instruction when given in constant application to engineering problems. It may be laid down emphatically that no engineering instructor in mathematics is performing his duty properly who does not in daily work develop his mathematical formulas in constant application to precisely those problems which confront the engineer in the practice of his profession. All intelligent engineering design work is fundamentally based upon precise quantitative treatment of those elements which enter it and no rational results can be accomplished without such a precise quantitative treatment; which is only another way of stating that all design work must be treated mathematically in order to attain safe and economical results.

One of the most difficult matters of mathematical application, one which requires the exercise of the highest grade of professional judgment, is the limit to which mathematical accuracy is to be carried in engineering work. It is simple enough to apply formulas to any given case, but frequently, as in the application of the theory of earth pressure, it is a matter of good judgment solely to determine to what extent the results of such application must be modified to meet the conditions of actual work which cannot be accurately measured or even represented by formulas. This matter of judicious application of engineering theory to many obscure problems, as in foundation work, calls for the highest professional skill, but it is no exaggeration to state unqualifiedly that the best solutions of such difficult problems of construction can be reached only through a wisely tempered application of engineering theory.

Again, there are many cases in which approximate methods may be most judiciously employed, although this legitimate license should never lead to careless or slovenly work in what may be termed the mathematics of engineering. Good sense and sound judgment are the concurrent requisites with the mathematical treatment of engineering problems.

Rankine practically created the true science of engineering and the admirable mathematical results of his work are the basis of that science, but no engineering instructor at the present time ought to assume for a moment that Rankine's formulas can even be considered in the class-room except in their practical application to engineering work. They should be used precisely as they would be employed in an engineering office, not without demonstration, but as an agency or appliance for obtaining practical results. Whether mathematical methods are those of graphics or analysis is a matter of no consequence. Both methods should be made familiar to the engineering student, but the acquisition of familiarity should be attained from start to finish by daily exercises in precisely such applications as the young engineer must make in his subsequent professional work.

The Appraisal of Railways.

A paper by Mr. R. A. Thompson on the methods of the Texas Railroad Commission in valuing railway properties was read before the American Society of Civil Engineers on Wednesday of this week, which merits an unusually thorough discussion. The Texas law which enables a public commission to determine the amount of bonds and stock that may be issued for a new line and the part of the capitalization of an old line which is entitled to receive dividends is not likely to find favor in most States. The problem of appraisal undertaken in accordance with its provisions is, however, essentially the same as that which arises in the valuation of railways for purposes of assessment. Work of that nature has been done in New Jersey and Michigan and is now in progress in Wisconsin under the direction of Prof. W. D. Taylor, of the University of Wisconsin. It is probable that similar valuations will be made in many other States, and for this reason the "Transactions" of the Society mentioned should contain a complete discussion of the subject. Outside of Mr. Thompson's paper, an article by Professor Taylor in the "Wisconsin Engineer," and a description of the Michigan work in this journal, there is little available information on the principles involved and the methods followed. The American Society of Civil Engineers' "Transactions" afford an unusually good place for frank and full discussion of the subject, from the position of the railway companies as well as that of the State assessors. It is to be hoped that the companies will take advantage of the opportunity and put on record their views concerning the proper procedure in such appraisals, and that the engineers who have been engaged on the work in the States mentioned will explain in detail the systems they adopted.

It is useless to expect any considerable assistance from the old reports of the railway companies. Most of them are lost, and it is only necessary to examine some of the documents in the McAlpine collection in the library of the American Society of Civil Engineers to learn that such records as exist have practically no value as a rule. The railways have usually changed owners many times since they were built and the price paid for them was fixed by other considerations than their actual cost of construction. The problem before the engineering assessors, is, therefore, not an appraisal of the actual value of the properties as much as an estimate of the cost of duplicating the right-of-way, roadbed, buildings and rolling stock. The Wisconsin law of last year indicates that the franchise value of the railways must also be considered, but that feature of the subject need not be discussed by engineers at the present time.

The difficulties of this work are evident as soon as any piece of road is considered. The right-of-way in many cases cost nothing, having been donated as an inducement to build the line. To-day, the property along portions of this strip may be of considerable value and if the railway were not there might be worth still more. It is not unlikely that in some situations the purchase of such a right-of-way at the present day could only be made at higher figures than the current value of the land, because the track would cut through the property and, by dividing it, render it less valuable. Again, the cost of the roadbed is not easily estimated in all cases. It may have been built originally without any of the modern plant for the purpose, and at a unit cost considerably higher than would be necessary in these days of steam shovels, graders and dumping cars. Moreover, an old embankment consolidated by years of use is worth more than a new one of the same dimensions, but how much more is a hard question to decide. Even the problem presented by the rails is full of difficulty. Mr. Thompson states that in Texas no allowance was made for any depreciation, while Professor Taylor states that in Wisconsin the subject was carefully considered. He points out that in that State an error of even $1 a ton in the assumed average value of rails would affect the total appraisal by nearly a million dollars.

The rolling stock presents features of even greater complication. If it never went beyond the State boundaries it would not be difficult to appraise, but it goes very far beyond them in many cases. In fact, every large railway system has a car tracing department for the purpose of finding such of its rolling stock as wanders too far from home and seeks an easy life on the little branch lines of other companies. A certain proportion of cars and locomotives of interstate lines are necessary in each State, but it is evident that an opportunity for considerable argument can be found in the determination of the proportion it is just to consider for purposes of taxation.

Enough has been said to show that this particular field of civil engineering presents so many novel problems that a comprehensive discussion of them is desirable. If this discussion takes place now it will be of much assistance to the engineers engaged on similar work in the future. The American Society of Civil Engineers has rarely had an opportunity to render such a service as Mr. Thompson's paper presents, and at the same time to make its "Transactions" of importance to non-technical men interested in problems of State government and railway management.

Data Concerning Concrete-Steel Construction.

The importance of concrete-steel construction and the unusual conditions which affect its present status among engineers call for comment, particularly as a communication from an esteemed correspondent indicates a misapprehension of the position of The Engineering Record with regard to such matters. It seems desirable to point out, therefore, that at the present time most of the engineers who have given the greatest amount of attention to concrete-steel construction are interested either in contracting or in the supply of material employed as the steel reinforcement for concrete. It is manifest to anyone acquainted with some of the work of this nature recently executed, that there are persons engaged in the construction of concrete-steel buildings and bridges who are unqualified for their task. On the other hand, there are many who feel that they cannot afford to risk their reputations by designing structures having elements of weakness. It must be remembered that at the present time there is no generally accepted procedure for designing such work. The Engineering Record prefers the methods outlined in the last edition of Professor Burr's "Materials of Engineering," but it is perfectly willing to acknowledge that some engineers of long experience prefer to employ other methods of design. With the data now at hand, the correct design of important concrete-steel structures calls for a complete acquaintance with the theory of stresses and a trained judgment; the engineer having such knowledge may be safely trusted to produce a satisfactory result, no matter what formulas he uses, while the engineer without such knowledge courts disaster.

This being the opinion held by The Engineering Record, it is evident that its columns are open for any discussion of the theory and practice of concrete-steel construction which is conducted in a manner in keeping with dignified argument. It makes no difference whether the principles of design are advocated by a professional engineer, a manufacturer of steel for purposes of reinforcement or a contractor for concrete-steel work. If these classes of readers choose to send this journal an account of the experiments they make, the structures they build or the theories they advance, space will always be given to so much of their contributions as the editor considers of value to the readers of the paper. But there is no room in the paper for articles of any other class. Bare statements without proof that a contributor is wrong, sarcastic references to his knowledge or experience, claims for any system of design which are not accompanied by sober discussion of its advantages, are of advantage to nobody. This statement seems necessary because of the peculiar condition of the concrete-steel industry at the present time. Many failures of such construction have already occurred and many more will happen, because work has not been properly designed or properly executed. The most valuable data on the subject are probably in the possession of the various parties who build such works. No one firm or individual can have more than a small part of the information which should be available to everybody if concrete-steel is to emerge from its period of probation unscathed. Instead of warring among themselves and hurting the business they are endeavoring to build up, the people interested financially in concrete-steel should look upon all published data of a reputable character as so much important information in their possession. They should, in fact, contribute information which will help to establish the good name of concrete-steel.

Concrete-steel construction is just at present more in danger from the people who are attempting to build unimportant works than from those who endeavor to introduce new methods of applying the steel reinforcement. There are many good general contractors who believe that the grade of concrete they have been accustomed to lay for low retaining walls, the footings of buildings and the foundations of pavements is concrete suitable for concrete-steel. The two materials are as far apart as angel's food and hoe cake, and it is the failure to recognize this fact that will lead to trouble. For this reason The Engineering Record is in full sympathy with Mr. Tucker's suggestion elsewhere in this issue, that the people interested in this new material should endeavor to secure the co-operation of the American Society of Civil Engineers in the proposed joint committee to investigate concrete-steel work. It is important to bear in mind that this committee project will fall through unless at least one-third of the members of the Society vote on the question and a majority of these votes are favorable. The friends of the project should use all their persuasive powers during the next fortnight to securing a large vote, for the plan may fail through a lack of sufficient interest on the part of the membership to send in their ballots.

The sooner an authoritative statement is made on the subject of concrete-steel the more quickly the dangers of the present situation will be overcome. At the present time the subject labors under the misfortune of being largely in the hands of people whose business interests lead them to adopt views of a somewhat biased nature. It is the province of a technical paper to give everyone an opportunity to make his views public, when they are properly presented, but it is reserved for national organizations like the American Society of Civil Engineers, the American Society for Testing Materials and the Association of Portland Cement Manufacturers, to put the subject on a thoroughly safe, unbiased basis by means of an investigation conducted by a joint committee.

The Design of Light Steel Work.

One of the most common sources of unnecessary expense in buildings requiring considerable steel work is to be found in the design of such construction by men without practical experience in the offices of works manufacturing the structural material. At the recent convention of the Iowa Engineering Society, Prof. L. E. Ashbaugh gave two instances of this fact which are worth repeating. A bid was made by a bridge shop for work for Mexican parties and designed by their engineer. The tender was accepted and then the shop submitted an alternative design much stiffer and better adopted to their needs. This was gladly accepted and it also yielded a nice extra profit to the company. In another case, a certain company maintaining a structural department called for tenders on its plans for a building, and the bid of the same shop for the work was accepted. Later an alternative plan was presented, but rejected on the ground of being too expensive. A few hours later it was accepted, however, at the same price as the first tender. The alternative plan was acknowledged to be better, but it was not known that it represented an additional profit of $5,000 to the builders. These instances could doubtlessly be multiplied many times from the experience of every structural steel shop in the country.

Anyone who has had an opportunity to become familiar with the process of design in such a shop is aware that there is a certain kind of knowledge, only acquired by long experience in the drafting room, which is essential for the most economical designing of steel work. Probably any graduate of a good engineering school is competent to design strong steel frames for mills and similar buildings, but none of them is able to design work which will be economical until he has obtained a practical knowledge of all the elements which go to make up the total cost. In the opinion of Professor Ashbaugh, it does not pay for a company or a city to design steel work unless it maintains specialists in such construction, and he advises placing this designing in the hands of the bridge companies. If all the information concerning the uses to which the structure will be placed is furnished, the shop draftsmen are able to work up plans which will be low in cost and of ample safety. If it is necessary to have them checked, this can be done by a consulting specialist for a small fee, for anyone familiar with such work is able to examine the steel details of an ordinary mill building in a short time. That is to say, he can do so if they have been drawn by competent men, but if they are the work of an amateur it is impossible to say how long a time must be spent on the examination. In submitting the requirements for steel construction, it is best to give a general layout of the building with the machinery placed as desired. In the paper mentioned, it is stated that the Allis-Chalmers Company once sent out for such a purpose, in connection with a five-story building for ore-dressing, a set of blueprints showing the position, weight and size of all heavy machinery, with connecting shafting, openings in the floors and walls and other features of arrangement. This is the common-sense method.

The reason such designing is usually best left to the bridge-shops, unless the engineer has had practical experience in such shops himself, is because of the saving in cost which will result. Occasionally steel work plans are submitted to bridge shops which are so weird that the tender is always accompanied by a proviso that in case the bid is accepted the shop shall not be held responsible for any failure due to defects other than those of material and workmanship. Fortunately such cases are rare. The shop design is usually preferable because it makes the best use of material, because the work is largely along standard lines with which the workmen are familiar, and because any special features are detailed so as to be as easily carried out in the shop as possible. Sometimes there is a scarcity of shapes of the sizes usually called for in designs for the class of work under consideration, and the shop designers are then able to get out plans which call for material on hand, thus saving time in construction. As steel work is generally wanted quickly this is a feature of the subject which may be of considerable importance.

In what is said there is no intention of reflecting on the work of the consulting specialist in structural steel design. As a rule, however, these engineers prefer to check over the plans of framing for mills and similar buildings to making the plans themselves. The work is merely routine designing, and is best done where the facilities for it are the greatest. This is unquestionably in the offices of the bridge companies or engineers making a specialty of mill architecture and employing designers trained in bridge shops.

Notes and Comments.

Reservoir Level Indicators, showing at the water works office and the pumping station the height of water in all the basins to which water is raised, are useful safeguards against accidents which often have very costly consequences. A recent accident illustrates this clearly. There were two reservoirs at different elevations, connected by a main having a gate which was kept closed when the upper basin was being filled and the lower one was full. This gate broke one night, and for some time the water pumped into the upper reservoir flowed into the lower one, overtopping it and finally washing a hole through it. The damage was many times the cost of indicators which would have shown the pumping station attendants that something was wrong, and thus given them a sufficient warning to have prevented any damage.

The Early Engineers of the country were obliged many times to rely on judgment rather than experience in designing their works, and as a result some amusing instances of conservatism are on record. For example, when some lattice bridges were built for the Little Schuylkill & Susquehanna R. R., there was no precedent for their use for railway service. Chief Engineer Solomon W. Roberts accordingly reported in 1838 as follows: "I propose that when the superstructure of each bridge is completed, the keys of the falseworks shall be loosened and the falseworks allowed to remain standing within a few inches of the lower chords of the bridge, so as to obviate the possibility of accident, and if found necessary, timber framed piers may be built half-way between the stones ones to render the bridge more than strong enough to sustain any possible load."

The Electric Train Service which the Lancashire & Yorkshire Railway will shortly establish for its suburban business between Liverpool and Crossens involves the electric equipment of about 25 miles of double-track road. Four-car trains seating 270 passengers and having room for a limited amount of baggage will be used. Each end car will have four 150-horse-power motors, so connected that the motors of both cars are controlled from either end. Sheet steel and uralite have been used plentifully to prevent any fire-hazard due to the electric equipment. A special form of vacuum brake is employed instead of the usual air brake. The power plant will furnish alternating current at 7,500 volts to four substations, where transformers and rotary converters will change it to 600-volt direct current. The third-rail system has been adopted, with gaps in the rail at grade crossings and timber guards at all frequented places. The center of the rail is placed 3 feet 11½ inches from the center of the track and its head is 3 inches above the heads of the main rails; these are the standard dimensions of all British companies. The equipment of the road is now nearly completed, and one of the trains has been given an experimental run. The results of the handling of this suburban service, a quite heavy one, with electric trains will be awaited with interest, because it will replace a long-established steam service and no attempt will be made to exceed the speed of the best steam trains now engaged in it. The electrical work has been carried out by Dick, Kerr & Company.

A New Type of Gas Engine, designed by Mr. Adolf Vogt, has lately received considerable attention in London. Only a model has yet been constructed, but with it a horse-power hour is developed with 16 to 18 cubic feet of city gas, a remarkable record for a motor with a cylinder a trifle over 3 inches in diameter and less than 6 inches long. This cylinder has an upright chamber at each end containing air, gas and exhaust valves. The cylinder and the lower part of each chamber are filled with water. The charge is compressed by the water in the upper part of the chamber and on ignition the pressure is immediately communicated through the water to the piston. There are two explosions to each revolution, so that the motor resembles a steam engine in this respect. The valves are mechanically actuated and there is a special device for insuring the presence of the proper amount of water on each side of the piston. The gas and air are supplied by pumps, and the quality of the mixture and the degree of the compression remain constant. The engine runs very cool without water jackets, which simplifies the construction, the air and exhaust valves are cooled by water submerging them once every stroke, and the gas valve is cooled by the inflowing and expanding gas. Whether a large engine can be operated on such a system remains to be demonstrated. The difficulty of making the water act properly when it is present in the large volume needed in an engine of fair size is certainly great enough to warrant withholding an opinion on the commercial value of the motor until experiments on a working engine are made.

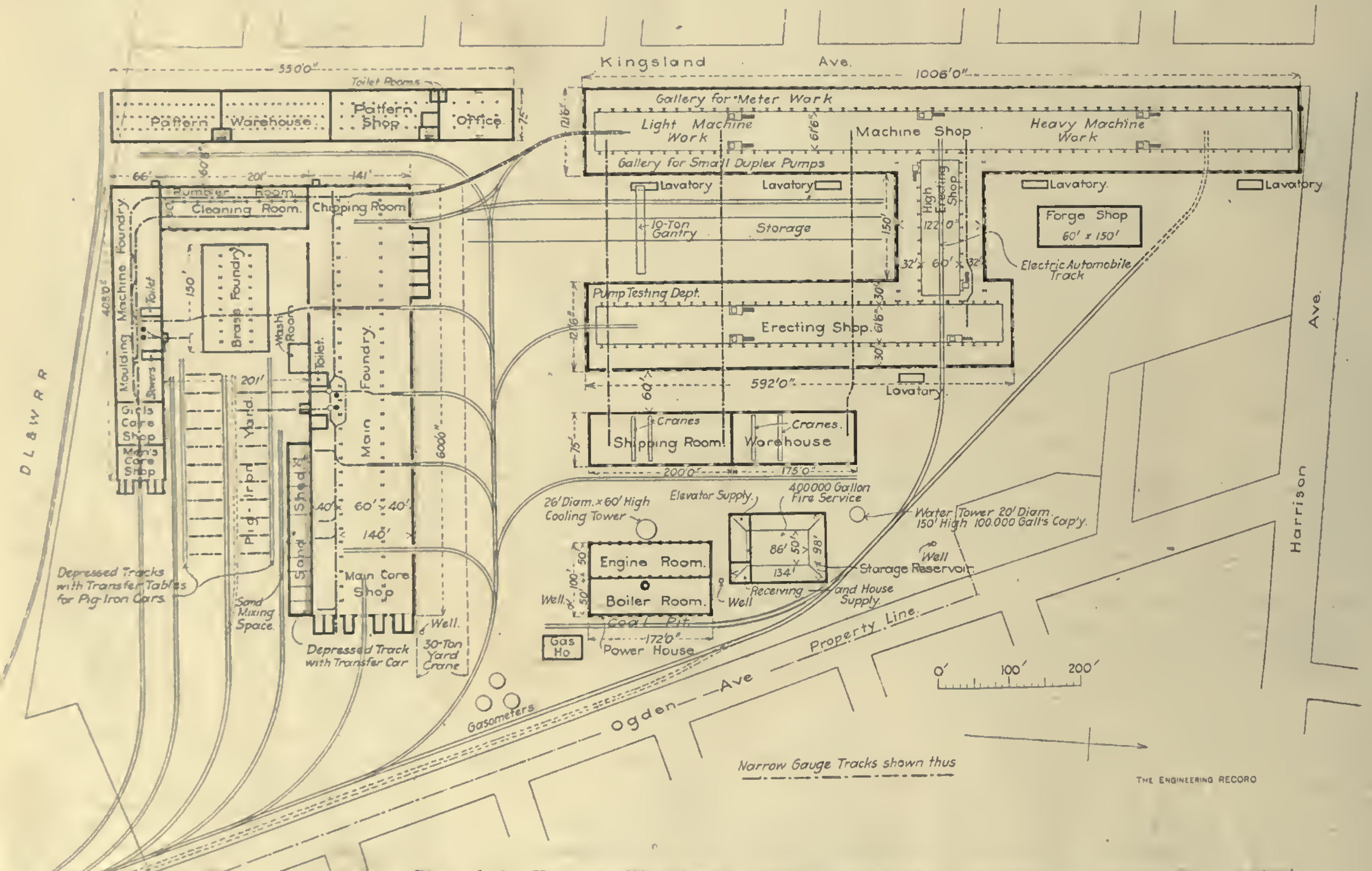
The New Henry R. Worthington Hydraulic Works at Harrison, N. J.

PART I.—FOUNDATIONS, POWER PLANT, TRANSPORTATION AND MACHINE ERECTING SHOPS.

A large manufacturing plant which will employ about 6,000 men, when running at its full capacity, is now in course of construction for Henry R. Worthington, at Harrison, N. J. It is of interest not only as an example of mill architecture for a long-established industry which has learned by years of experience just what arrangements are best suited for the conduct of its work, but also because the establishment is the largest one yet to occupy the region of the famous Hackensack meadows. It is located on the high ground just beyond the "meadows" proper, which some people expect to become the most important center for heavy manufacturing in the vicinity of New York. Here the Lackawanna and Pennsylvania and Erie railroads afford facilities for rail shipments, and there is plenty of level ground on which to lay out the various buildings so as to have the work in them proceed in the most economical manner. This work will comprise not only that conducted at present in the Worthington shops in Brooklyn and the Worthington foundries at Elizabethport, but also some of the pump and air compressor construction now carried on by other companies affiliated with the Worthington company.

It is not considered by the designers that the plant is unusual in design or operation, but that a special effort has been made to select and combine the best features of advanced practice in construction and equipment, to provide for all operations in continuous sequence and to avoid hand labor wherever possible. The most novel structural features are the projecting elevator platforms in the machine shop galleries and the arrangements for dumping the sand automatically from the flasks through the foundry floors, receiving and handling it in the basements and delivering it by elevators and conveyors to the moulding room.

Foundations.—The thirty-odd acres of the Harrison site was originally a slightly undulating salt meadow. A topographical survey showed that the average level could be established at about 10 feet above high water, the hillocks being graded down by horse-plows and scrapers for the purpose of filling the depressions. The original intention had been to put in the footings and part of the foundations in the few low places and ponds before grading, but the soil under the ponds proved too soft and muddy for this to be practicable. The low places were accordingly drained and filled before the trenches were opened. As one of the most serious objections to this meadow tract for manufacturing plants has been its supposed treacherous character for building purposes, it is of interest to note that extensive tests of the bearing power of the soil were conducted by the mill architects in charge of the work, Messrs. Bert L. Baldwin & Company, of Cincinnati and New York. The method of testing was as follows: A pit was dug at the place of a test until a hard stratum was encountered. On this firm material there was placed a vertical timber with its foot exactly 0.1 square foot in area. At the top it carried a platform, and it was held in a vertical position by guides on the surface of the ground. A card was tacked to the post opposite one of the guides, and a line drawn on the card by means of a straightedge laid across the top of the guide. The platform was then loaded with a known weight of brick and a second mark made on the card. This process of loading and marking was continued until there was an upheaval of the ground just beyond the edges of the post and the latter settled more rapidly with each increment of load. When this occurred, the load was partly removed and another mark made, which was often above those previously drawn. More brick were taken off until no further settlement was indicated by a careful comparison of the marks. From the last figures the equivalent load per square foot was quickly deduced and assumed to be the bearing capacity of the soil. The footings were then designed to impose a load of not more than half this amount on the bottom of the trench in the vicinity. When it was necessary to carry on such examinations as rapidly as possible, the loading of the post was continued only to the amount when the rate of settlement began to increase rapidly; this amount was taken as the bearing capacity of the soil. The architects state that this method of testing the foundations has been proved by many experiments to be a safe one, and that the results obtained correspond closely with those given by first loading and then unloading the platform. Those in charge of the work believe that tests made with posts are comparable with those in which larger areas are loaded, and that the results are amply accurate for use in proportioning footings.

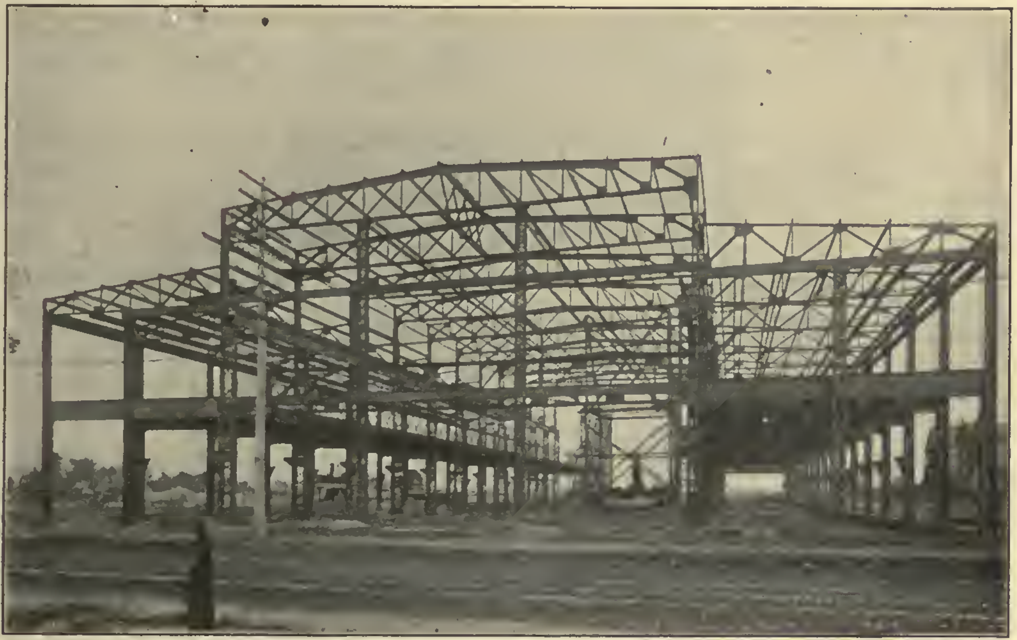


Plan of the Henry R. Worthington Hydraulic Works at Harrison, N. J.

Originally the site was partly covered by a chain of small ponds with their surface about 1 foot above mean high tide. They were filled with fresh water from rains and surface drainage and one of them had an outlet through tide gates into a small creek. Channels were cut connecting all the ponds and their drainage was easily accomplished by closing the gate at low tide. After this was done the deepest water remaining in any place was about 2 feet, near the high erecting shop, and this was absorbed by the material filled in to establish the new grade.

Before construction was commenced, about twenty wash test holes were sunk in different parts of the site to an average depth of about 25 feet and a maximum of 40 feet. They indicated good sand and gravel and were reported to reach solid rock, but this was thought to be a mistake, and it was concluded that they had encountered boulders, a belief of which was justified by later developments. The test holes were sunk about 5 feet below the footings and no test pits were sunk any deeper as the soil there was satisfactory. The areas of the footings were all proportioned in accordance with the results of the loading tests made at the nearest points, and it was intended to load the soil uniformly to about one-half of its indicated bearing capacity, except where that was unusually high. Many of the piers themselves weighed nearly or quite as much as that portion of the building which they supported; it was believed that there would be no appreciable settlement and that the slight amount which might occur would take place before the construction of the superstructure and so would be negligible, a conclusion which has been justified so far by the results.

All footings have been laid in trenches kept open, when necessary, with sheet-piling and drained by hand pumps. These footings rest on gravel, sometimes mixed with loam, clay or sand. These mixed materials differ considerably in their bearing capacity. In one place where the soft material was very deep and the piers for the steel columns had to be carried down 26 feet, the walls were carried by arches sprung between concrete piers; these arches are just below the surface of the ground. These pits were 16 feet below mean high tide and were drained by an 8-inch centrifugal pump working at intervals about an hour at a time. The average depth of the footings below the surface is about 8 feet, and the minimum depth is about 6 feet. The concrete used in this part of the work was mixed in the proportion of one part of Saylor's Portland cement, three parts of sand and five parts of stone broken to pass a 1½-inch ring. Both gravity and Ransome mixers were used.


View of Steel Framework of the Worthington Machine Shop Taken Last June.

Transportation.—The general arrangement of the buildings is so clearly indicated in the accompanying plan of the works that little comment is needed on this subject. The foundry departments are entirely distinct from the machine and erecting departments. Spurs from the neighboring tracks of the Delaware, Lackawanna & Western Railroad enter each building in which manufacturing is carried on, while a very complete system of industrial railway tracks, furnished by the C. W. Hunt Manufacturing Company, connects all the buildings. Some of these tracks are located permanently, while others can be shifted readily as the necessities of the work require. These standard and narrow-gauge tracks will be supplied with steam and electric locomotives and locomotive derricks and will be supplemented by a large number of traveling overhead cranes in the buildings.

The more important portions of the crane installation are as follows: In the main foundry there will be two 20-ton and two 30-ton cranes of 60-foot span in the center aisle and five 10-ton cranes in each side aisle, besides four 5-ton traveling jib wall cranes in the center aisle. In the machine-moulding foundry there will be no longitudinal traveling cranes, but each transverse panel between roof trusses will be supplied with a 1 or 2-ton traveling pneumatic hoist. In the cleaning shed there will be two 10-ton cranes of 36-foot span and one 5-ton crane of 24-foot span. In the center aisle of the machine shop, provision is made for four 20 to 30-ton cranes of 61½-foot span and in each side aisle six or more 5-ton cranes of 30-foot span. In the erecting shop the plans call for three 20-ton cranes of 61½-foot span in the center aisle and four 5-ton cranes of 30-foot span in each side aisle. In the high erecting shop, there are to be one 30-ton and one 50-ton crane of 60-foot span in the center aisle and two 5-ton cranes of 32-foot span in each side aisle, besides numerous stationary 5-ton jib cranes in the center aisle. In the shipping room and warehouse there will be one 10-ton crane of about 35-foot span in each aisle. In the yard there will be two 10-ton locomotive derricks with 15-foot radius, and it is proposed to install a double-cantilever traveling gantry of 150-foot span and 30-foot track to command the space between the machine shop, erecting shops and the foundry, thus providing especially for the transfer of large castings. In the pig-iron yard there will be a large number of narrow-gauge transverse surface tracks intersecting, a depressed track on each side of the yard, where there will be a transfer car to shift the loaded stock cars to the cupola tracks. A similar provision will be made for the sand sheds, where temporary narrow-gauge transverse tracks will be laid on the top of the sand in different bins and will connect with a longitudinal depressed track on which the cars will be transferred from tracks in the main foundry.

Power Plant.—All power will be furnished from a 100x172-foot central station. In it there will be installed six 300-horse-power Babcock & Wilcox boilers connected to a chimney of the Alphons Custodis type 9 feet in diameter inside and 200 feet high. This stack has an octagonal concrete footing 8 feet thick and 30 feet in diameter, which reduces the foundation pressure to 6,000 pounds per square foot on the soft sandy clay. The engine foundations are monolithic concrete blocks extending 6 feet below and 10 feet above the ground surface. The boiler foundations are concrete walls from 2 to 3 feet wide and 6 feet deep.

The boilers will be supplied with anthracite coal from storage bins of about 300 tons capacity alongside the boiler house. These bins will be built of concrete with their bottoms about 4 feet below the boiler room floor. They will be filled with coal up to the boiler room floor level, where a temporary pavement will be formed with tar and slack. Above this floor the bins will be filled with coal for regular use. Below it the coal will be kept indefinitely as a reserve for emergencies. The coal cars will be drawn up an incline by an electric hoisting engine and will be dumped directly into the top of the bins or through chutes to the boiler room. About 300 tons more of coal will be stored directly under the inclined trestle leading to the coal pockets and a total storage sufficient for about 30 days' supply can thus be maintained.

The power house is divided by a center longitudinal wall and row of enclosed columns into nearly equal parts for the boilers and for the engines. The boiler room has a clear height of 17½ feet to the lower chords of the roof trusses, from which is suspended a pipe gallery. The roof trusses are of simple construction seated on the tops of the side columns and riveted to the sides of the center columns. They are braced together by purlins, by four lines of longitudinal struts in the planes of the lower chords and by X-bracing of diagonal clevis rods in every third panel of the top chords. The wall columns are also X-braced by diagonal rods in corresponding panels. The columns have I-shaped cross-sections and solid webs in the planes of the roof trusses similar to the construction in the shops.

At first there will be two compound condensing direct-current electric units each of 500 kilowatts wound for 250 volts and arranged with collector rings so that a three-wire system can be run for 250 and 125 volts for the motor and lighting service. They will be furnished by the General Electric Company and each will have a horizontal cross-compound steam engine of the Corliss type. There will also be furnished by the General Electric Company an auxiliary steam turbine of 200 kilowatts capacity for night work and reserve service. Electric motors, many of them transferred from the old plants, and including all the principal makes, will be used to operate all machine tools, separate motors being usually provided for those tools requiring more than 10 horse-power. Small tools of the same class will be grouped together and each group driven by a motor of about 20 horse-power, usually installed overhead and driving the tools from jack shafts.

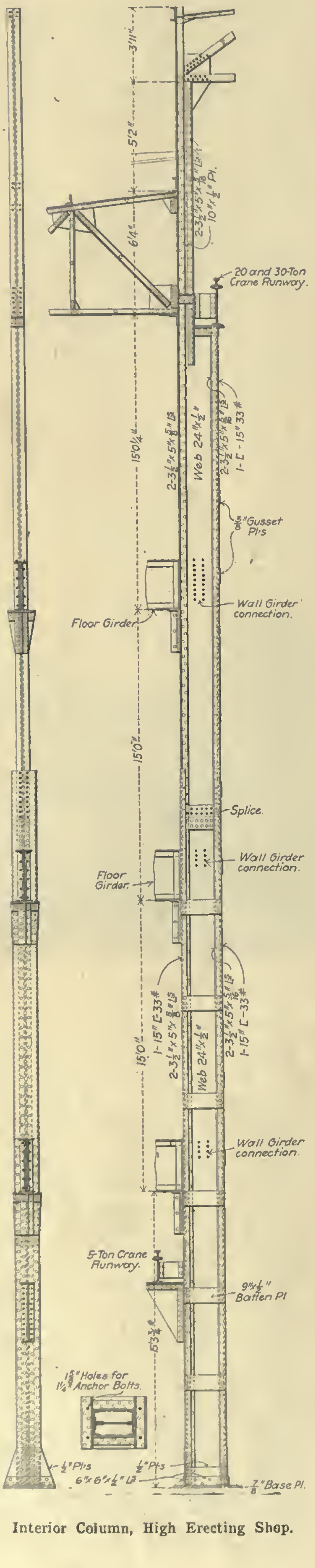
The boiler feed pumps will be of the vertical compound marine type arranged so that either side can be used independently or both together, and of such a capacity that either side alone can suppdy all the boilers and thus provide a reserve system in one unit. These pumps are to be installed in the engine room of the power house, where the electric units and the main air compressors are also located. The compressor which supplies air for tool service and pneumatic hoists, is a cross-compound condensing two-stage Laidlaw-Dunn-Gordon machine with a capacity of 1,500 cubic feet of free air per minute, and provides compressed air at 100 pounds pressure for numerous uses throughout the plant, including pneumatic hoists, chipping tools, rumbling machines, vibrators, pneumatic hammers and rammers and for drying pumps after testing. A reduced pressure is also used for sand blast to clean the castings. There are also in the power house two horizontal Worthington surface condensers. One of them, for the main units, has 6,000 square feet of cooling surface and its cooling water is circulated by a cycloidal pump, which also delivers water to a cooling tower. The air pump for this condenser is of the vertical Deane type. The other condenser with 3,000 square feet of surface receives the steam from the pumps and compressors, and has a horizontal Worthington air pump and cycloidal steam-driven circulating pump.

The water supply for the plant will be derived from four 8-inch driven wells from 350 to 500 feet deep, which have yielded 1,350 gallons per minute throughout a five-hour test. The water is to be pumped from these by compressed air furnished by a G. F. Blake single-stage machine with a capacity of 500 cubic feet per minute. The well water will be delivered to an open concrete reservoir having a capacity of at least 1,000,000 gallons. It will have division walls so that it can be cleaned in sections, and from it the different pumps will draw their supplies, which can be supplemented when desired from the city mains. The general supply for the shop service and lavatories will be furnished under direct pressure by a small duplex Worthington pump. The elevators will be operated by a triple-expansion duplex Worthington pump with a capacity of 1,500 gallons per minute at a pressure of 200 pounds.

The plant will be equipped with yard hydrants at frequent intervals and with fire mains and hose reels throughout the shops, which will be supplied by fire mains from 3 to 6 inches in diameter connected to two Worthington underwriters' pumps with a capacity of 1,500 gallons each per minute. All shops will be equipped with an automatic fire sprinkler service operated from a 100,000-gallon tank on a tower 150 feet high, filled by a cycloidal motor-driven pump.

Machine and Erecting Shops.—The erecting shop and the machine shop will be, when completed, parallel and substantially duplicate structures, each 1,000 feet long and 122 feet 10 inches wide on centers of columns. The machine shop has been completed to the full length and a section of the erecting shop, 592 feet long, has been built and will later be extended to correspond with the machine shop. These two buildings, 150 feet apart, are connected by a four-story wing of similar construction, called the high erecting shop and used for assembling very large vertical pumping engines. The water and steam ends of such engines are generally erected successively and seldom have a height of more than 50 feet each, but this shop will permit high erection of 60-foot structures if necessary.

The machine shop has four longitudinal rows of columns, 30 feet 9 inches and 61 feet 5 inches from the center line, which support the roof trusses, crane girders, gallery floors and wall girders and are braced together in transverse bents 18 feet apart, except at the intersection with the transverse wing where the spacing is irregular and varies about 15 to 21 feet. The framework is braced longitudinally by twenty-seven lines of channel purlins seated on top of the roof trusses, by four lines of longitudinal struts, by X-brace rods in the planes of the lower chords in every fourth panel between roof trusses, by seven lines of I-beam stringers in each gallery floor, by the traveling crane runway girders, and by the wall girders and lintels which support the brickwork. The total weight of structural steel in the machine and erecting shops is about 5,000 tons, and it is made entirely of unreamed medium steel. The roof is proportioned for a total live load of 50 pounds per square foot and the galleries for a live load of 300 pounds per square foot. The outside columns have a line of horizontal wall girders near the middle and another line of girders and one of struts at the top. The center line of columns has lattice-girders two panels in length near the center and the runway girders at the top of the lower sections.



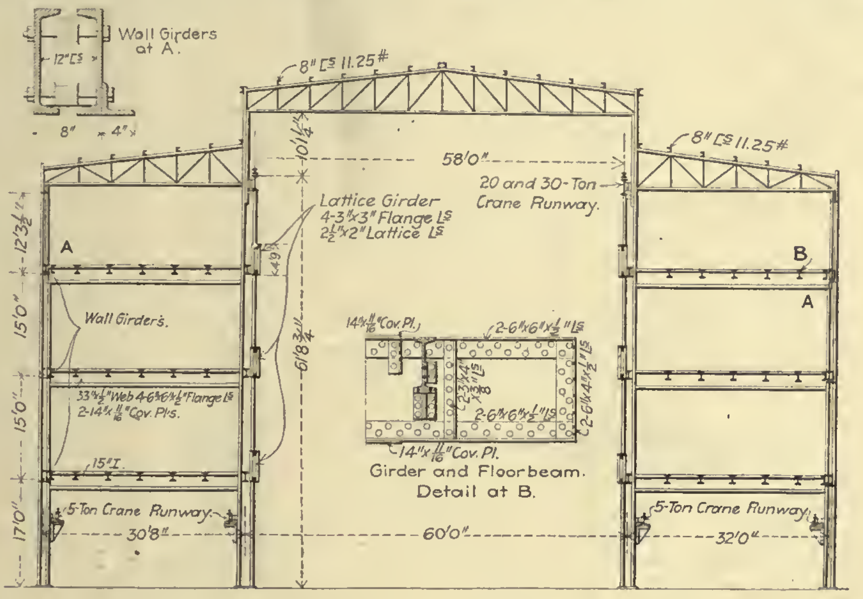
Interior Column, High Erecting Shop.

At the ends of the building the purlins are carried on trusses similar to those in the intermediate panels, and there are also intermediate columns from 15 to 20 feet apart which are connected at the top to the lower chords of the roof trusses, but do not support them, being intended only to carry the framework for the masonry. Expansion joints are provided about thirteen panels, or 234 feet, apart where the ends of the longitudinal members have bolted connections with slotted holes. The gallery floor is made continuous across the ends of the building with platforms about 9 feet wide, between which there is no transverse communication. At three approximately equi-distant points on each gallery the floor is extended 8½ feet beyond the centers of the columns and supported on cantilever brackets to make platforms 18 feet long, which contain the wells for the hydraulic elevators and the landings for the stairs to the main floor. These platforms also provide points where materials can be transferred from the gallery to the main aisle girder cranes. Their construction is simple, consisting of 15-inch longitudinal I-beams supported on the top flanges of pairs of transverse 8-inch channels riveted across the column flanges and having their outer ends knee-braced to the columns with similar inclined channels.

The lower sections of the main columns are made with one 12-inch I-beam and two 12-inch channels latticed together, as shown in the detail. The outside 12-inch channel is about 14 feet long and has the upper end milled to receive the seat of the gallery floor girder in the side aisle. The other channel is continuous to the top chord of the center aisle roof truss. On the opposite side of the column a 12-inch I-beam extends to a height of 29 feet 4½ inches, and is milled to receive a cap plate, on which the main runway girder is seated. Above this cap the column, up to the bottom chord of the roof truss, is composed of two 12-inch channels connected together by flange tie-plates and having at the upper end a vertical transverse gusset-plate shop-riveted to the center of the web to receive the field-riveted connection for the roof truss. This plate is notched so as to engage the web of the short channel and of the projecting one. The gallery girders are connected to the column with web angles as indicated in the detail.

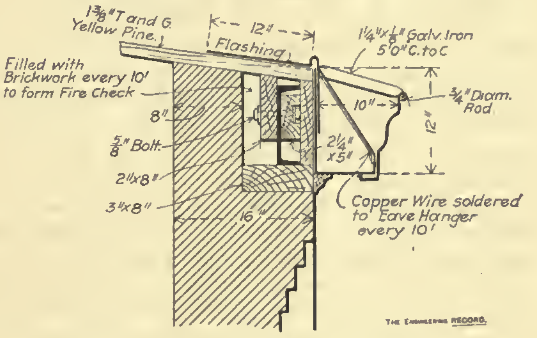
The wall columns have I-shaped cross-sections made with two pairs of flange angles and a solid plate in the transverse plane of the roof trusses. These columns are also made with offset seats to receive the gallery girders and support them on the milled upper ends of the lower flange angles. The upper sections of the columns have reduced widths with their inner flanges clearing the runway girders and riveted to them. The tops of the columns have short sections of web-plates projecting beyond the flanges to receive the field-riveted connections of the roof trusses. The roof trusses are of simple construction, as indicated in the portions shown connected to the columns, and all their members have T-shaped cross-sections with connections to gusset-plates riveted between the flanges of their angles. The top chords of the main aisle trusses have a 12-inch web-plate riveted between the flange angles throughout, except in two panels at each end. The gallery girders have solid web-plates 33 inches deep and pairs of 6x6-inch flange angles with 14-inch cover-plates. They are field-riveted to the columns through the vertical end web-stiffener angles and have bracket and web connections for the I-beam stringers. The runway-girders are 24-inch I-beams which have the track rails seated on the top flanges and connected to them by hook bolts with nuts and washers on the rail web. These are specially designed to afford a quick and positive gauge adjustment, in case of possible displacement, and to always give secure fastening. The longitudinal struts between the trusses are lattice-girders 57 inches deep with T-shaped flanges made with pairs of angles connected by X-bracing of single angle. The brick walls are carried on plate and lattice-girders and have door and window lintels composed generally of a pair of channels or a channel and an I-beam, with a projecting cover-plate riveted to their lower flanges.

The steel columns and wall framing are entirely within the brickwork, pilasters being formed where necessary to enclose the columns. The interior surface has smooth struck joints and is covered with cold-water paint. The outer surface has concave tooled joints. The window sills and copings are of bluestone. The first

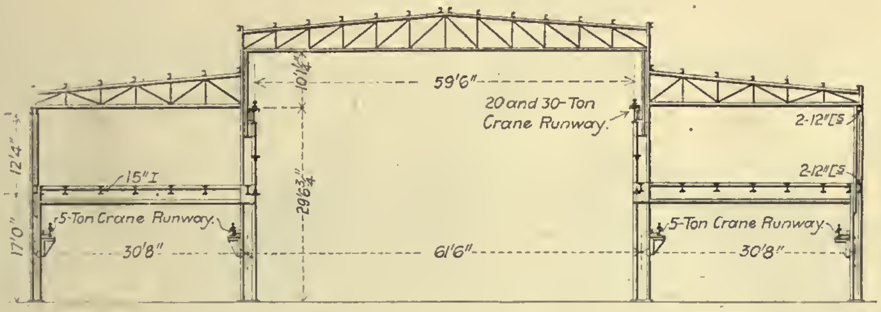


Girder and Floorbeam. Detail at B.

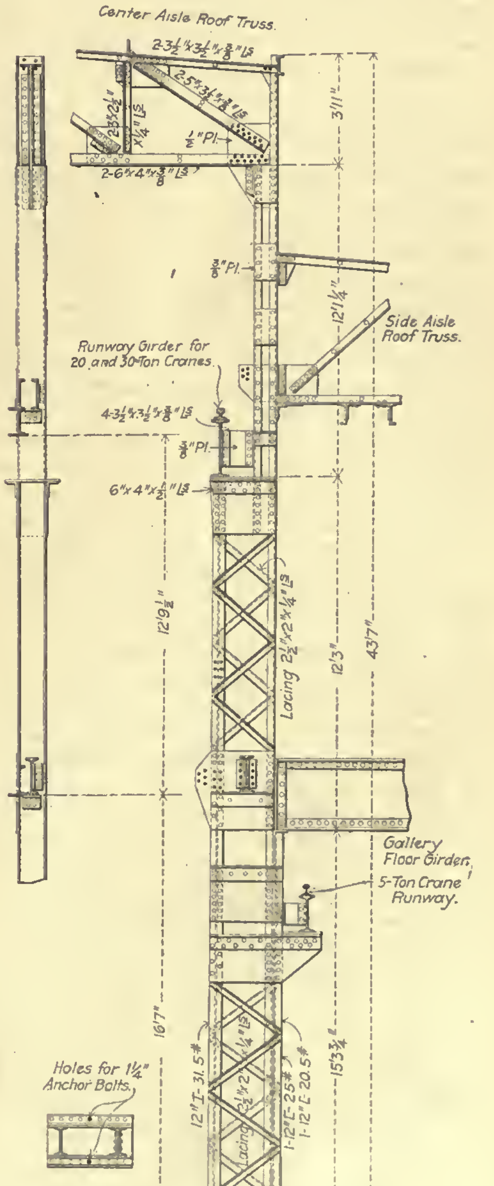
High Erecting Shop.


1⅜" T and G Yellow Pine.
12"
Flashing
1¼"x⅛" Galv. Iron 5'0" C. to C.
Filled with Brickwork every 10' to form Fire Check
8"
⅝" Bolt
2"x8"
3"x8"
16"
10"
¾" Diam. Rod
12"
2¼" x5"
Copper Wire soldered to Eave Hanger every 10'
THE ENGINEERING RECORD

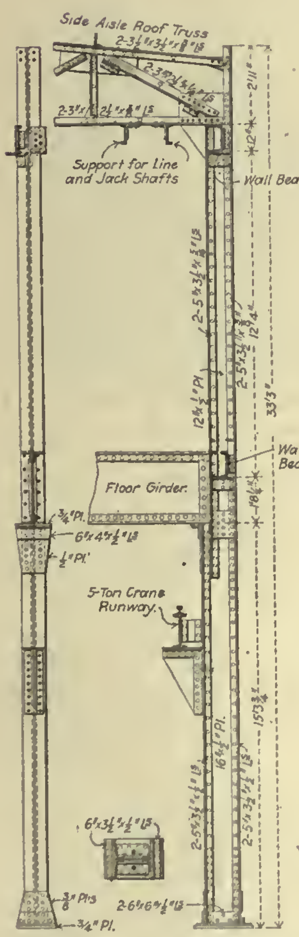
Detail of Main Eave Trough.



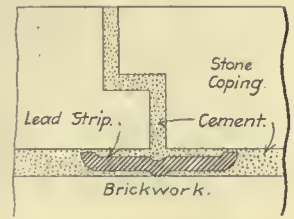
Machine Shop.



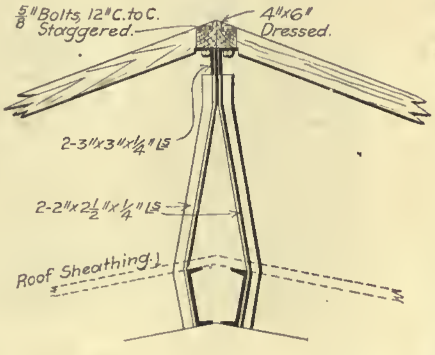
Center Column in Machine Shop.



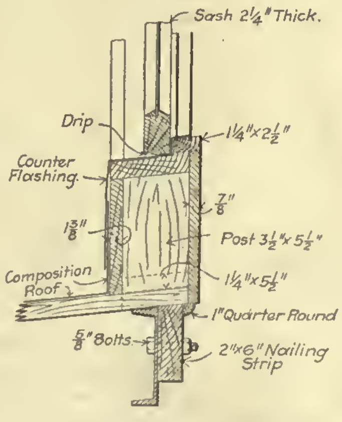
Outside Column for Machine Shop.



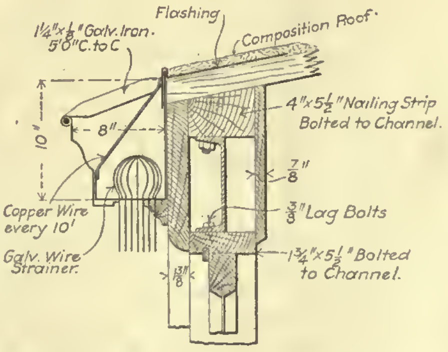
Lead Strips under all Joints in Coping Machine Shop.



Detail of Skylight Support.



Detail of Window Sill for Machine Shop.


Flashing
1¼"x⅛" Galv. Iron. 5'0" C. to C.
Composition Roof
4"x5½" Nailing Strip Bolted to Channel.
10"
8"
⅞"
¾" Lag Bolts
Copper Wire every 10'
Galv. Wire Strainer.
1¾"x5½" Bolted to Channel.

Detail of Gutter for Machine Shop.

CROSS-SECTIONS AND STRUCTURAL DETAILS OF MACHINE AND ERECTING SHOPS, HENRY R. WORTHINGTON HYDRAULIC WORKS.

floor is made of 1:3:5 concrete 3 feet thick in the high erecting shop and 1 foot thick elsewhere. To make it about 10,000 barrels of Saylor's Portland cement and 10,000 cubic yards of fine gravel were used. The floors are monolithic and except in a few cases afford sufficient foundation for the machine tools which are anchor-bolted to them in any required location. The gallery floors have a lower course of 2¾-inch splined, tongued and grooved yellow pine laid diagonally, covered with tar paper and a ⅞-inch course of transverse tongued and grooved maple. The roof sheathing is tongued and grooved yellow pine 1⅝ inches thick dressed on the underside and covered with the highest grade composition roofing made by the Philip Carey Manufacturing Company.

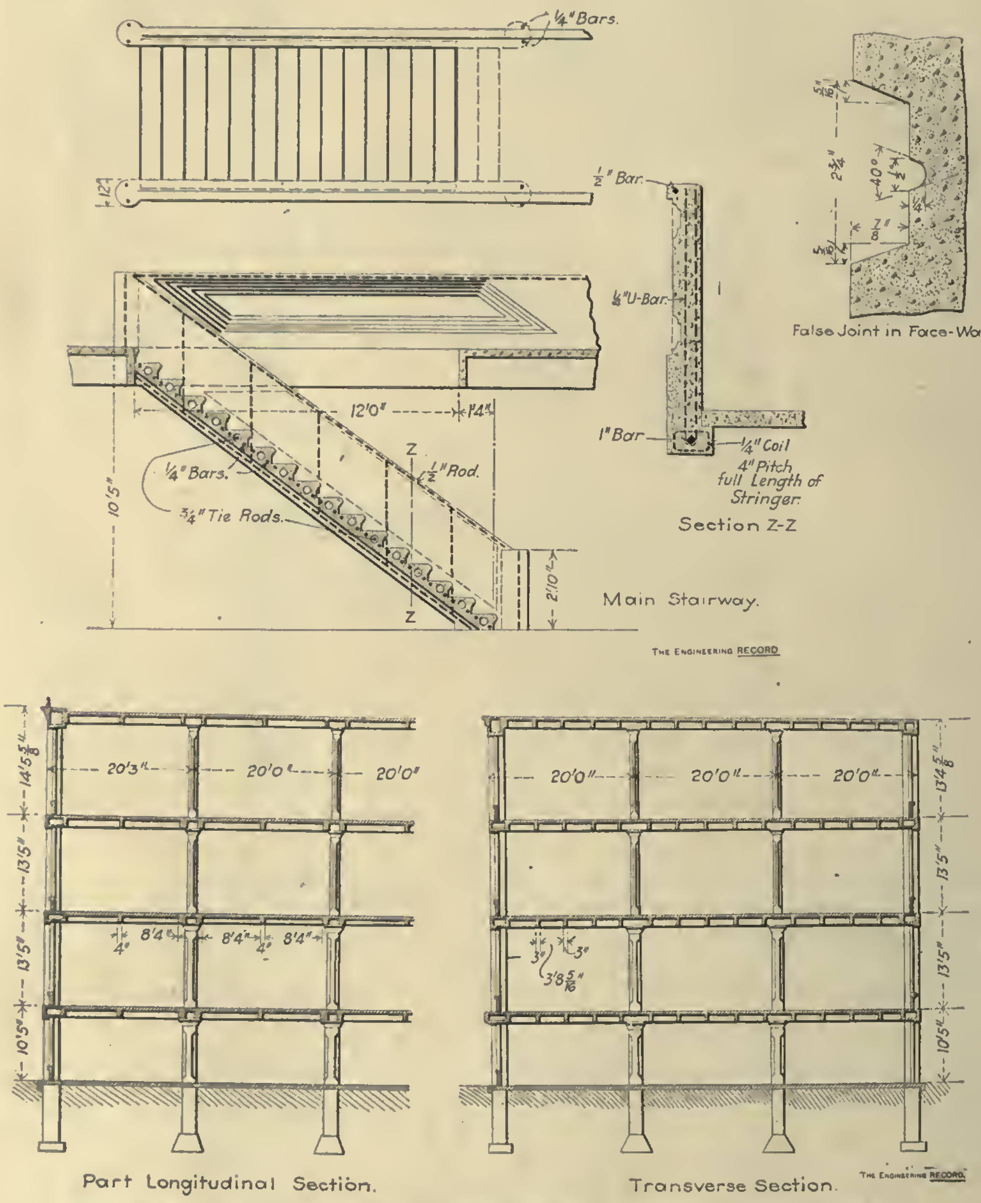
The sides of the shop have two tiers of windows, lighting the lower story and gallery respectively. Each tier has three windows in every panel, except where doors occur. They are all glazed with 12x16-inch clear glass and have balanced sash. The clere-story windows occupy the whole of the vertical space and are glazed with 9x14-inch glass. The sash have horizontal center pivots and are operated by links riveted to eccentrics on a shaft commanded by suspended cords. The flashing around the window sills and the galvanized iron cornice and gutters are carefully designed and clearly shown in the special details. The main doors are 14 feet high and are suspended from overhead horizontal tracks. They are paneled and have frames 3 inches thick and small hinge doors with glazed upper portions. The upper part of the main door is also glazed.

In the roof there are three almost continuous lines of skylights. The center one is about 18 feet wide and is in lengths of from 178 to 252 feet separated by transverse spaces 8 feet wide which afford passageways and locations for the 36-inch tubular ventilators. The side skylights are about 10 feet wide and in sections 48 to 54 feet long separated by 3-foot passageways. The surfaces of the skylights are inclined slightly more than the flat roofs. They are of the Plenty system with steel gutter bars, copper sash and ribbed glass 5/16-inch thick. They are set in wooden curbs and underneath them is stretched wire netting of 2-inch mesh to protect the men in the shop from broken glass. The center skylight is double-pitched and is supported in the middle by a pair of bent angles riveted to the double channel purlin and carrying a longitudinal horizontal angle to which the wooden center strip is bolted.

The high erecting shop corresponds to the machine shop in general features, but has a much higher roof, four stories in the side aisles, slightly different widths between the column rows, runways for crane girders of greater capacity and provision for jib cranes on the center columns. The columns are very much taller than those in the machine shop. They are shop-riveted in two sections with a splice made with web and flange cover-plates shop-riveted to the upper end of the lower section, so as to form jaws, which are field-riveted to the lower ends of the upper sections. The lower part has an I-shaped cross-section made with solid web-plate and flange angles reinforced on both sides with channels. One flange is cut off at a height of about 62 feet above the floor and capped to receive the 24-inch I-beam gallery floor girder. Above this point the column is made much narrower, with the other flange carried up continuously to the roof truss connection. The upper section of the column has no reinforcement channel on the outer flange.

The gallery floors are used chiefly for storage and are proportioned for live loads of 400 pounds per square foot. At the ends of the high erecting shop the gallery floor is carried across the center aisle to connect with the side aisles and is supported on a lattice-girder 6½ feet deep; this is carried by longitudinal plate-girders web-connected to the main columns, as at the ends of the machine and erecting shops. These girders are made with T-shaped members riveted back to back with connection plates between their flanges. They have panels about 5 feet long with zigzag diagonal members and vertical posts at alternate panel points. The vertical posts have web tie-plates connecting them with pairs of vertical channels, back to back, which just clear the girder flanges and extend 3½ feet above the top flange; there they receive the ends of overhead transverse struts which are field-riveted to the wall girders and stiffen the trusses laterally without obstructing the passageway in the gallery. At each end of the high erecting shop, on opposite sides of the center line, there is an electric elevator with the shaft passing through the gallery floors. The side walls of the erecting shop, like all the other walls in the plant, are proportioned to resist a wind stress of 50 pounds per square foot. There are in the sides of the high erecting shop four tiers of windows corresponding to the gallery stories and a fifth tier in the clere-story of the center aisle. In the ends of this part of the building there are two tiers of windows in the third and fourth gallery stories above the roofs of the machine and erecting shops. In the roof there is a center skylight 146 feet long and 18 feet wide, and there is on each side aisle roof one center skylight 34 feet long and two end skylights 51 feet long, all of them 12 feet wide with skylight and window details corresponding to those in the machine shop.

(To be continued.)



Sections and Stairway of the Kelly & Jones Concrete-Steel Factory Building.

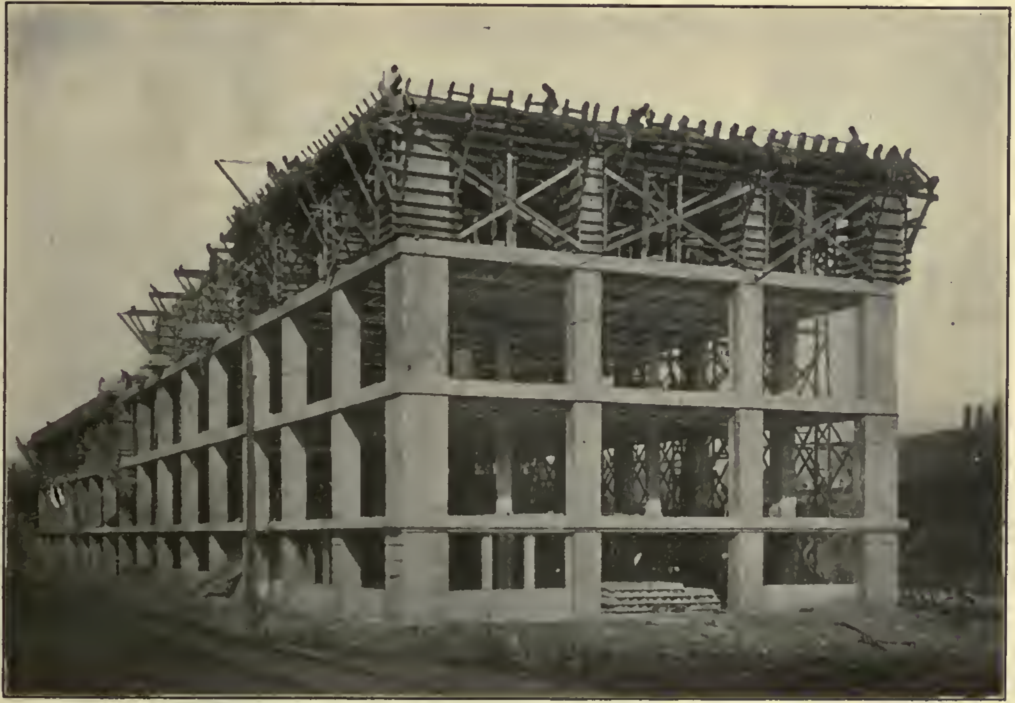
The Safety of the Spire of Trinity Church, New York, has been questioned lately in connection with the excavations being made adjacent to its foundations for the construction of the Broadway extension of the Rapid Transit subway. A letter from the Trinity Church Corporation, calling attention to the possible danger and asking for protection from it, was recently read at a public meeting of the Rapid Transit Railroad Commissioners. The matter is now under consideration by the engineers of the Commissioners, the Rapid Transit Subway Construction Company, the contractors for this division of the work, and the Foundation & Contracting Company, engineers for the Trinity Church Corporation. The Trinity Church spire is 266 feet high, of slender proportions. Its foundations extend only about 9½ feet below the curb and are seated on coarse sand. In this locality the sand generally increases in fineness downwards and has a ground water line not above 25 feet below the curb. The nearest subway excavation is about 15 feet from the east buttress of the spire and will have a depth of about 20 feet below the curb. At present it has been carried down only to the first level, not more than 12 feet below the curb, and no protective construction has yet been required or undertaken at this point.

The Kelly & Jones Company's Concrete-Steel Factory Building.

Part I.—The Design.

The Kelly & Jones Company's new factory at Greensburg, Pa., for the manufacture of small brass work is a 60x300-foot four-story building, constructed entirely of concrete reinforced by the Ransome system of twisted steel rods. It is somewhat special in the construction of the floors and outer walls, in some features of the reinforcement, in the details of the moulds and falsework and in the methods of handling them and the concrete. Each floor is a solid continuous concrete slab 60 feet wide and 300 feet long separating the tiers of columns above and below it. The roof is similar to the floors, except that it is pitched about 1:50 transversely. All sides of the building are glazed throughout a large portion of their area, so that the wall piers between them become narrow and are equivalent to ordinary columns, except at the four corners and at two intermediate points 60 feet distant from them in the side walls, where the piers are made of about twice the regular width to secure architectural effect and to divide the building into panels.

There are, counting the wall columns, sixty-four four-story columns 20 feet apart in both directions. They have extended footings of concrete, without reinforcement carried down to rock at a depth of about 9 feet below grade. The first-story columns are made in two sections, a short lower one which reaches from the footing to the under side of the floor and a regular upper section which extends from floor to floor. The second-story columns are seated on the second floor and extend to the under side of the third floor, which they support, and so on. All columns are square at top and bottom with corners chamfered off to give them octagonal cross-sections except at the ends. The upper ends are corbeled out by mouldings on all sides which form capitals and nearly double the area of the bearing which receives the floor load. The foot of the column is not extended and is seated directly on the surface of the floor.



Walls, Floors and Columns of the Kelly & Jones Factory.

The widths of the interior columns are 24 inches below the first floor, 23 inches in the first story, 20, 15 and 10 inches respectively, in the second, third and fourth stories. They are reinforced in each story by eight ¼-inch vertical bars spaced equi-distantly in a circle about ½ inch clear of the surface of the concrete. These bars are surrounded from end to end by a helix of 4-inch pitch made of ¼-inch twisted steel, to which they are wired at intersections. The wall columns have rectangular cross-sections and are made hollow with air spaces cored out so as to leave a minimum thickness of concrete of 3 inches. They are reinforced at each corner by a ¼-inch rod, which is made continuous from foundation to roof by lapping 12 inches for a splice at every floor. These rods are wired to loops of ⅛x½-inch horizontal bars 12 inches apart vertically.

The first floor is of concrete 4 inches thick without reinforcement, and was laid on the rammed and leveled earth. Like the other floors it is carried continuously over the tops of the lower sections of the columns and projects beyond them on the outer faces of the exterior walls. Unlike the upper floors, it has no beams or girders, and the projecting outer edges have an L-shaped cross-section, reinforced by single ½-inch bars at top and bottom, virtually forming fascia girders 12 inches deep, which enclose the building at grade. The upper floors are all proportioned for a live load of 250 pounds to the square foot and are divided into panels 3 feet 8 5/16 inches wide and 8 feet 4 inches long in the clear by the transverse and longitudinal girders, which have a uniform depth of 12 inches below the under side of the 3-inch unreinforced floor slab. The main transverse girders are in pairs supported on each row of columns, as shown in the general cross-section and by the details. They carry thirteen lines of intermediate beams connected by transverse girders in the center of each panel.

The longitudinal beams are 3 inches wide and 3 feet 8 5/16 inches apart in the clear. They are reinforced by one 1⅛-inch bar in the lower side and by one ¼-inch bar in the upper part of the floor slab, which is integral with the upper portion of the beam. In all beams and girders vertical U-bars of ½-inch steel with their loops engaging the lower tension rods are arranged close together at the ends of the beams and farther apart in the middle, being spaced so as to conform with the strain sheet of maximum shears, and relieve the concrete from all the computed shearing stress. All angles between the under surface of the floor slabs and the vertical sides of the beams and girders are filleted with solid concrete. On the sides of the longitudinal beams this is rounded off to a radius of about 5 inches; elsewhere it makes an angle of 45 degrees. The exterior ends of all beams and girders are reinforced by a single horizontal ⅝-inch bar 4 feet long, which is bedded in the floor slab and extends nearly through to the outer face of the wall. The main transverse girders 9 inches wide are reinforced by three 1⅛-inch rods in the lower side of each and are arranged in pairs, each girder being 9 inches in the clear from the center line of the columns. Where these girders intersect the longitudinal beams at column centers their inner faces enclose an 18x30-inch rectangle concentric with the cross-section of the column, which varies from 23x23 inches in the first story to 10x10 inches in the fourth story. This space, instead of being left vacant or being made open around the faces of the column, is filled solid with concrete integral with the beams and girders, thus making a solid slab 3 feet square and 17 inches deep over all which includes portions of the beams, girders and floor and forms a cap on top of the lower story of the column. The upper part of the slab is reinforced by four horizontal ¾-inch bars 4 feet long and 8 inches apart, at right angles to a ¼-inch bar 8 feet long which connects the upper sides of the longitudinal beam across the top of the column. The roof is similar to the floors except that the transverse girders, arranged in pairs, are only 3 inches thick, and in order to stiffen them laterally the lower edges of each pair are connected by a horizontal slab like a ceiling strip, 3 feet wide over all, which with the roof surface virtually makes a box girder of each pair.

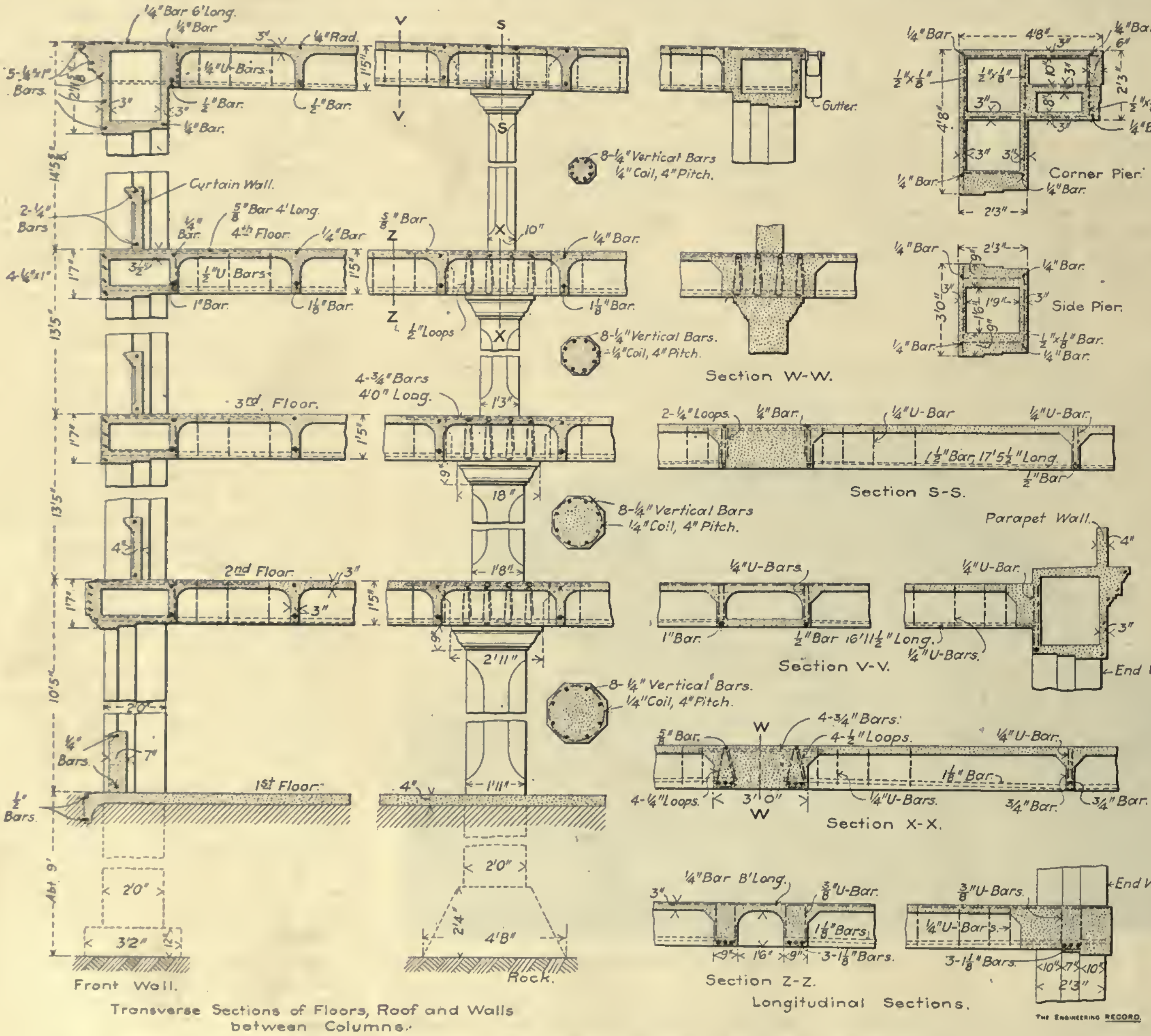
In the planes of the side and end walls all the beams and girders are made special with double webs and are substantially box girders with rectangular cross-sections having sides and tops from 3 to 4 inches thick. The inner web is reinforced with a 1-inch bar at the lower and a ¼-inch bar at the upper edge; the outer webs, which form exterior wall panels between the tiers of windows, are reinforced with four 4x¼-inch bars set obliquely. These beams, called belt courses, were at first designed to be made with removable moulds and to have the floor slab between the webs rest in rebates on the webs, and be removable to allow the core moulds to be taken out, but this plan was abandoned and the beams were made with a core of ⅜-inch hemlock boards permanently enclosed in the concrete.

All space between the wall piers and the outer faces of the wall girders is occupied by very large windows, and by solid concrete panels 2 feet deep between their sills and the floors. The panels under the windows are about 4 inches thick with exterior mouldings on the upper edges to form the window sills. They are reinforced with a single ¼-inch rod in the upper and lower edge and were built in place after the completion of the floors and columns.

There are in each story two flights of stairs, built entirely of concrete and independent of the walls. The string pieces are inclined girders about 3 feet deep and 5 feet apart over all, which have their lower flanges flush with the under sides of the stairs and have the upper flanges moulded to serve as hand rails. The inner face of the solid 2-inch web is plain and the outer face is paneled. They are reinforced by a single 1-inch bar in the lower flange and a ½-inch bar in the upper flange. The lower flange is also reinforced by a 4x5-inch rectangular coil of ¼-inch twisted steel with a pitch of 4 inches, which encloses the tension rod from end to end. The shear in the stringer is provided for by ¼-inch U-bars engaging the lower rod, but not the upper rod. The lower flange projects inwardly and serves as a seat for the steps. These are triangular concrete slabs cast in moulds and built up to position on the stringers. A 3-inch circular hole is cored out of the center and each of the corners is reinforced by a ¼-inch bar, as indicated in the cross-section.

The fireproof doors are made with double leaves each about 9 feet high and 6 feet wide. They are built with crossed diagonal layers of 1-inch tongued and grooved pine covered both sides with tin, and have special heavy strap-hinges bolted to them. The hinges engage forked eyes moulded into the vertical concrete slabs 5 inches thick, which form the door jambs. The door sills are made of single 4-inch channels, flanges down, bedded in the floor concrete with the webs flush with its sloping surface.

Mr. E. L. Ransome, M. Am. Soc. C. E., of New York, was the architect and engineer for the building, and the Ransome & Smith Company, also of New York, was the general contractor.



Details of Concrete-Steel Construction in the Kelly & Jones Factory Building.

An Experimental Septic Tank of 220 gallons capacity was put in operation in November, 1897, by the Massachusetts State Board of Health and continued through 1902. It is divided into three sections, and was at first airtight; later petcocks and pipes were attached above for the ready escape of the larger volume of gas generated. According to the recent report of the Board, the tank has been operated without removal of sludge, and at the end of 1902 about 30 per cent. of its capacity was filled with this matter.

A One-Thousand-Foot English Transporter Bridge.

A transporter bridge of 1,000 feet clear span is now being built to carry highway traffic at low level across the River Mersey between Widnes and Runcorn, England. It will have two pairs of steel towers 190 feet high above water level. These will support two cables from which will be suspended the two stiffening trusses to carry the trolley. Each tower has four cast-iron cylindrical piers 9 feet in diameter seated on solid rock and filled with concrete. Two of them are bolted to the surface of the rock and the other two were sunk about 35 feet below water level by the pneumatic process. The pyramidal towers are 70 feet apart on centers, transversely, and each has a curved outline with four tapered legs 30 feet apart at the base and 6 feet 9 inches apart at the top, where there will be a powerful electric light in a lantern 7½ feet in diameter and 8 feet high.

Each cable will be made of nineteen ropes wrapped with two layers of sail cloth, all well saturated with bituminous compound. Each will contain 2,143 steel wires 0.16 inch diameter with an ultimate strength of 190,000 pounds per square inch and a diameter of about 12 inches. The anchor chains will be connected to three sets of cast-iron plates in each anchor pit. These pits are excavated 30 feet deep in solid rock. Longitudinal and transverse tiers of rails will be laid over the anchor plates and bedded in 7:1 Portland cement concrete rammed solid around the anchor chains. The stiffening trusses will be 18 feet deep, 35 feet apart on centers and will have a clearance of 82 feet above high water level. They will be proportioned for a wind pressure of 56 pounds per square foot and will be hinged in the center and supported on vertical rocker bents at the towers, beyond which they will cantilever several panels towards the shore to carry the trolley over the approaches.

The lower chords of the trusses will carry the track for the thirty-two-wheel trolley car 77 feet long, which is to be propelled by two 35-horse-power electric motors fitted with powerful automatic and hand brakes. The 24x55-foot car will have a capacity for four two-horse wagons and 300 passengers and will be suspended 12 feet clear of the water by inclined steel ropes arranged to prevent transverse or longitudinal oscillations. The car will make a single trip in about 2¼ minutes and is expected to make ten trips per hour. The bridge will be provided with a three-story power station equipped with two 70-horse-power gas engines, two dynamos, a booster and a 246-cell accumulator for the illuminating and operating plant. The total estimated cost is about $650,000; about one-third of that for an ordinary bridge of the same span with high level approaches. Mr. John J. Webster, M. Inst. C. E., of Westminster, and Mr. John T. Wood, M. Inst. C. E., of Liverpool, are the engineers, and Mr. L. H. Chase, M. Inst., C. E., is the resident engineer.

The Philadelphia Filtration System.

PART V.—TORRESDALE FILTERS.

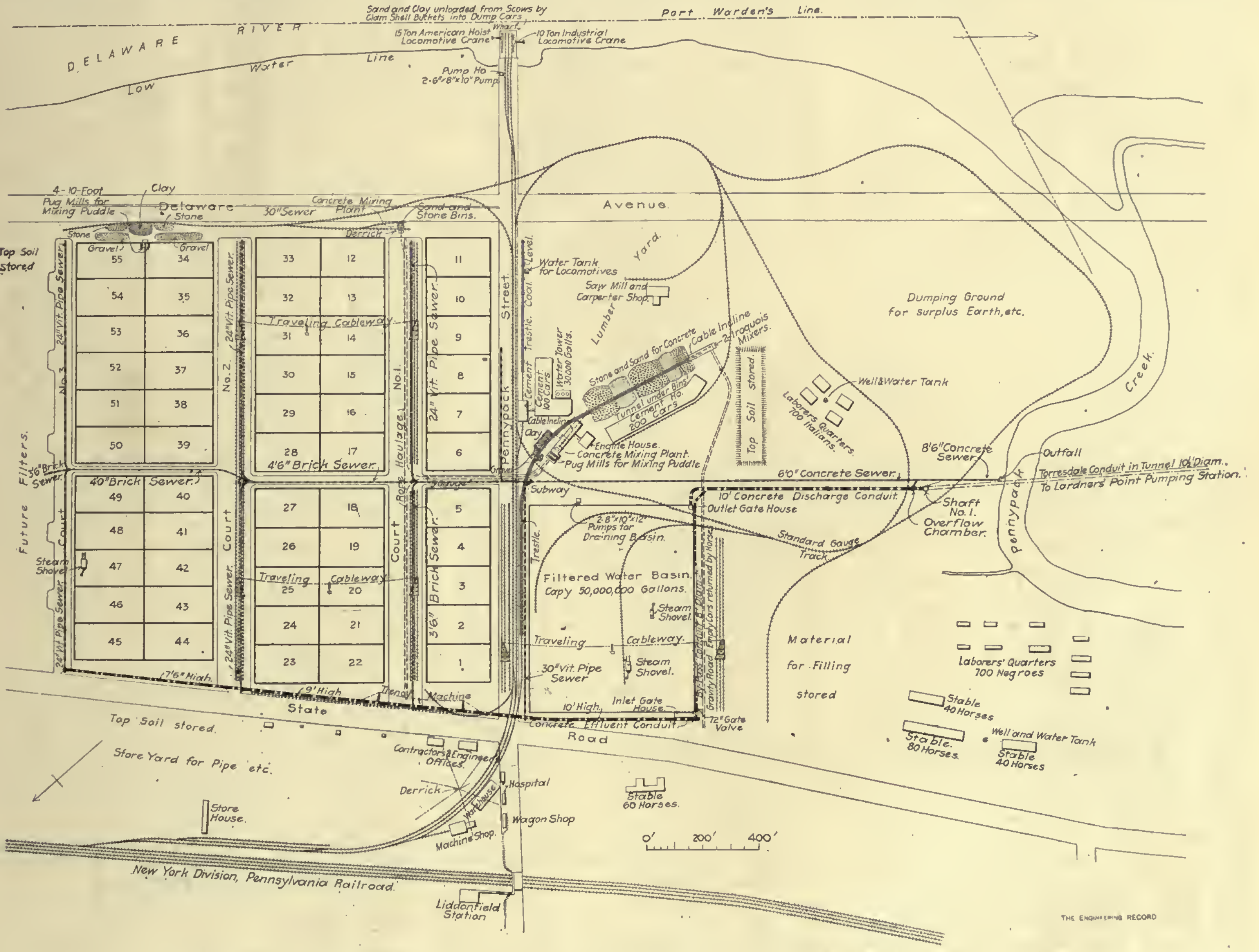
The Torresdale filter plant is the largest in the world and the last of the four plants of the Philadelphia system to be put under construction. The filters are of the same design—covered, slow-sand, concrete groined arch type, with clay puddle under the bottoms and on the sides—as the others described and illustrated January 3, March 28, April 11 and September 12, 1903, and the methods of construction have been similar, but on a larger scale. The position of this plant in the system is shown on a map published Jan. 3, 1903. It is located on the shore of the Delaware River, close to the New York Division of the Pennsylvania Railroad, at the Liddonfield station, in the part of Philadelphia known as Holmesburg, eleven miles by air line from the city hall, and embraces 55 filters of ¾ acre net area, a 50,000,000-gallon filtered-water basin, preliminary filters and a low-lift pumping station. The intake from the river, the low-lift pumping station with its machinery and the preliminary filters have been studied and the final drawings for construction are now being completed. The whole plant is to be equipped with a system of electric lights and with the necessary sand washers, pumps and portable sand ejectors. The ejectors and washers will be like those at the Lower Roxborough plant described and illustrated October 10, 1903. Coal-handling machinery and local pockets will be installed and a spur track laid into the grounds from the Pennsylvania Railroad. A wharf on the river front affords facilities for receiving supplies by water.

General Description.—At a rate of 3,000,000 gallons per acre per day the capacity of the plant will be 106,000,000 gallons, allowing ten or eleven filters to be idle for cleaning or other reasons at all times. With the preliminary filters in operation the rate may be increased to 6,000,000 gallons, thus making the capacity of the plant 212,000,000 gallons. The tract of land secured by the city contains 370 acres and is large enough to accommodate ninety additional filters of the size adopted. The land is substantially level and all the filters will be at the same elevation. On account of the low level of this plant the water cannot flow by gravity into the distribution system, but will pass through a 300,000,000-gallon conduit in tunnel to a large pumping station now being built at Lardner's Point, about 3 miles distant, which will give the water the necessary lift for the requirements of distribution. Water from these works will be supplied to about three-quarters of the area of the city, containing nearly 1,100,000 people at present.

Contract No. 25 for constructing the fifty-five filters, the filtered-water basin and the appurtenant conduits, drains and pipe lines was awarded to Mr. Daniel J. McNichol, of Philadelphia, December 23, 1901, and requires the work to be completed within 780 working days or about July, 1904. Work was begun in January, 1902, and 80 per cent. of the construction required by this contract had been accomplished by January 1 of this year. Aside from the size of these works and the details of design, which are like those in the other plants and have already been described, the principal interest centers in the contractor's plant and methods, and the large reinforced concrete conduits. The extent and general arrangement of the works are well shown by the panoramic view, taken with a camera set up in a central position and revolved to cover contiguous portions of the field successively, presenting at various points different parts of the works in almost every stage of progress. This panorama is reproduced on the inset sheet, and, of course, contains certain distortions unavoidable with this method of photographing, while the general plan herewith shows the locations not only of the filters and their principal appurtenances but also of the contractor's plant and camps.

Thirty-three filters are 140 feet 8 inches by 235 feet 8 inches, and the remaining twenty-two are 133 feet 2 inches by 253 feet 2 inches inside. Topographical conditions necessitated building nine or ten filters wholly or partly on fill, mostly along the old bed of a brook, which was diverted, and the floors of these filters were reinforced with one layer of 3-inch mesh No. 10 expanded metal embedded in the concrete 1½ inches above the bottom, adjoining sheets being lapped 6 inches. The fifty-five filters are arranged in five rows forming three banks separated by courts, with granolithic pavements 122 feet wide to provide for sand washing and storage and other necessary operations, and each bank is subdivided by a cross court.

The raw water will be delivered to the preliminary filters by low-lift pumps, and flow by



General Plan of the Torresdale Filters, Philadelphia, Showing the Contractor's Plant and Laborers' Quarters.

gravity through cast-iron pipes to the main filters. Five lines of 48-inch pipes have been laid along Delaware Avenue to court No. 1, where two turn at right angles, one being laid on either side of the court close to the filters; three mains continue to court No. 2, where two more turn off, and the fifth pipe extends to court No. 3, up which it turns to feed the fifth row of filters. As these mains extend up the courts, they are reduced in diameter successively to 42, 36 and 24 inches. Before any of the 24-inch feeders to the filters are taken off, the two 48-inch mains in both court No. 1 and court No. 2 are cross-connected by a 48-inch pipe, three 48-inch gates being set to control the flow so that water from either or both mains may be supplied to either or both rows of filters. These and the other principal pipes and the drains for court No. 1 are shown on the accompanying plan of piping, which is typical for all the courts. For handling these heavy pipes and fittings, as well as for many other operations, a 5-ton locomotive revolving crane, built by the Brown Hoisting Machinery Company, of Cleveland, was found very serviceable.

The regulating chambers and their piping, as well as the superstructures which cover them, are similar to those at Belmont, described and illustrated September 12, 1903. The principal pipes and valves for each regulating house were set and their joints made soon after the concrete floor had been placed and before the walls were built, as is clearly shown in one of the pictures. The filtered-water basin is 601 feet 10 inches by 762 feet 2 inches inside, with an available depth of 15 feet, giving a capacity of 50,000,000 gallons; it is of covered, groined arch concrete construction, similar to the Belmont basin. The filtered water will enter it at one corner through an inlet gatehouse and be drawn out through another gatehouse on an opposite corner, or the water can be by-passed through an 8-foot circular concrete and expanded metal conduit 800 feet long.

In the construction of the portion of the plant comprehended by contract No. 25, the following principal quantities are involved: 935,200 cubic yards earth excavation, 298,000 cubic yards of embankment, 117,850 cubic yards clay puddle, 168,650 cubic yards Portland cement concrete, 300,000 barrels Giant, Lehigh and Star Bonneville Portland cement, 7,000 tons cast-iron pipe and 960 tons of special castings, 680,000 square feet expanded metal, 434 tons of structural steel and approximately 5,000,000 feet board measure of lumber for forms, railroad trestles and similar purposes. A slight amount of rock excavation was necessary. The total payments for the work under this contract will amount to about $4,940,000, and the estimated total cost of the work ready for operation is in round figures $10,470,000. For handling such large quantities of materials and executing work of such magnitude evidently a complete extensive and costly contractor's equipment was necessary.

Contractor's Plant.—The general layout of the contractor's plant and its relation to the works are shown by the accompanying general plan. At the maximum about 200 horses and over 300 wagons and scrapers of various kinds were used, and to care for them large stables and blacksmith and harness repair shops were built. Besides the smithy work for horses and wagons, the sharpening of picks and miscellaneous jobbing had to be provided for and so two blacksmith shops were built and six forges, furnished by the Canedy Manufacturing Company, of Chicago Heights, Ill., were set up in them. Owing to the distance from the city and the magnitude of the plant, it was found economical to build a machine shop and equip it with drill presses, a lathe and other tools necessary for doing quite a range of shop work. A 12-horse-power Turner rotary compound engine furnished the power, and steam for this engine and for heating several buildings was supplied by a 60-horse-power vertical boiler. For the extensive woodworking operations in making centers and forms, a small sawmill and carpenter shop were placed in the lumber yard and equipped with one band and two circular saws, power for which was furnished by a 20-horse-power engine and boiler. A large number of forms and centers were needed for the concrete work, although many of them were used several times; they were generally made considerably in advance and stored as shown in the views.

Two camps were established for laborers, one with accommodations for 700 Italians and the other for 700 negroes, besides which there were buildings for housing other men, providing in all for about 1,000 colored and 1,200 Italian laborers. To care for the injured a hospital was built and equipped, and arrangements made for attendants and a physician. The maximum number of men of all classes employed at any time has been about 1,600.

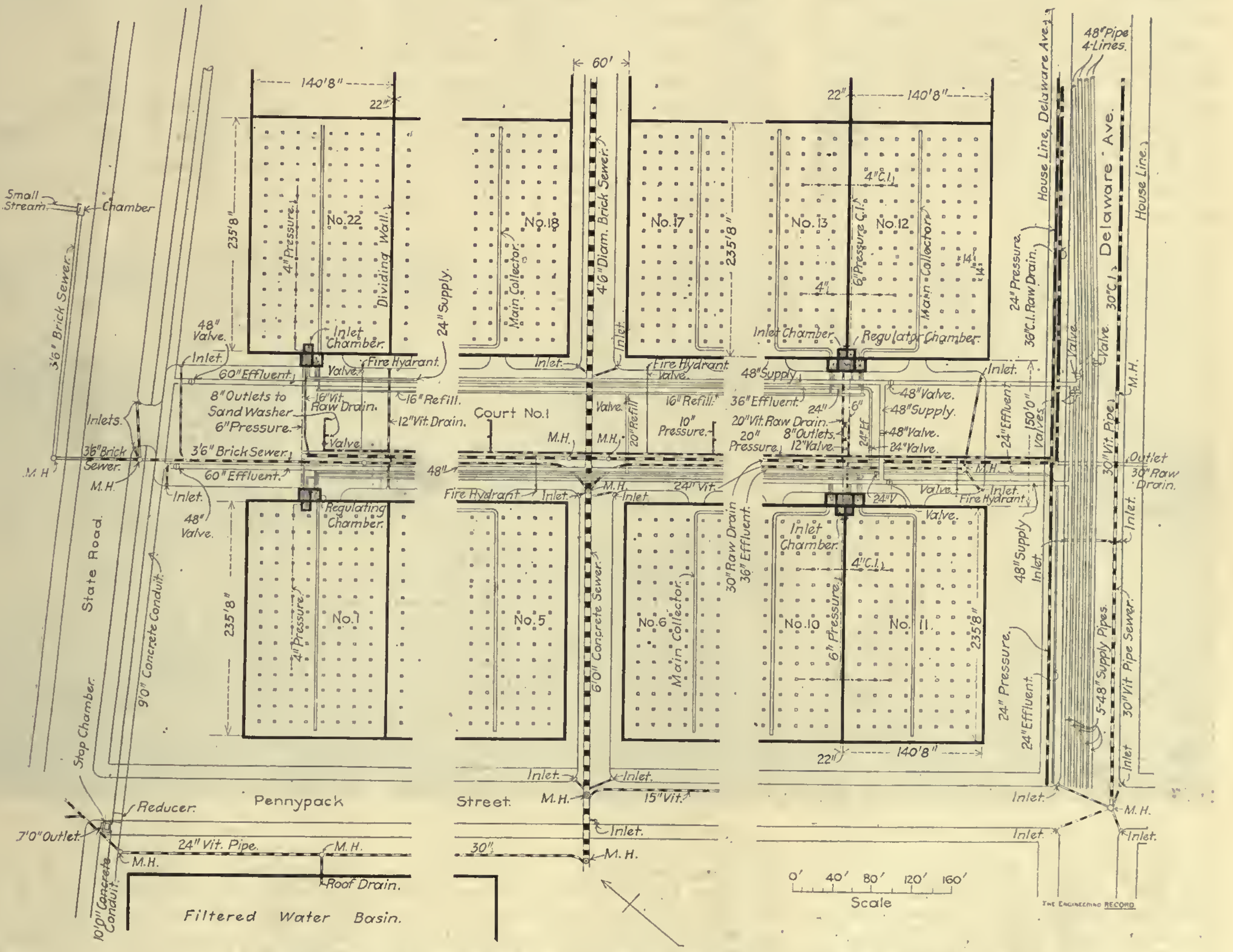
Coal, cement, broken stone, lumber, steel, pipes and most of the miscellaneous supplies were delivered over the Pennsylvania Railroad, from which spur tracks were run on to the site and to the various storehouses and yards, as shown. Sand and clay were brought in barges to the 70x300-foot wharf and unloaded into cars by 10-ton and 15-ton locomotive cranes built respectively by the Industrial Iron Works, of Bay City., Mich., and the American Hoist & Derrick Company, of St. Paul, Minn. From the wharf standard-gauge tracks were laid to connect with the other parts of the plant railroad system. In all there are some 6 miles of standard-gauge tracks for freight-handling and excavating purposes, and to move the cars on these tracks one 35-ton Baldwin locomotive, with tender, and one 26-ton, one 42-ton and two 30-ton Baldwin saddle tank locomotives have been used. Coal was stored in piles under a railroad trestle on to which the loaded cars were run and then dumped; likewise sand and broken stone for concrete and clay for puddle. There are in all 1,460 feet of trestle, parts of which are shown in the illustrations, the part at the storage piles being 30 feet high. There is a store yard for pipes and fittings and another for lumber. For unloading heavy materials from the cars and handling them in the yards two guyed derricks with 60-foot booms and double drum Lidgerwood hoisting engines were installed. In order to keep a good stock of cement on hand one small and two large storehouses were built, having a combined capacity of over 300 carloads.

Excavation.—Although the sites for a few filters required filling to a maximum depth of about 5 feet, the topography of the greater part of the site necessitated excavation. The average depth of cut for the filters was about 8 feet and the maximum 15 feet; the cut for the filtered-water basin averaged 20 feet in depth with a maximum of 24½ feet, and in some spots 4 or 5 feet of mud were taken out below grade and the holes refilled with cobbles covered with gravel and rolled. In view of the depth, size and character of the excavations, which were mostly in sand and gravel, steam shovels were employed for a large part of the work. The filter excavations were made by a 45-ton Bucyrus shovel with a 1¾-cubic yard dipper loading wagons, while a 55-ton Marion shovel with a 2½-cubic yard dipper, a 65-ton Vulcan shovel with a 3-cubic yard dipper and a 35-ton Vulcan traction shovel, with a 1-cubic yard dipper were worked in the filtered-water basin and loaded into dump cars, of which there were sixty of 6 cubic yards capacity and 30 of 5 cubic yards capacity, all standard gauge. Ample and convenient spaces, as shown on the plan, were reserved for dumping the spoil from the excavations and for storing the top soil and other selected materials to be used in refills and embankments. The fills for the foundation required for some of the filters were made soon after the work was well started, being built to an elevation of 1 foot above subgrade, in 4-inch layers well rolled by one 12-ton and two 10-ton Buffalo-Pitts steam rollers. The surplus on these fills was subsequently excavated just before the placing of the puddle for the filters.

Puddle.—A 12-inch lining of puddle made of equal parts of rich stiff clay and fine broken stone or gravel has been placed, as at all the other plants, beneath and on the sides of the filters and filtered-water basin and on the roof of the basin. Three puddle-mixing plants, each containing two pug mills, were set up at convenient points and delivered the puddle to carts by means of which it was conveyed to the places where used. The equipment of two plants included four Wallace mills 10 feet long, driven by two 50-horse-power Nagle portable engines and boilers, and the other plant consisted of two 12-foot Raymond mills driven by the engine of an adjacent concrete-mixing plant. The combined capacity of the three puddle plants was about 450 cubic yards per day. The puddle, while in a plastic condition, was spread in layers about 6 inches thick and allowed to partially dry out, during which process it was rolled until all shrinkage cracks were closed and the entire mass thoroughly compacted and made watertight, the time required varying, of course, with weather and other conditions. For this service there were used a 12-ton, an 8-ton, a 3-ton Universal steam roller, with curved ribs on the rolls, made by Julian Scholl & Company, of New York, a 2-ton and two 4-ton grooved horse rollers and a 2-ton stone roller. In those places, on the sides of the filters and elsewhere, which could not be reached by the rollers, the puddle was thoroughly rammed. Portions of this puddle, after being rolled in place, passed through a winter and other portions through protracted summer droughts, uncovered, without injury.

Grading.—Excepting the excavated materials, taken in cars to the spoil dumps and storage piles, the earth for the fills and enbankments was mostly hauled in 2-cubic-yard dump wagons and tip carts, some 120 wagons of the Austin, Day and Watson makes and 30 carts being used for this purpose and for hauling puddle, concrete materials, etc. The spreading of the earth in embankments and similar places was accomplished by means of a Champion and a Western Wheeled Scraper Company's road scraper. A New Era grader and a traction engine were used for removing top soil.

Concrete.—For the filters, filtered-water basin, conduits and sewers all concrete was mixed in the proportion of 1:8 by volume, there being usually three volumes of sand and five of broken stone, but these were varied slightly so as to obtain always a dense mixture. It was specified that in measuring the ingredients the cement should be considered as of the same compactness as in the original package, so that 380 pounds of dry Portland cement would have approximately a volume of 3.6 cubic feet. The sand was required to be composed of grains ranging from fine to coarse, thoroughly screened to reject all particles having greater diameters than ¼ inch, and to contain in the aggregate not more than 3 per cent. by weight of loam, clay or other impurities. For ballast broken limestone brought from Norristown, Pa., was used almost exclusively, and it was required to be graded from fine to coarse, crushed so that its greatest dimension would pass through a 1½-inch ring and screened to remove all particles having a less diameter than ¼ inch. For the piers supporting the roofs the stones were restricted to ¾-inch maximum dimension. Some of the excavations yielded large quantities of small boulders, and these were picked out and stored in piles for concrete ballast. To crush them a Kennett Square portable stone crusher, with engine and boiler, was set up, and bins for storing and loading built nearby. Sufficient water was used to make a rather wet mixture for most of the work, especially for the piers.



The Torresdale Filters, Philadelphia: Partial Plan of the Pipes, Conduits and Sewers.

With so large quantities of concrete required in the filters and filtered-water basin, how and where to mix it and how to deliver and place it, were interesting problems for the contractor to solve. The specifications called for mixing in batches by machinery in cubical box mixers. A large central plant was determined upon, arranged as shown in general on the plan and in some detail by the views, with a battery of three 5-foot Carlin cubes having a combined capacity of 500 to 600 cubic yards in ten hours, at one end, and a second battery of two 1-cubic-yard Iroquois asphalt-type mixers with an output of 225 cubic yards in ten hours, at the other end. To drive the larger battery an 80-horse-power Hollidaysburg engine was installed in a small house nearby, while for the other battery a 50-horse-power Nagle portable engine was provided. Besides this plant two single 5-foot Carlin cubical mixers, with a capacity of about 200 cubic yards each in ten hours, driven by 25-horse-power Nagle portable engines, mounted in suitable trestle towers were employed, being moved to suit the convenience of the work. One of these is shown in an accompanying illustration. The ingredients fed to each of these isolated mixers were handled by means of a 55-foot-boom stiff-leg bull-wheel derrick and a Lidgerwood double-drum hoisting engine set up close by. Certain exigencies of the work made it necessary occasionally to mix small quantities of concrete by hand close to the place of deposit, but the total of the hand work was insignificant compared to the whole.

The three Carlin cubes in the central plant were installed in a trestle tower near the stone and sand bins under the end of one of the railroad trestles previously mentioned. From the tower an incline leads down to a tunnel beneath the bins. Through the tunnel and on the incline narrow-gauge tracks were laid over which small measuring cars holding a charge of sand, cement and stone for a 1½-cubic-yard batch for one mixer are hauled by a ⅝-inch steel wire cable winding on to the drum of a Lidgerwood hoisting engine installed in a small house at the head of the incline. The cars had three compartments and, as each one was pushed through the tunnel, the cement was put into the small compartment as the car passed the gangway from the cement house, and then the stone and sand were measured into the larger compartments from the bins overhead. Two of the cars have hopper bottoms and by setting a stop and tripping device these cars are stopped and dumped automatically into the hopper over any one of the three mixers as desired. However, as some annoyance was experienced with the latching of the bottoms of these cars after they were emptied, the other cars were made with the dumping door on one side at the bottom, with a hand lever for latching. The water is supplied from three automatic steel measuring tanks standing on the top deck of the tower, as seen in one of the views. Empty cars return down the incline by gravity, under control of the cable. In both directions the cars travel at high speed. The arrangement for the Iroquois mixers is similar, as shown by the illustrations.

To distribute the concrete mixed in this central plant a system of cable haulage, installed by the Trenton Iron Company, of Trenton, N. J., a 3-foot-gauge gravity railway and three Lidgerwood traveling cableways are used. The gravity railway is double-tracked and extends from the Iroquois mixers to and along the nearer side of the filtered-water basin, the empty cars being returned to the mixer by horses. It is equipped with small platform cars for carrying 1½-cubic yard buckets. The cable-haulage equipment comprises 5,000 feet of 3-foot-gauge tracks, with an equal length of cable, and seventeen grip cars for carrying 1½-cubic-yard steel buckets. A 50-horse-power Erie high-pressure engine, installed in a house near the three Carlin cubes, actuates the cable, and in this same house are two 65-horse-power boilers in brick settings, which furnish steam for this engine, for those running the concrete plant, for the two adjacent pug mills and for the pumps which drain the filtered-water basin excavation. The cable system was first laid in court No. 1 and later transferred to court No. 2. In its first position it delivered concrete for filters Nos. 1 to 11 and Nos. 12 to 33, and in the second position it supplied the remaining filters.

On both gravity and cable roads the cars run beneath the mixers, and after receiving their loads of concrete carry them to the towers of the proper cableway. At first one cableway was set up to span the filters between Pennypack Street and court No. 1, while the second spanned the filters between courts Nos. 1 and 2. Later both were set to serve this second bank of filters, as shown on the general plan, their span being 750 feet. Afterwards they were set to span the filters between courts Nos. 2 and 3, and in this position will complete the filters now under construction during the coming summer. The third cableway, of 800 feet span, serves the filtered-water basin. The method of operation has been the same in all cases. The buckets of concrete are lifted from the cars by the cableway hoist, transferred to the place where the concrete is being deposited on the bottom or in the forms and dumped. The cableways handle on the average about 200 bucketfuls each per day, and it requires about two minutes to lift a bucket from the car, carry it to place, dump it and return. The maximum record for one cableway was 330 batches, equivalent to 495 cubic yards, deposited in roof and floor in one working day. The floors have been laid in blocks, each block being one-half of the square whose corners are at the centers of four columns. Such a block contains 3 cubic yards, or 2 bucketfuls, of concrete, and is deposited and rammed in layers. About thirty men have placed and finished 300 cubic yards of floor in a day at a cost of about 45 cents per cubic yard after the delivery of the concrete by the cableway. For rapidly spreading the large batches of concrete immediately after they were dumped from the cableway buckets on to the roof forms, long-handled four-tined hooks or rakes were found useful. The method of using these tools is shown in one of the illustrations. The spreading with them was supplemented by the use of shovel and by ramming.

Each day a 6-inch test cube has been made from concrete taken from one of the batches, these samples being taken from different places on succeeding days so as to represent the concrete in all parts of the works. Proper records are made of the date and location of the concrete represented by each cube. These cubes are broken at the end of 30, 90 and 180 days and 1 year. The 180-day cubes have shown an average crushing strength of about 1,500 pounds per square inch, frequently running as high as 2,500 pounds and seldom or never below 1,200. As is not surprising on such extensive works, at a few places the concrete has been found unsatisfactory on the removal of the forms and has required correction. The great bulk of the concrete in the completed filters and the portion of the filtered-water basin which has been built is of excellent quality and presents very smooth surfaces free from voids or protruding stones. Time and trouble were saved and smoothness gained in the roof groins by tacking strips, a few inches wide, of heavy sheathing paper over the groin joints of the forms after the various sections of forms for a given portion of a roof had been set. This remedy was used, however, only on joints which failed to match within ¼ inch; these cases, which were not numerous considering the total number, occurred generally with forms which had been used more than once; large cracks in forms were closed by strips of wood.

Some cracks have occurred in the concrete walls, usually at intervals of about 50 feet. Many of these are only fine cracks requiring but little more than a brushing of grout to close them; the comparatively few larger cracks have been cut out and calked. A number of the completed filter basins have been tested for leakage and have given remarkably good results, as is shown by the following examples:

No. of filter.	Date started.	Date last report.	No. of days.	Final 24-hour leakage. Gallons.	Date accepted.
1	5-21-03	6-8-03	18	244	6-9-03
2	8-10-03	8-26-03	16	244	8-26-03
3	9-4-03	9-23-03	19	0	9-24-03
4	9-29-03	10-24-03	25	0	11-13-03
5	11-1-03	11-24-03	23	488	11-27-03
8	10-31-03	1-12-04	57*	732	1-14-04
9	10-3-03.	10-24-03	21	0	11-13-03
11	10-29-03	11-24-03	26	244	11-27-03
29	12-19-03	1-12-04	24	732	1-14-04

*Water drawn off to repair filter 16 days.

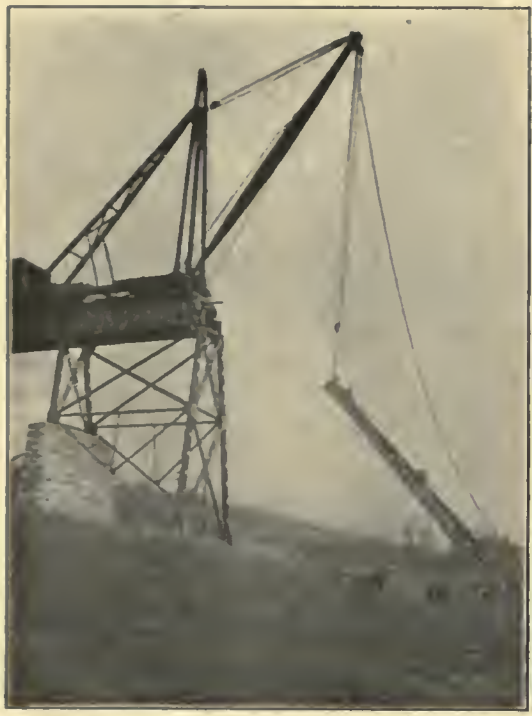
Filter Sand and Gravel.—The filter sand and the gravel for covering the underdrains will be of the same kinds and sizes as those used in the other works and previously described. The main collectors will be like those at Belmont, for which drawings were given in a preceding article. The appearance of the gravel, as placed over the underdrains ready to receive the sand, is very clearly shown in an accompanying interior view of a finished filter at Upper Roxborough. For the fifty-five filters now under construction, 99,000 linear feet of 8-inch perforated terra cotta collectors, 62,600 cubic yards of gravel of all sizes and 198,900 cubic yards of sand will be required, and will be introduced through the sand runs and the ventilator openings. The traveling cableways will probably be used to some extent to assist in distributing these materials. The total cost of the sand, gravel and collectors in place will be, in round numbers, $1,027,000. The delivering and placing is expected to begin about May 1, and will be finished about January 1, 1905.

Mr. John W. Hill is chief engineer of the Bureau of Filtration, and the plant at Torresdale, like the others, is being constructed under his general supervision; Mr. Frederick C. Dunlap is resident engineer.

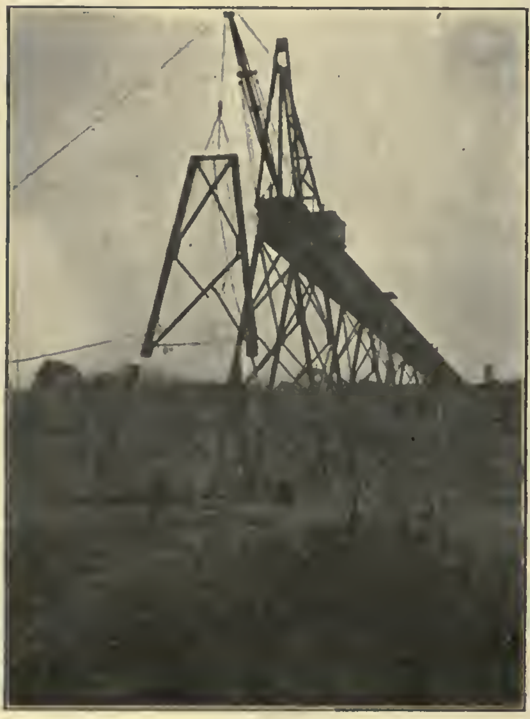
(To be continued.)

The Des Moines River Viaduct of the Chicago Great Western Railway.

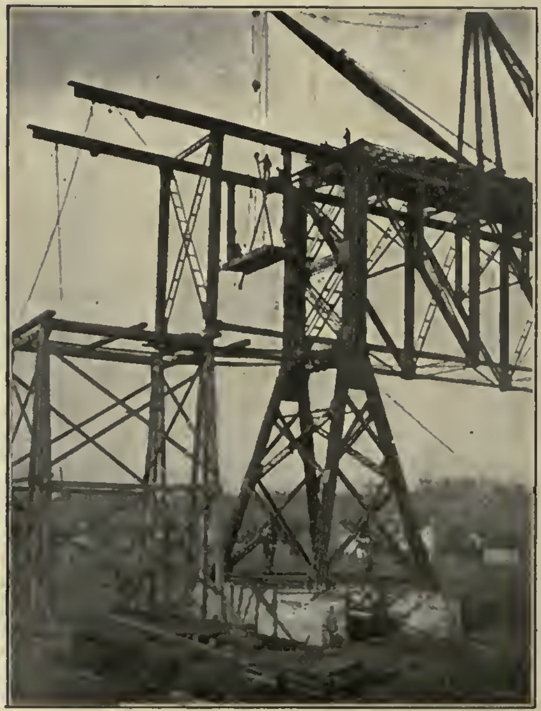
PART II.—PLATE-GIRDER SPANS AND ERECTION.



Erecting a Complete Tower Bent.



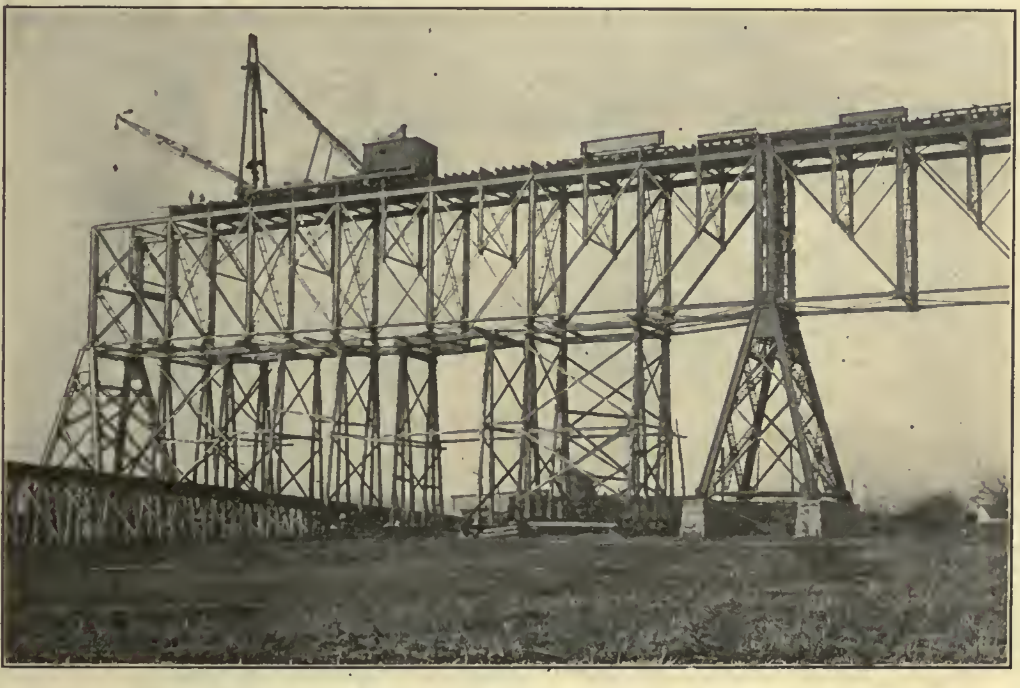
Erecting Upper Section of a Tower Bent.



Erecting a Deck Span.

There are two lines of main girders 10 feet apart on centers which are braced together by ordinary sway-brace frames and top and bottom zigzag angles riveted to connection plates on the girder flanges. They have a uniform depth of 7 feet from back to back of flange angles. The regular girders on top of the towers are 39 feet 3 inches long from out to out and 38 feet long on centers of bearings. They are made with two ⅜-inch web plates spliced with two cover plates and four vertical rows of rivets. Each flange has two 6x6x9/16-inch angles and the web projects ¾ inch above the top flange angles to lock the ties in position. Panels from 2 feet 6 inches wide at the ends to 3 feet 8 inches wide in the center are made by pairs of 3x5x⅜-inch vertical stiffener angles riveted to the opposite sides of the web, with filler plates at sway brace points only, and fitted ends. These girders extend across the full width of the tower caps and their end panels are notched from the top flange to the center line to form seats 16 inches long to receive the ends of the connecting span girders which have the lower sides notched to correspond. The lower halves of the end panels of the webs are reinforced to a thickness of 1½ inches and have ten vertical stiffener angles riveted to them to form a sort of pedestal on the center line of the tower column for the seat of the supported girder.

The regular connecting girders are 76 feet 3 inches long over all, 75 feet long on centers of bearings and 73 feet 7 inches long on the lower flange. They are made like the 38-foot girders, except for the dimensions of the materials. The web is made in three lengths and both top and bottom flanges are reinforced by three cover plates of different lengths. The ends are notched on the lower side to correspond with and be the reverse of those in the 38-foot girders and are similarly reinforced, except that the outside web plates extend the full depth of the girder. The drop ends are seated, as indicated in the view at the top of the tower post, on the ends of the 38-foot girders, and the top flanges of both girders are connected by cover plates, which are generally field-riveted to the long girders and bolted through slotted holes to the short girders at expansion joints and riveted to them at fixed joints. At their bearings the girders are bolted together with four bolts which, at the expansion joints, engage slotted holes in the lower flanges of the long girders. This arrangement permits the 75-foot girders to expand and contract freely with temperature changes, the tower girders being riveted fast to the towers at both ends.



Falsework and Trestles for Erecting a Deck Span of the Des Moines River Viaduct.

At the towers nearest the truss spans the 75-foot girders have expansion joints at the tower girders at both ends. In all other cases the 75-foot girders have expansion joints at one end of the tower girders and fixed joints at the other ends. At the east end of the viaduct the girders connecting the tower to the abutment are 38 feet 9½ inches long over all and resemble the 75-foot girders, except that the ends are not notched at the abutments, but are full depth there and are seated on special cast-steel pedestals with transverse ribs engaging holes mortised in their base plates.

At the west end of the viaduct the abutment girders are similar to those at the east end, except that they are 75 feet 9½ inches long over all. In both cases they are anchor-bolted through the pedestals to the abutment masonry and have expansion joints on the tower girders. The girders at both ends of the truss spans are also special and are like the regular 75-foot girders at the ends away from the spans. At the ends adjacent to the spans they are made full length and are seated on cross girders connected to the end posts of the trusses. At this point the end sway brace frame consists of three horizontal struts and two panels of X-bracing. Near the center line of the girder there are horizontal angles riveted to the outsides of the web about 6 feet from the ends of the girders, which diverge to connect with the top chords of the trusses, which are spaced about twice as far apart as the girders are.

The adjacent ends of the trusses and girders both have fixed connections to the tower and the arrangement of braces makes the lateral system continuous between the viaduct and the span. The braces are pairs of 6x6x7/16-inch angles and are calculated for a tensile or compressive stress of 66,500 pounds. At the river ends they are connected directly to the top lateral system of the spans and at the shore ends they distribute their stresses to both top and bottom lateral systems of the viaduct through the intermediate cross struts made of two 6x6x⅜-inch angles which connect the webs of the girders at their extremities.

Five hand-car retreats 12 feet long and about 9 feet wide outside of the track were placed at intervals of about 500 feet and were supported on angle-iron brackets riveted to the girders opposite the sway frames, and on the trusses they were supported directly by the floor-beams. All of them were covered by a solid plank floor and protected by a hand rail which extended the full length of the viaduct, offsetting at the hand-car retreats.

All steel was delivered at the east end of the viaduct and stored outside of and between the tracks, where it was handled by a derrick car on a standard-gauge track, which served as a tender and delivered it from the storage yards to the traveler. The traveler was essentially a large derrick car with a long timber platform mounted on ten wheels running on a track of 10-foot gauge. At the rear of the platform the hoisting engine, boiler and coal and water supplies were located in a small house and at the front of the platform there was a three-post vertical bent about 45 feet high like a shear frame. The vertical middle post of this bent served as a mast and terminated about 10 feet from the top of the two battered side posts. At the foot of it was pivoted a 64-foot trussed boom with three spreaders and a 4x12-inch Douglass fir truss plank on each of the four sides. The boom had a capacity of 52,000 pounds at full radius. It was rigged with eight-part wire rope hoisting and topping-lift tackles, and the latter was connected to the top of the mast, where it was braced by a pair of stiff-legs which spread out to the full width of the derrick platform near the rear end. For light work the rope was reeved through only four or six sheaves. A horizontal beam about 6 feet long was attached to the boom about 15 feet from its point and to its extremities four-part Manila rope tackles were attached which were also secured to the ends of the transverse sill at the forward end of the derrick platform. These tackles were operated by the hoisting engine to swing the boom about 20 feet from the center laterally and enable it to set the tower columns and the members of the trusses.

Material was delivered from the storage yards by the derrick car on a standard-gauge track concentric with the 10-foot track of the traveler. As near as possible to the required place it was unloaded on the ground or on the ends of the truss-span floor-beams outside the rails of the 10-foot track. After the derrick car had been removed, the traveler lifted the material and carried it to place.

The first tower bent of the viaduct was assembled on shore, lowered to position by the traveler and guyed until the girders of the first span were connected to it and the floor was built. The traveler then moved out of this span and erected the second bent and its girders and so on until the truss spans were reached. When the tower posts were in single lengths, the transverse bents were assembled together horizontally on the ground and revolved up into position on their pedestals by the traveler boom, the lifting tackle being attached to a bridle connected to the tops of both posts. The first bent of each tower was a little beyond the reach of the boom so that when it was revolved nearly into position, it was necessary to pull it forward to a vertical plane by hand guys assisted by runners from the hoisting engine on the traveler. When the tower posts were spliced in the field, the lower sections of the first bent were assembled and set on the masonry, as above described, and guyed with the tops inclined a little backwards towards the traveler. The top sections were then assembled and connected to them and the floor erected before the second bent was raised. When this bent had spliced posts, the lower sections were erected separately and braced together and afterwards the upper section of the bent was assembled horizontally on the ground fully bolted, except for the lower diagonal braces, and lifted by the derrick and set in position, it being possible to spring the posts sufficiently to make the splice connections. The ends of the girders adjacent to the first truss span were temporarily supported on falsework bents, while the traveler moved out on them and erected the A-towers which carried the ends of the truss spans. The traveler then erected and braced two bents of falsework on which the end panels of the trusses were assembled.

In order to erect the second sections of the top chord readily (the splice being just a little toward the end from the second full panel point), a temporary bent was added upon the falsework to support the top chord and allow the floor-beams and stringers to be put in up to the middle of the second panel, when a third bent of falsework was put out and the second section of the chord and the third vertical were bolted together and raised, coupled to that which had been previously put up, and braced; and so on, completing to the third panel. In this way each truss was erected until the last full panel point was reached, when the next tower was raised and braced before the last panel of the truss was put in place. The same falsework was used for all the truss spans, each bent as wanted being taken from its position under the completed span, raised at the side of the truss (guys being carried out on the opposite side from the point of the boom to prevent overturning) and carried forward above the deck and launched into its new place.

The study of the site was commenced in July, 1901. Sub-structure work was commenced in October, 1901, and finished in June, 1902, and included the building of about 3,900 yards of stone masonry and about 9,300 yards of concrete. The superstructure weighed about 3,350 tons and its erection was commenced October 8, 1902, and finished March 10, 1903. The 220-foot spans weighed about 341 tons each, and the heaviest pieces in the viaduct were the 75-foot girders which weighed 36,000 pounds each.

It is an unusual fact, and extremely creditable to the supervision of the work, that from beginning to end of its construction, a period of about seventeen months, while there were from 50 to 200 men constantly employed, working in dangerous positions and handling heavy materials in inclement weather, that no serious accidents of any nature occurred, the most important one being the loss of a finger. The difficulties encountered in the exposed situation are indicated by the fact that when the viaduct was painted, splashes of the black paint were carried by the wind along the track of the Minneapolis & St. Louis Railroad 300 feet away and 100 feet below.

Mr. H. C. Keith, bridge engineer of the Mason City & Ft. Dodge Railroad, was in direct supervision of the design and construction, and to him acknowledgment is made for data. The Bates & Rogers Construction Company, of Chicago, was the contractor for the substructure. The American Bridge Company was the contractor for the superstructure, and the 38-foot girders and towers were built at their Milwaukee plant, the 75-foot girders at the American shops, Chicago, and the truss spans and towers in the Detroit plant, except the eye-bars, which were made at the Pencoyd plant. The Kelly-Atkinson Construction Company was the sub-contractor for the erection of the steel-work.

Notes on Railway Construction from the Resident Engineer's Standpoint.

A paper read before the Iowa Engineering Society by F. C. French, Continued from page 134.

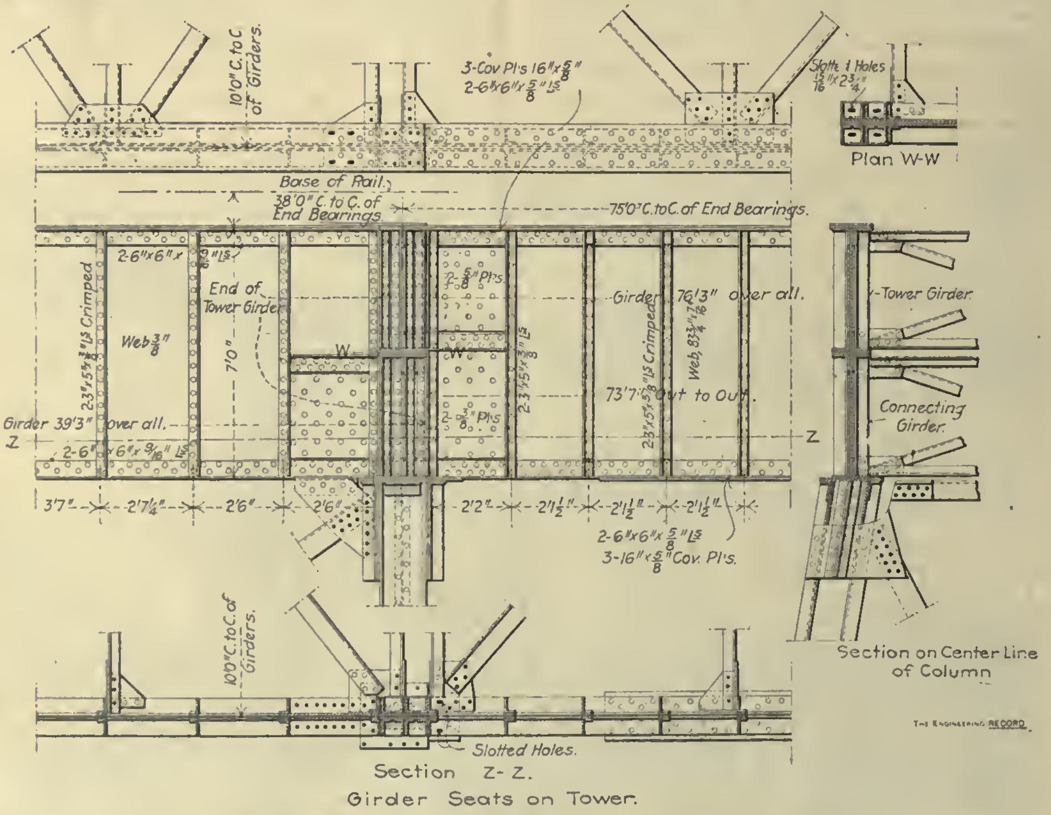
Masonry.—In staking out masonry, the stakes for the neat lines should be set far enough back from the work to permit of its being carried on without interference with the stakes and in such a position that lines stretched between tacks will intersect at the neat corners. The working plan furnished the contractor's foreman must show locations of all stakes. The slope stakes should be set at such points as will reasonably prevent caving during construction, and the cross-sections taken in squares over a larger area so that in case caving occurs a complete record of the surface is at hand. Stakes should not be set on these squares, but the slopes set independently.

All foundation courses must be spread well below the frost line, unless placed on solid rock, and in concrete foundations without grillage the excavation should be of dimensions equal to the footing course, while in stone masonry excavation should be made one foot larger each way than the dimensions of the footing course.

A complete record and sketches of all masonry must be kept, particularly of the foundations which will be covered up later on. The depth in every case must be given below some fixed point such as the coping or bridge seat. In all cases of uncertain foundations, special instructions will be issued by the chief engineer.

Culverts.—All culverts should be laid out at right angles to the center line when possible and have their foundations below the frost line and at sufficient depth and grade that the culvert will drain itself and, in general, the borrow bits adjacent. Every culvert must be placed so that it may safely work under a moderate head without injury to itself, and at as large a grade as the nature of the ground and its safety will admit. Both ends should be protected by a sunk wall extending at least three feet below the floor and the lower end must be protected by an apron or some arrangement to prevent undermining by the backwash.

Vitrified pipes, when used, must be at least 3 feet below sub-grade and crowned a few inches at the center. The bottom of the trench for pipe must be rounded and holes dug for the sockets. In case the foundation is poor, it must be excavated and suitable material placed. Stone must never be permitted in contact with the pipe. When filling over pipe use drag scrapers to build up walls parallel to pipe and as close as possible to each side, giving the space over the pipe a more moderate packing. This will imitate to a degree the usual practice of pipe laying in trenches. When two rows of pipe are used, they should be far enough apart to admit of thorough work between them.



The Des Moines River Viaduct: Details of Girder Seats on Towers.

Blind drains are sometimes made of rough stones thrown in without particular order and covered over with brush and sod. Their use is objectionable, however, and should be restricted to few cases.

Piling.—All pile bridges should be staked out ahead of the driver, setting a hub for the center of each bent and a stake for each pile, being careful to use the near face of the pile for the station, as centers can then be plumbed up from the hubs without the continual use of an instrument.

Pile inspectors should be appointed by the engineer, whose duties are to watch the driving of all piles and keep a record of each, seeing to it that every pile is driven deep enough to be secure against wash and scour as well as against sinking under the load. The inspector should be provided with a pile record book in which to keep a careful record of the bent number of each pile, and the pile letter, together with sketches of all pile foundations other than trestles, in order that the piles in the record may be identified. The bents are numbered consecutively, the bank bent being (1) and so on, and the piles in each bent lettered A, B, C, D, etc., from left to right when looking with the stationing. The pile record will then show on the left hand page: First, station; second, bent number and pile letter; third, length put in leads; fourth, kind of pile and whether treated or untreated; fifth, penetration below surface; sixth, length below cut off, to be filled in later; seventh, penetration under last five blows; eighth, weight of hammer and last drop in feet. On the right hand page all remarks on the progress and method of conducting work should be made.

The pile inspector will see that long piles are not used where shorter ones are ample, and that due precautions against brooming are used by having the heads well chamfered or pile rings used. In hard driving, piles should be shod. A good formula for safe load in pounds is 2 WH ÷ (S + 1), where W is the weight of the hammer in pounds; H the fall in feet; S the set of the pile in inches under last blow.

When leaving a residency, the inspector will turn over the records to the resident engineer, who will hand them in with his final notes. Where piles are driven by the company, the company foreman will keep the records of the inspector.

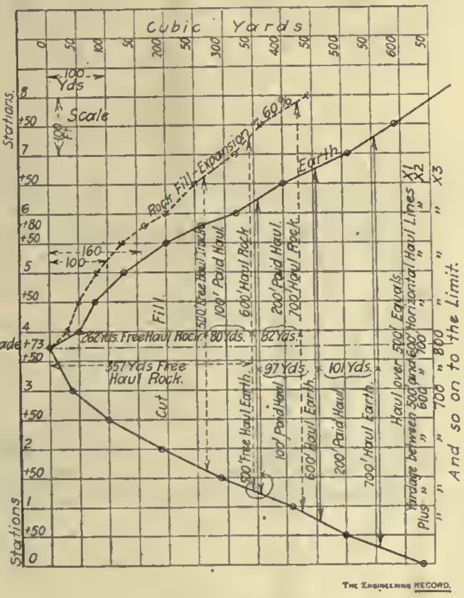
Cut-Offs.—In setting cut-offs on curves drive a tack in the pile under the inside rail at some convenient whole number of feet below the cut-off, blazing the pile around tack and marking on it the number of feet up to the cut-off, the distance being recorded in the notes. The outside pile is treated in the same way, allowing for the elevation.

On tangents, drive a tack in the two outside piles in a similar manner and let the sawyers line up the remaining inside piles. In every case the distance from the cut-off to the top of the pile must be noted, as this with the pile record fixes the length of the pile in bents.

Timber Structures.—All timber must be free from wanes, shakes, large knots, rot, or any defects which will impair its strength and durability, must be sawn square and be of proper dimensions, all imperfect sticks being rejected where they may be placed under transverse strain or tension.

Frame trestles will usually have foundations of piles and where in the judgment of the engineer piles cannot be driven mud sills should be permitted. Where mud sills are used all beds should be in excavation and to secure this "step bents" are sometimes necessary. Care must be taken to avoid covering any part of a sill with earth.

Care must be used in the framing of all timbers, as shimming should not be permitted, all adjustment of heights due to settlement being made by jacking up from below. Foundations must be firm and unyielding. Bents must be jacked and braced to right line. Cut-offs must be true and piles water tabled. All timbers must be placed to a true and full bearing on piles and other timbers. Ends of caps and ties must be sawed to line from end to end of bridge; ties adzed to full bearing, without shoulders, over the entire chord, guard rails well secured in line. Sway bracing must be ample and well bolted and spiked. The whole structure must be in good line and surface, completely bolted and washered, waterways well cleaned out and all framing so arranged that water is not retained.



Haul Diagram.

Excavation.

Station.	Yards per station.	Total.
0	130	630
+ 50	90	500
1	120	410
+ 50	100	290
2	90	190
+ 50	60	100
3	40	40
+ 73	00	..

Embankment.

Station.	Yds. per Sta.	Total.	Total solid rock.
3 + 73	0	..	..
4	50	50	31
+ 50	30	80	50
5	50	130	81
+ 50	70	200	125
6	60	260	163
+ 50	60	320	200
7	80	400	250
+ 50	110	510	318
8	80	590	363
+ 50	120	710	444

Overhaul Earth.

97 cu. yds., 1 station, equal	97
101 cu. yds., 2 stations, equal	202
Total overhaul to 700 feet equals	299

Overhaul Rock.

80 yds., 1 station, equal	80
82 yds., 2 stations, equal	164
Total overhaul to 700 feet equals	244

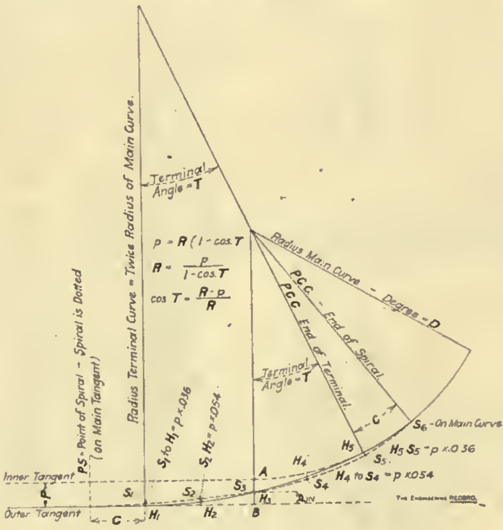
In the above table the amount of solid rock is taken which will, when broken to swell 60 per cent. of itself in place, fill the yardage marked in the earth column opposite.

Quantities.—The engineer must calculate the quantities as the work proceeds, and as a rule the end area methods will be sufficient. For this, as before stated, the sections should be taken as often as the difference in elevation of the center line exceeds 2 feet. In the calculations where the solid has only one end area, as at the end of a side hill cut, you should calculate as a pyramid instead of a wedge. As a check, see that the sum of pay quantities less the waste equals the total embankment. In all calculations use the better man as the final checker, otherwise it may result in no check.

Haul.—The positions of the mile posts are fixed, consequently when material is hauled past a post that fact and the quantity hauled must be stated in the notes on both miles affected; for instance, "On mile 50, 500 yards hauled from mile 51, and on mile 51, 500 yards hauled to mile 50. All excavated material from cuts or borrow must be estimated and paid for on the mile upon which the material is excavated.

The pound-of-flesh method of checking to the last decimal of a yard is not required. In figuring the overhaul, the profile of quantities method is used as shown in the accompanying diagram.

In making this diagram, the total yardage, both in cuts and fills both ways from the grade point, is summed up to the various cross-section stations within the limit of haul. These stations are then platted on a horizontal line to the scale chosen. The total yardage from the grade point to each station is then platted vertically under that station to the scale chosen and connecting lines drawn as shown. Then a horizontal scale is slid downwards until it measures between the cut and fill projections 500, 600, 700 feet. These horizontal lines are then ruled in.



Six-Chord Spiral.

The six-chord spiral and terminal curve having a radius twice that of the main curve, has each chord, C, one-fourth of the length of the terminal curve. Hence the spiral is 1½ times the length of the terminal curve and the quarter points, H_1, H_2, H_3, H_4, of the terminal curve are abreast the one-sixth points, S_1, S_2, etc., of the spiral. S_3 and H_3 coincide. $S_3A = S_3B$. One-half the terminal curve is inside the spiral, the other half outside, and the offsets between them at equal distances from H_3 or S_3 are equal. $H_1S_1 = H_5S_5 = 0.035$ p and $H_2S_2 = H_4S_4 = 0.054$ p. The offset $p = R(1 - \cos T) = R \text{ ver sin } T$, where R = radius of main curve and T = the terminal angle. To locate the spiral, take the distance for gaining the required elevation = L + C = 7 C. Here C = chord and L = 6 C = length of spiral. The distance is taken to the nearest multiple of 7 feet to avoid fractional chaining. This gives one-seventh of the total elevation at the P S. Then 2 CD ÷ 100 = T, where D = degree of main curve, T = terminal angle in degrees and C = length of chord in feet. Next calculate p from the equation already given, and run in the terminal curve and offset to spiral. Locate P S and S_6 on the outer tangent and main curve one chord length from H_1 and H_6 respectively.

This diagram may be made on plate "A" profile paper or cross-section paper, on a horizontal scale of 1 inch to 200 to 400 feet, and a vertical scale of 1 inch to 200 to 2,000 yards.

In the diagram, the amount of solid rock is taken which will in each case when broken to swell 60 per cent. of its volume in place, fill the yardage marked in the earth column opposite.

Shrinkage and expansion affect distance hauled, but not yardage hauled; this latter is always to be measured in excavation. In the diagram, 1 yard of solid rock is taken equal to 1.6 yards in embankment, hence the dotted line is platted in proportion, vertically, thus: at the point where the regular cross-section quantities sum up to 160 yards, the dotted line passes through the 100-yard point.

Free haul points and all other quantities taken from this diagram are to be entered in the notes as final, no further numerical calculations being necessary. The haul diagrams from which the final estimates have been made are to be turned in with the cross-section notes and become a part thereof.

The engineer will note the expansion of the rock by taking stations between which cut and fill actually balance on the ground.

Haul must be estimated separately for each cut, and paid for on the section from which the excavation is made.

Vertical Curves.—Vertical curves will be put in at all changes of grade where the algebraic difference exceeds 0.2 foot, and in sags the rate of change per station should not exceed 0.1. In summit cuts the rate may be increased to facilitate drainage.

To determine the length of the curve in stations, divide the algebraic difference of the intersecting grades by the desired rate, thus if a —0.7 grade meets a +0.4 at station 60, the length of curve for a rate of change of 0.1 per station, would be (—0.7 — 0.4) ÷ 0.1 = 11 stations and the curve would begin at 54 + 50 and end at 65 + 50.

Reports.—The engineer usually compiles from his diary and records on the first and fifteenth of each month, and forwards to the chief engineer a complete report of the progress of the work, good and bad methods of carrying it on, and any other items of importance, this being accompanied by a force report, on standard forms, giving by stations, sections and contractors the full average force at work on the line, or which might, if conditions were favorable, be at work on the line. In this, men and animals are not to be counted unless the contractor has a sufficient plant for handling them.

Progress Profiles.—Progress profiles are sent at the end of each month to the chief enginer's office, showing graphically all material delivered and work done, and by percentages, the amount of the totals completed. The location of all bridges and size of same should be plainly marked and the depth of the lowest pile in each bent. Where track is laid or fencing done or telegraph lines put up, a line should show the end of each day's work. The marking on profiles by months should be by water colors or section lining, so arranged as to be apparent at a glance which months the work was completed in.

Standard record books are furnished for the final notes and such notes are written in ink when they are final and not until then. They should comprise everything having a bearing on the final estimate and be arranged according to special instructions. A summary should be compiled at the end of each mile, showing at a glance the estimate by totals in each section, the records being kept up so far as possible while the work is in progress.

As soon as the construction permits, the engineer should establish permanent bench marks every half mile, preferably on masonry bridge seats or other permanent objects; where these are not available, the engineer should call for standard bench marks which will be furnished. As soon as the work is completed, the engineer must make a final profile showing all information required on profiles in accordance with the actual work as constructed. This profile must be made as per standard sample, on Plate "A" profile paper, continuous roll, in scale 200 feet wide and long enough to leave 18 inches of blank paper at each end.

To the usual title, add:

Final Profile, Residency No.——
Miles, 18 to 27,
Stations, 1081 to 1566.

In the preparation of this paper, thanks are largely due to J. R. Stephens, assistant chief engineer, Grand Trunk Railway, formerly engineer of construction of the Atchison, Topeka & Santa Fe Railway, for first suggesting to the author the idea of the necessity of such instructions, and for help in their preparation received from his able instructions issued while the author had charge of a residency under him in Oklahoma, on the Santa Fe. The author has also received help and valuable suggestions from the book issued by the Northern Pacific Railway, and the circular information from the Kansas City, Mexico & Orient Railroad.

Steel Roof Trusses in the New Union Railroad Station at Washington.

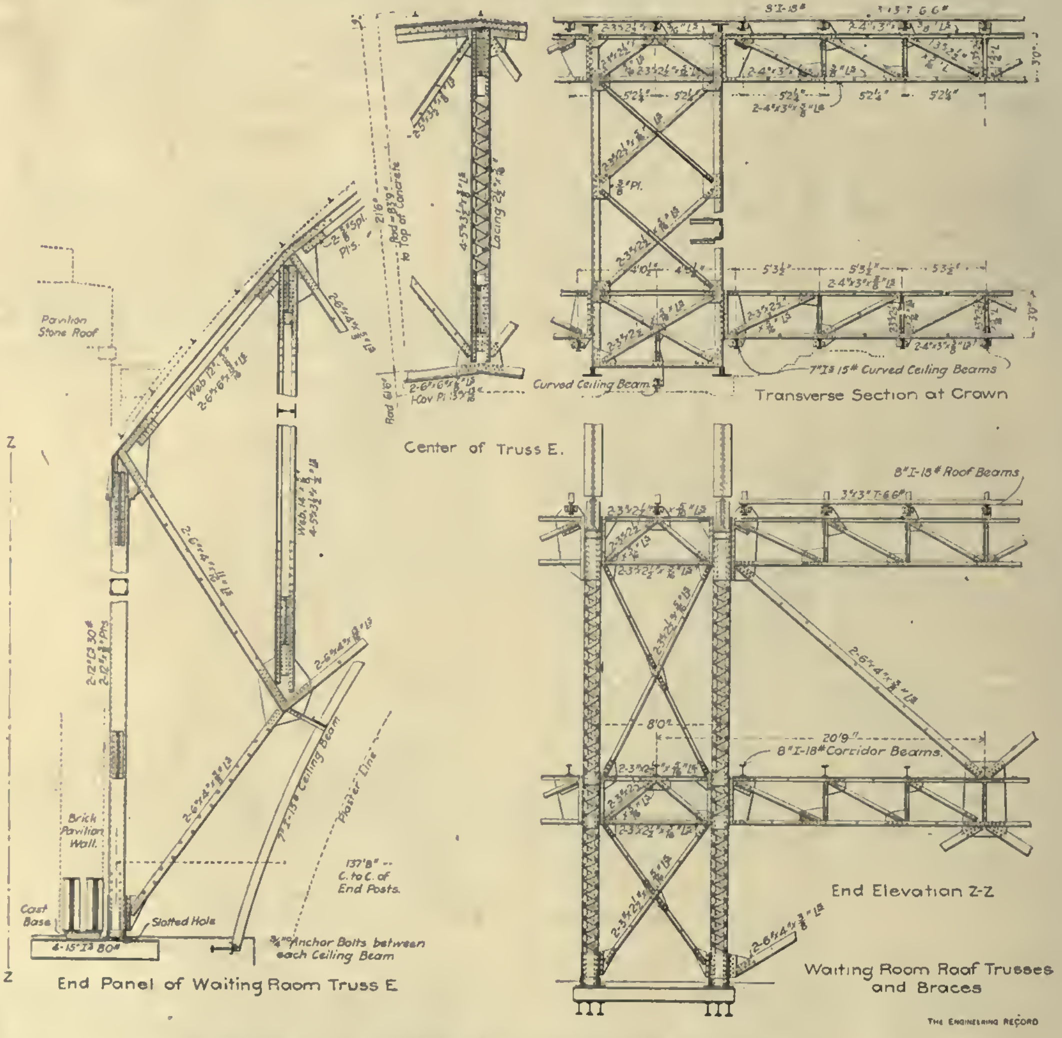
The new union railroad station in Washington, D. C., a general description of which was published October 31, 1903, will have a head house 627 feet long and 120 feet high, with masonry walls and a rather elaborate roof, which comprises several spans, supported by steel trusses. The exterior lines of the roof and the vaulted ceilings under them form important elements of the architectural design, and the details of their construction are among the most interesting features of the structural work in the building. The most prominent section of the roof is that in the central part of the building, which covers the 130x220-foot main waiting room. Here the framework consists essentially of ten steel arch trusses of 137 feet 8 inches span, connected by 11 lines of lattice-girder purlins and longitudinal girders, and the lateral and sway-bracing and secondary members for supporting the ceiling and roof covering.

All but the two end trusses are braced together 8 feet apart, on centers, in pairs, and the pairs are spaced 41½ feet apart on centers. Each end truss is connected to the nearest pair with lateral and sway-bracing. Each truss is made with ten panels and has top and bottom chords in concentric circular arcs, giving vertical depths on center lines of about 21 feet at the crown and 29 feet at the ends. Each pair of trusses is supported on a single 11x22-foot hollow masonry pier at each end. The single end trusses are carried by the main walls of the building. The trusses are of very simple riveted construction with T-shaped top and bottom chords, the former having a vertical web and a cover plate and the latter being composed simply of a pair of 6x6-inch angles, back to back.

The intermediate vertical posts for the single end trusses all have I-shaped cross-sections made with two pairs of angles. At the ends of the truss they have solid web plates and at the center are latticed together. The intermediate vertical posts for trusses in pairs are similar, except that they have a channel section made with one pair of angles, web plate and lattice as for single trusses. The end posts have rectangular cross-sections made with a pair of channels latticed together, with their flanges turned inwards. The diagonal members are all pairs of 6x4 and 5x3½-inch angles, back to back, with separators between. The top and bottom chords were shipped in two panel lengths with web-connection plates shop-riveted to them so as to serve also for splice plates. All the web members were shipped loose and field-riveted to the chord connection plates, which are engaged between the pairs of angles.

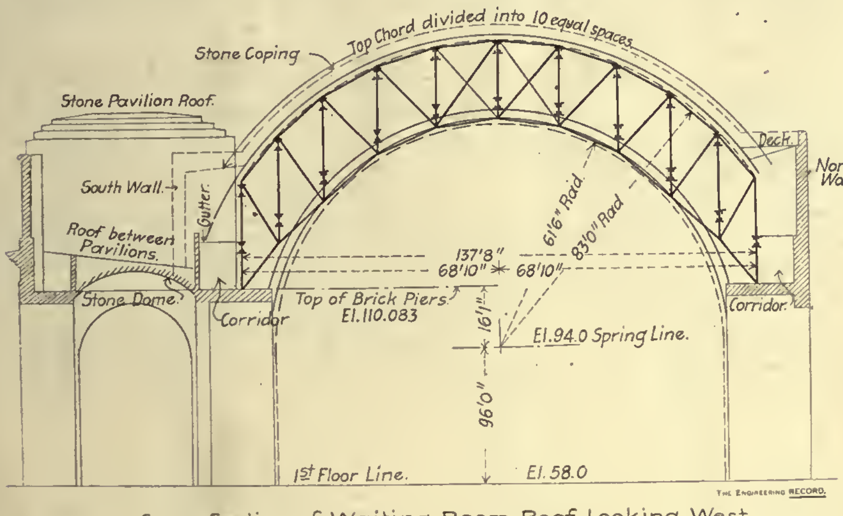
Each vertical post is web-connected at the top through its gusset plate to a lattice-girder purlin 3 feet deep, and at the bottom above the gusset plate to a horizontal longitudinal strut corresponding to the lattice-girder. The strut carries the ceiling joist, as shown in the cross-section, through a pair of trusses at the crown, the details of the trusses corresponding throughout to those shown at the end posts and at the crown. The end posts project beyond the lower chord and terminate with horizontal base plates with slotted holes for connection bolts to I-beam grillages. These grillages also support the double girders which carry the upper parts of the brick walls, as shown in the detail, and distribute the combined loads on the pier masonry in which they are embedded. The single end trusses have similar end posts seated on cast-iron pedestals and curved I-beams carrying the roof from their upper ends to the ceiling beams over the adjacent corridors, as indicated in the diagram of the general cross-section.

The web-connection plates at the panel points of the purlins project beyond the top chords to receive the web connections of the 8-inch transverse I-beams, which support the 3x3-inch roof Ts 4 feet apart on centers. The T-bars carry the concrete and tile roof which, together with the trusses, is proportioned for a total load of 105 pounds per square foot, including 30 pounds for snow and wind. The ceiling is plastered on a furring of metal lath and light angles carried by a framework of curved 7-inch I-beams, in the planes of the trusses and horizontal longitudinal channels. The lower ends of the I-beams penetrate the pier masonry and are riveted to horizontal anchor channels embedded below its surface. The ceiling surface forms a barrel vault, paneled with deep projecting ribs, enclosing the lower chords of the arches. The longitudinal girders connecting it to the lower parts of the end posts do not help support the ceiling of the main hall, but carry the ends of horizontal 8-inch beams for the ceiling of the corridor. At the ends of the waiting room the purlins are supported on the brick cross walls about 19 feet in the clear from the end trusses. In these panels the ceiling is coved with a curve resembling an ellipse. The furring consists of angles bent to template and field-riveted to make a rigid framework, which includes the skeleton for a circular window 75 feet in diameter.

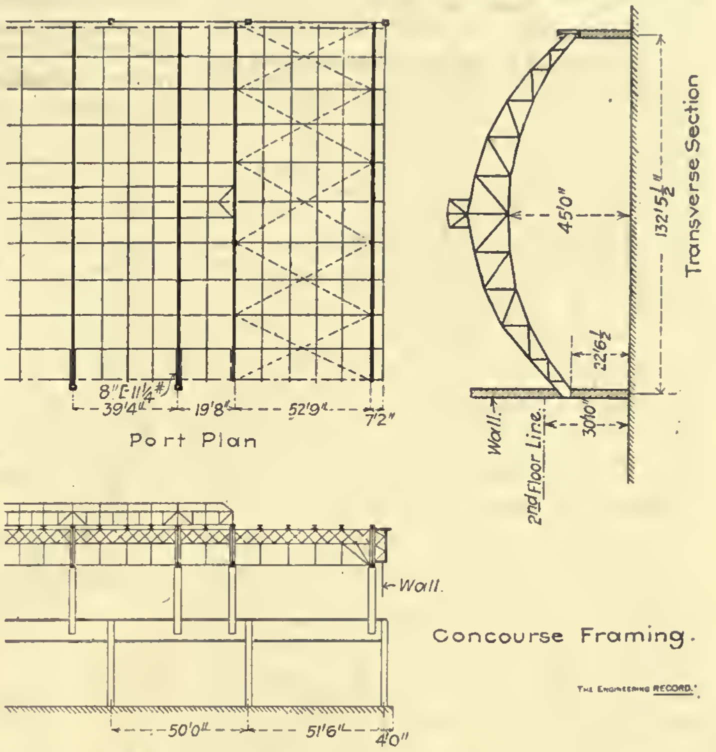


Details of Roof Trusses, New Union Depot at Washington.

The ticket lobby is about 51 feet wide and 104 feet long, from out to out of its walls, and its roof has five two-hinge steel-arch trusses of 54-foot span. The trusses are simple lattice-girders, with eccentrically curved T-shaped top and bottom chords, each made with a pair of 6x4-inch angles back to back. They are divided by radial members into panels, which have a uniform length of about 6 feet above the springing line and 3 feet below it. Each panel has a single diagonal member, and all web members have T-shaped cross-sections made with pairs of 2½-inch angles back to back. The chords of the trusses are vertical and parallel from the ends to the springing line at a height of 12½ feet above the hinge pins, where they are 3½ feet apart, out to out. From this point they are curved with radii of about 25½ and 29 feet. The center for the top chord is 3 feet above that for the bottom chord, the rise at the bottom chord is 26 feet 1¾ inches, and the depth of the truss at the crown is about 6½ feet. The end panels have a solid web plate and the chords converge there to the 3-inch hinge pin, which engages the double webs of an ordinary riveted shoe anchored to the masonry at a height of 23 feet above the first floor. The truss is shop-riveted in four sections and is field-spliced through the vertical flanges of the angles at the crown and at the haunches. At every panel point above the springing line there is in the radial plane a lattice-girder purlin with its top flange in the plane of the top chord of the truss and its lower flange clearing the upper side of the bottom chord. These purlins are made with zigzag web members and their bottom chords carry the curved angle and T-bars supporting the ceiling, which is furred out to form wide ribs enclosing the bottom chords of the main trusses. The top chords carry copper ribs supporting the skylight.



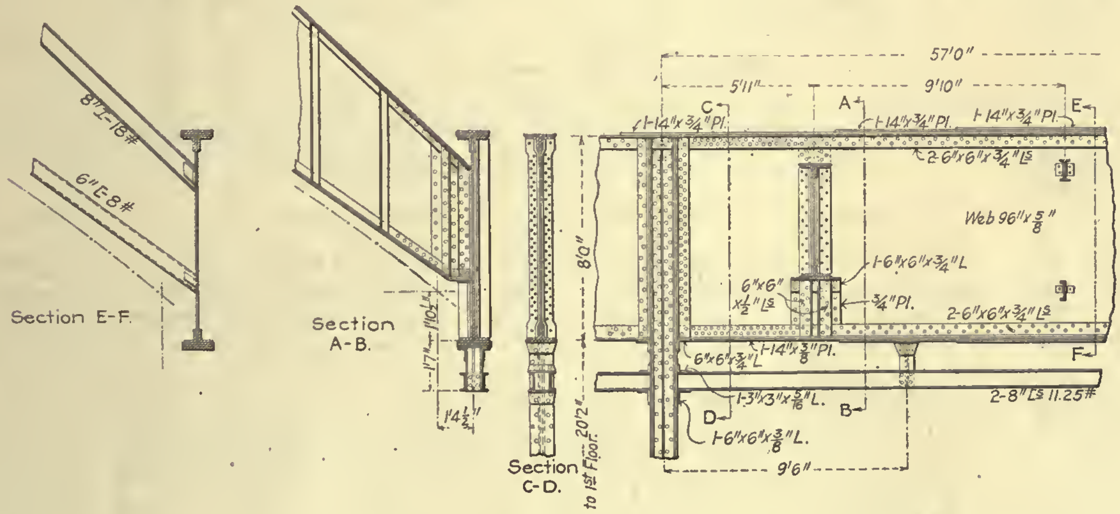
Cross-Section of Waiting Room Roof, Looking West.



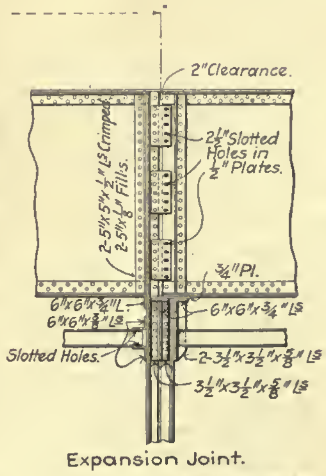
Part Plan

Concourse Framing.

Part Sectional Elevation.



Girder supporting Concourse Roof Trusses.



Expansion Joint.

Some Diagrams and Details of the Roof Framing of the New Union Railroad Depot, at Washington.

The concourse between the waiting room and the train platforms is 130 feet wide and 760 feet long and is covered by a single-span arched ceiling and roof supported on lattice-girder trusses 39 feet 4 inches apart. These trusses are carried at one end on a masonry wall and at the other end on a continuous line of plate girders 8 feet deep and from 41 to 57 feet long, which are supported on the tops of the columns about 20 feet above the floor. The trusses have T-shaped top and bottom chords, each made with a pair of 6x4-inch angles, a 12x¾-inch web plate and one or more 14-inch flange cover plates. The web members are made with pairs of 3½-inch angles back to back, except for the center vertical, which has a double pair of angles. The end panels have solid web plates about 7 feet wide reinforced by vertical stiffener angles. The trusses carry lattice-girder purlins connected to their vertical members with the top flanges about a foot below the upper chords. The purlins are made with X-brace web members and have web-connection plates projecting above their top flanges to carry the intermediate 8-inch transverse I-beams, which support the concrete roof. Corresponding bottom gusset plates afford connections for vertical angles, which carry the 6-inch longitudinal and transverse channels for the ceiling in the plane of the lower chords of the roof trusses.

The panels between the purlins in the end bays and in four intermediate bays of the roof have pin-connected diagonal rods in the planes of the top chord.

Where the trusses are seated on the walls they have horizontal bed plates with anchor bolts. Five of the trusses are supported directly by the columns. They are seated on horizontal angles and have vertical flange angles field-riveted to the column cover plates. The girders which support the north ends of the trusses are made with 96x⅝-inch web plates spliced with pairs of 14x½-inch cover plates. Each flange is made with two 6x6x¾-inch angles and cover plates, varying in numbers and size according to span. The girders are seated on horizontal angle brackets riveted to the sides of the columns and are field-riveted to the columns through the flanges of their vertical web stiffener angles.

The columns extend to the tops of the girders and their caps are riveted to the top flanges on both sides. At the expansion joints one side of the column extends to the top flange of the main girders and the fixed girder is connected to it in the usual manner. The other side of the column is cut down the full depth of the girder and has a cap plate on which the end of the sliding girder is seated. This girder has the end web-stiffener angles set back from the end of the girder so as to leave room for connection with pairs of vertical jaw plates which are shop-riveted to the column, engage the girder web and have slotted holes through which it is bolted, as shown in the detail. Below the girders a pair of 8-inch channels are rigidly suspended by vertical struts flange-riveted to the girders. These channels serve as wall girders to carry the brickwork and support the terra cotta lintel.

Messrs. D. H. Burnham & Company are the architects, Mr. J. G. Giaver structural engineer, and the American Bridge Company is the contractor for the steel work, which weighs about 15,000,000 pounds.

ALGARROBO WOOD BLOCKS have been used for street paving in Buenos Aires, on a practical scale, during recent years, and are reported to give satisfaction. According to the "Surveyor," a small area of street in London was paved with some of these blocks, as an experiment last spring. It is stated that this wood showed practically no swelling after a month's immersion in water.

More Light on the Theory of Concrete.

A paper read before the Indiana Engineering Society, by Mr. Spencer B. Newberry. Slightly abridged.

Materials.—The sands which give the highest tests with cement are those having rounded grains with a dull surface. A mixed size of grain, from fine to coarse, is better than a grain of uniform size. The presence of a small amount of clay, up to 4 or 5 per cent., does no harm, if concrete be thoroughly mixed and sufficiently wet.) Gravel and broken stone should be hard and sharp, and as free as possible from soft particles. The harder the stone the better the concrete will be; trap rock or crushed flint or quartz are superior to soft limestone or sandstone. As in the case of sand, a mixed material, fine to coarse, is preferable, and screening is generally injurious. It was formerly supposed that the presence of fine dust in the materials was objectionable. This is not the case if the mixing be thorough. It is quite possible that with imperfect mixing a film of clay or stone-dust might coat the stone or gravel and prevent adhesion of the cement. If the mixing be thorough, however, these fine materials will help to fill the voids and increase the strength. The most competent engineers now use crushed stone without screening, containing all the dust from the crusher. Many engineers consider broken stone superior to gravel for concrete. With this view the writer does not agree. Good quartz gravel is harder than any broken stone, except trap or quartzite, and owing to its rounded form contains much less voids than stone. There is no ground for believing that rounded stone or rounded sand gives less strength with cement than material composed of angular fragments. Certain natural sands, with nearly spherical grains, show much higher tests with cement than angular crushed quartz. Comparative tests of crushed stone and gravel concrete are not available, but the many examples of faultless work with cement, sand and gravel show that where good, coarse gravel is abundant there is no need of going to a distance for costly crushed stone.

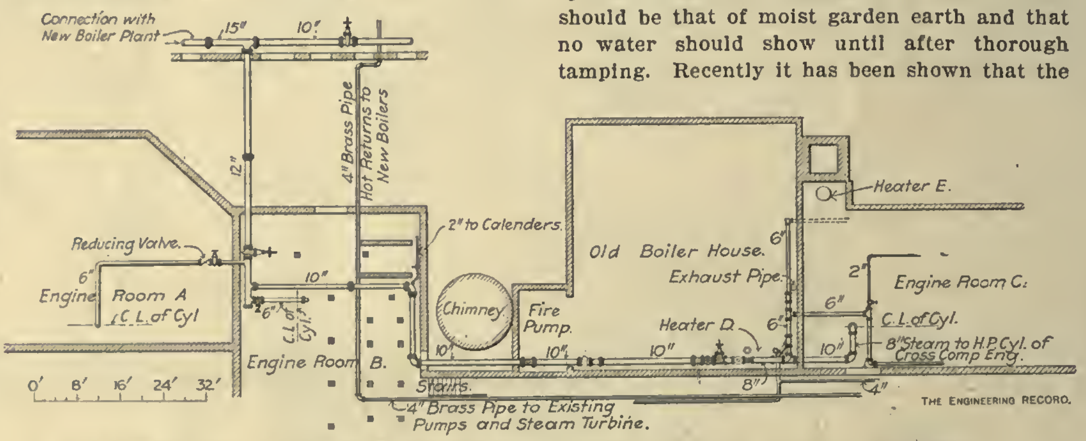
Proportions.—The chief object in compounding concrete is to produce a compact mass, as free as possible from open spaces; in short, to imitate solid rock as closely as possible. To produce a compact mass from fragmentary materials the voids must be filled. In practice it is well known that the use of materials of varying fineness gives the best concrete, since the voids are much less than in materials composed of pieces of uniform size. Hence, the common practice of making concrete with cement, sand and broken stone, instead of with cement and sand or cement and stone only. The sand fills the voids of the stone, the cement fills the voids of the sand, and if the proportions are correct a practically solid mass results. As an example of this, the writer found that briquettes of cement with three parts sand and four parts gravel showed higher tensile strength at twenty-eight days than those made with three parts sand only.

The determination of the percentage of voids in the gravel or broken stone to be used is of the greatest importance. This determination is most easily made by the use of a metal box of exactly one cubic foot (or a known part of a cubic foot) capacity. This is weighed, filled with the material, well shaken down, and again weighed. One cubic foot of solid quartz or limestone, free from voids would weigh 165.4 pounds. The difference between the weight actually found and 165.4 represents the amount of voids. For example, a cubic foot of sand was found to weigh 112 pounds, or 53.4 pounds less than a solid block would weigh. The percentage of voids was, therefore, 32.2.

The following table gives the percentage of voids in a number of materials, as determined by the writer:

	Per cent.
Sandusky Bay sand, not acreened	32.2
Sandusky Bay sand, through 20 mesh	38.5
Sandnsky Bay sand, through 20-30 mesh	40.7
Gravel, ¼ to ½ inch	42.4
Gravel, ¼ to 1/20 inch	35.9
Marblehead broken stone, about egg size	47.0

Comparison of the three different grades of Sandusky Bay sand shows how greatly the percentage of voids varies with the proportion of fine and coarse grains present. The first is the natural sand and contains a large amount of fine gravel. The second is the same passed through a 20-mesh screen. It will be seen that this operation increases the proportion of voids from 32 to 38 per cent. The third is the same sand passing a 20-mesh and retained on a 30-mesh screen, thus brought to the fineness of the "Standard sand" used in cement testing. This shows 40.7 per cent. of voids, owing to the uniform size of the grains. The same relation is seen in the two grades of gravel given in the table, that containing finer grains showing much the lower percentage of voids. These figures illustrate the imprudence of screening any of the material used in making concrete. As an aid in determining the voids in concrete material, the writer has prepared tables in which the percentage of voids corresponding to various weights per cubic foot may be seen at a glance, and also how to calculate the proportions in which the materials are to be used.



Old Steam Plant of Tileston & Hollingsworth Company, Showing Piping to New Plant.

In the mixtures of sand and gravel the maximum weight obtained was 133.7 pounds per cubic foot, and the minimum voids 19.1 per cent. This will vary considerably with different materials, but those materials are certainly best which, when mixed in the most favorable proportions, give the greatest weight per cubic foot. Any good gravel and sand, rightly proportioned will show at least 130 pounds; the best results the writer ever obtained was 139 pounds, corresponding to 16 per cent. voids. Broken limestone and sand give less density, rarely more than 125 pounds. A few trials with available material will enable an engineer to specify a minimum weight per cubic foot for materials to be used in a given piece of work.

Proportion of Cement.—Mr. Fuller's rule is to "add cement as economy dictates, possibly up to 10 per cent. in excess of the voids in the combined material." The lowest proportion of voids obtained with the gravel and sand used in the above experiments was 19.1 per cent. Addition of this proportion of cement would give a very rich and expensive concrete; about 1 to 5—far beyond anything that could be required for any use except watertight work. On the other hand, if a volume of cement equal to the calculated voids in the mixture, 13.9 per cent., be taken, we shall have a 1:7 concrete of abundant strength for engine foundations or other important uses. Mixtures much poorer in cement, containing 10 per cent. or even 7 per cent. may safely be used for foundations, filling of abutments, etc. If the materials are well selected and correctly proportioned, these poor concretes will be found to have surprising strength, and often to be superior to rich mixtures injudiciously combined.

Many series of tests of strength of concrete have been published, but in none of them have the influences of proportions on density and density on strength been clearly stated. Such a series of experiments, consisting of crushing tests of 6-inch cubes of concrete, is now in progress under the writer's direction, and results will be published as soon as complete. It is believed that the strength of concrete will be found to be more or less closely proportional to the ratio of percentage of cement to voids, and that mixtures in which the voids are filled to the same degree will be approximately equal in strength. There is, however, another factor which enters into the question, and that is the amount of surface the mixture presents. It is evident that all surfaces must be coated with a film of cement to produce adhesion between them; therefore, the greater the surface, the more cement will be required. It is probably chiefly for this reason that coarse materials give greater strength than fine materials.

Proportion of Water.—It was formerly supposed that the best concrete was obtained by using very little water, and engineers generally specified that the consistency of the mixture should be that of moist garden earth and that no water should show until after thorough tamping. Recently it has been shown that the use of more water—at least enough to make the mass decidedly plastic—gives better results.

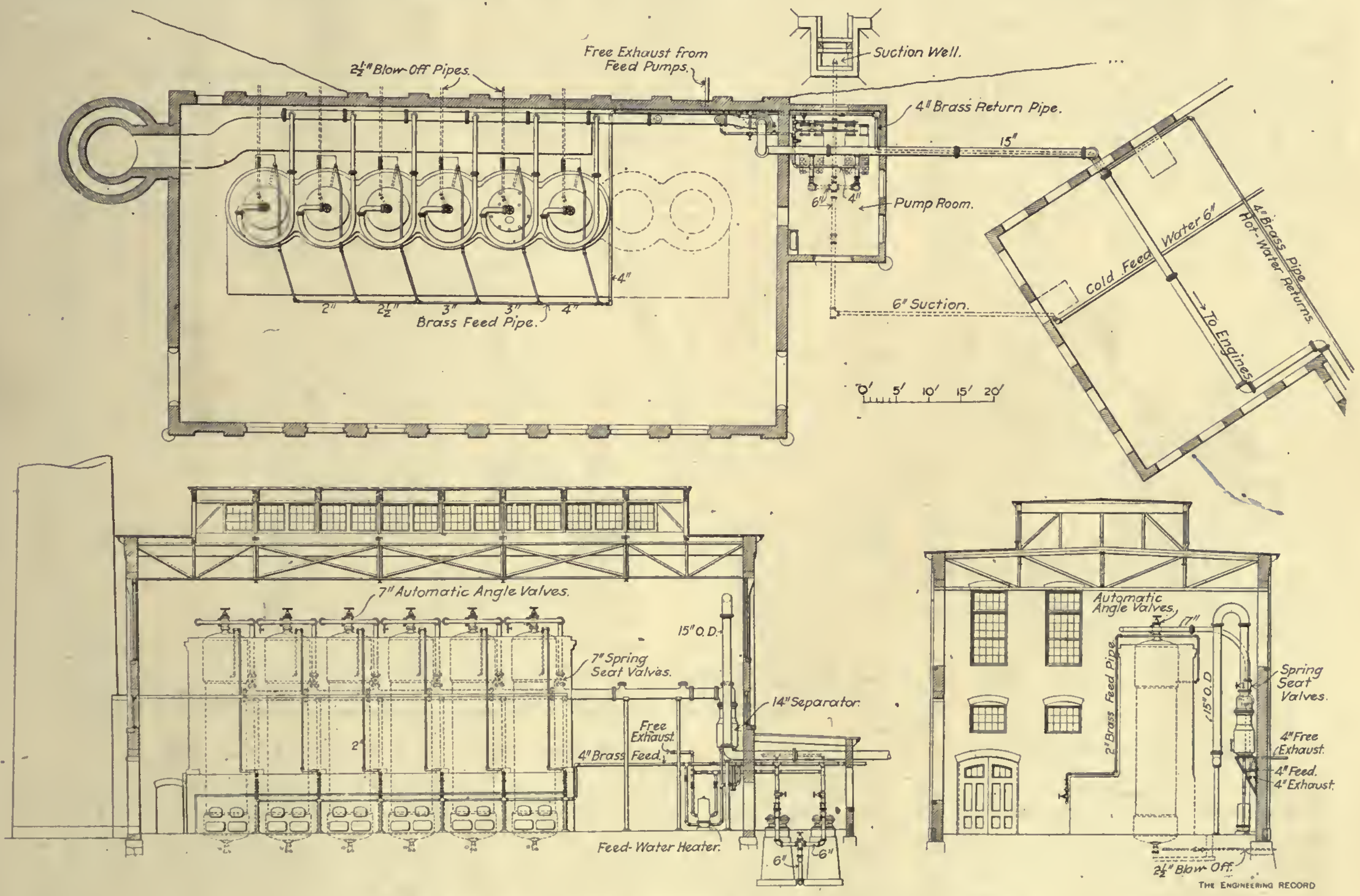
Mixing and Laying Concrete.—Engineers appear to be generally convinced of the advantage of using a suitable concrete-mixer, instead of hand labor. When large amounts of concrete are to be mixed the saving by using a power mixer is very great, and there can be no doubt that the danger of imperfect and careless mixing is avoided by use of a suitable machine. The writer has successfully used mixers of the pug-mill type, consisting of a trough with revolving blades. Several excellent machines of the revolving drum type are in use and giving excellent satisfaction. In mixing concrete, the sand and cement should first be mixed dry, then the water added, and finally the stone or gravel, previously well wetted, introduced, and the whole thoroughly mixed together. Large masses of concrete should be laid continuously, by day and night work if necessary to avoid partings between set and fresh work. If the laying must be interrupted, the set surface should be thoroughly wetted and dusted with neat cement before fresh concrete is applied. This method should also be used in plastering the surface of concrete with cement mortar. A break in a cement floor or sidewalk may be successfully patched in the same manner.

Concrete in Freezing Weather.—Freezing does no harm to Portland cement after the mass has fully set. The hardening of the cement is interrupted by freezing, but proceeds again without hindrance after thawing takes place. Damage from frost is to be feared before the setting, especially if excess of water is used. When work in extreme cold cannot be avoided the sand and water should be warmed and the proportion of water reduced to a minimum. After putting in place the work should be covered with straw or other non-conductor to protect it from frost. Mortar for use in freezing weather is often made with the addition of salt (about one pound to one gallon of water) and appears to give good results. Cement plastering in extreme cold weather should not be attempted.

Steam Plant of the Tileston & Hollingsworth Company.

The steam plant described in this article is for the paper mill of the Tileston & Hollingsworth Company at River Street Station, Hyde Park, Mass., and is located on the Neponset River. This river is badly contaminated with refuse from the mills above, and the water is unfit for boiler use. It is, however, the only water available, and at this plant it is passed through mechanical filters until it is perfectly clear. Nevertheless it has elements in solution that are very injurious to boilers, and so acted on the vertical type which were in use until recently and, before them, on horizontal tubular boilers, that it was thought desirable by Messrs. Dean & Main, of Boston, the engineers consulted on the subject, to make a radical change in the pattern to be used in the new plant. For this reason the Wickes vertical water-tube boiler was selected with the hope that all precipitates forming in the tubes would fall to the bottom of the lower drum where they would be harmless. This proves to be the fact, and the tubes are found to be perfectly clean. Some of the tubes towards the fire have, nevertheless, bulged and cracked from overheating, but it is hoped that the substitution of steel tubes for the front row in place of the charcoal iron tubes originally used, will prevent a recurrence of this trouble.

This type of boiler consists of a lower and an upper drum connected by tubes, the water being inside of the tubes as well as of the drums. A portion of the upper drum is used for steam space. The firebox is built of brick in front of the boiler, and there is a vertical layer of tiling separating the front and back tubes from each other and making of them two equal groups. This tiling rests on the lower drum and terminates a few feet below the upper drum. The effect of this tiling is to cause the gases as they leave the firebox to pass upward among the front half of the tubes, across the top, and thence downward among the back half, and thence to the chimney.



New Boiler Plant of the Tileston & Hollingsworth Company, Hyde Park, Mass.

The boilers are five in number and of 250 horse power each. Each boiler has 2,556 square feet of heating surface, and 49 square feet of grate surface, or about 10 square feet of heating surface per horse power, and about five horse power per square foot of grate.

As these boilers are very high and the steam is taken out of the top, the rise of the steam nozzle is so much when the boilers are fired up that a very flexible steam connection between the boilers and the drum is necessary. For this reason the pipes referred to are bent in the manner shown so as to give considerable length and therefore flexibility. In each individual steam pipe there are two stop valves with a bleeding pipe between. In this way it is certain that with both stop valves closed and the bleeder open, it is possible and safe for a man to enter a boiler. Pearson's automatic stop valves are used on top of the boilers and Crosby globe valves on top of the steam header. The individual pipes are of steel and have Van Stone flanges.

The steam header consists of several lengths of extra strong cast iron with the nozzles cast on. The metal of these pipes is heavy, the changes in form are made with large fillets, the flanges are thick and the bolts are large and numerous. The joints are made with corrugated copper gaskets and plumbago paste. This header rests on wrought iron pipe columns with curved forms on top and flanges at the bottom, and is supported on piers below the floor level. In this way it is certain that a heavy line can be supported without danger of its supports yielding so as to bend the pipe and render the joints leaky. A prolific cause of leaky pipe joints is the yielding of supports. In this case, however, there is no danger of this trouble.

The remainder of the line of pipe is of steel with Van Stone flanges and heavy bolts, but with heavy fittings from an extra strong mixture of cast iron. The pipe covering is of magnesia, and the flanges are covered.

In the boiler house there is a separator, and in its vicinity there is a high loop in the main steam pipe for the purpose of providing for expansion and contraction in the main pipe system, which is very long. Where the main pipe crosses from the boiler house to the mill, and is out of doors, it is encased in sheet iron. In the middle of the out-door lengths there is a support made of structural steel. The feed pipe where it crosses this space is also inside of the casing.

The water collected by the separator is returned to the boilers by the Holly gravity return system.

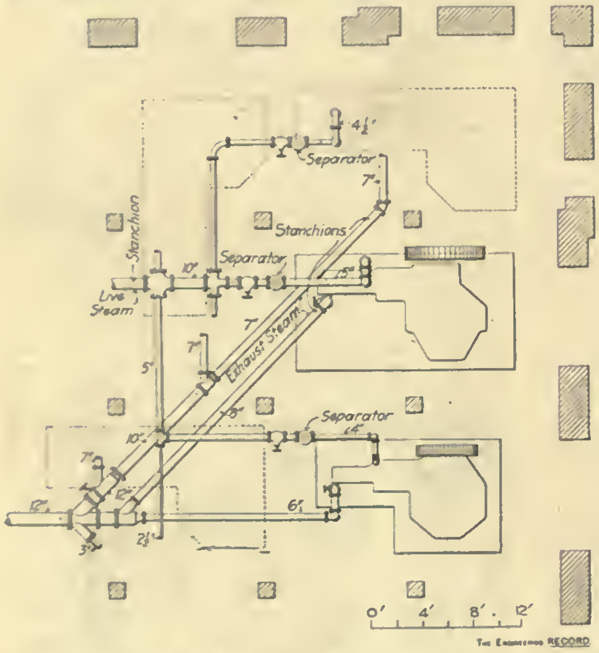
The pumping system is such that hot or cold water can be pumped from the mill, or cold water, either filtered or directly from the river, can be pumped by pumps in the annex of the boiler house.

The chimney is 8 feet in diameter and 150 feet high. The main flue lies at a low level behind the boilers and is of sheet steel.

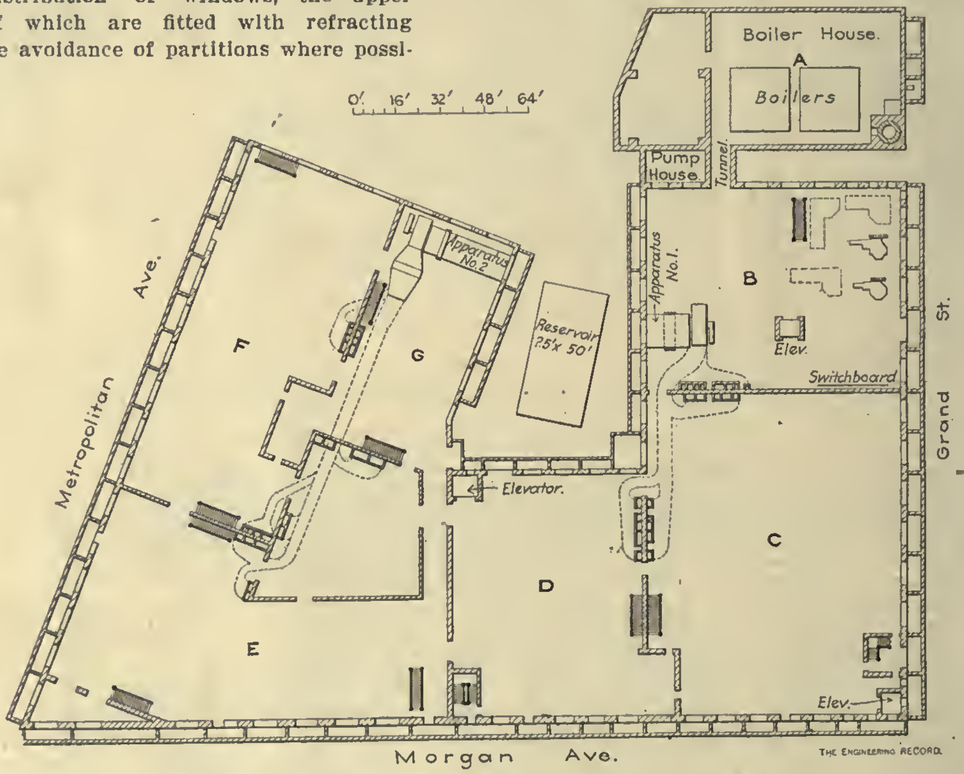
The boiler fronts are made of steel plate. The floor of the boiler house is of granolithic pavement, except that immediately in front of the boilers it is of cast iron, with a track for the coal cars.

The Power Equipment of the Sackett & Wilhelms Lithographing & Printing Company.—I.

A new printing establishment has recently been completed in Brooklyn, N. Y., for the Sackett & Wilhelms Lithographing & Printing Company, which is particularly interesting as providing facilities for the two rival processes of lithography and type printing. Where a single establishment contains facilities for every variety of presswork from stone, aluminum plates, type and engraved blocks, and is also equipped to make such blocks, it is evident that the plant is one of unusual completeness. The long experience of the company in both publishing periodicals and carrying on job work has given it full information concerning the equipment necessary for all departments of such work, and it is proposed in this article and a succeeding one to describe briefly some of this plant and the power installation for its operation. As a general thing, direct-current motors supply the power by individual drive, though there are a few cases where short line shafts are employed for group driving. Nearly seventy Crocker-Wheeler motors from ½ to 7½ horse-power in capacity are used, their aggregate rating being about 350 horse-power.



Piping System in Engine Room.



Basement Plan of the Sackett & Wilhelm's Printing Plant.

Building.—The building occupies a trapezoidal area of about 55,070 square feet, with a frontage of 261 feet on Grand Street, 330 feet on Morgan Avenue, and 232 feet on Metropolitan Avenue. It is of slow-burning, mill-type construction, and is divided by fire walls into eight sections, enclosing three sides of a court wherein is located a 25x50-foot covered reservoir, having a capacity of 125,000 gallons, and a store-house for the automobile delivery wagons. The designation of the several sections by letters is given on the accompanying plan. Sections B, C and D are four stories in height, sections E, F, G and H are two stories, and section A is a practically isolated, one-story building for the accommodation of the boiler plant. This separation of the fire room helps to minimize fire risk and is in keeping with the extensive precautions taken against interruption to the business by fire. The wall openings between all sections is commanded by gravity fire doors automatically released in time of fire, and a stand-pipe sprinkler system fed from a 30,000-gallon tank on the roof covers all rooms. In addition fire pails and extinguishers are plentifully distributed. The complete installation for fire protection and the electric wiring were specified to meet the requirements of not only the New York Board of Fire Underwriters, having jurisdiction in this territory, but also those of the Associated Factory Mutual Insurance Companies of Boston.

The plumbing, ventilation and lighting have been given careful attention. By day, even though the rooms are deep and wide, they are remarkably bright. This is the result of a generous distribution of windows, the upper sashes of which are fitted with refracting glass; the avoidance of partitions where possible, and the painting of the walls, posts and ceilings with white magnite fireproof paint. Artificial illumination is never required for more than a small part of the day. For this purpose there are some 900 incandescent lamps and 150 arc lights.

Sections B and G in the basement contain all of the mechanical plant. Section C is used for the storage of lithographic stones and plates, and a label stock room, D as a store room for "Judge" and a carpenter shop where crates and boxes for shipping purposes are made, E for embossing, dusting and dampening machines, and hydraulic presses for straightening dampened paper, all of which are used for commercial stationery; F for paper stock, and H as a paper seasoning room and a fireproof vault for the storing of electrotype plates belonging to customers and the company.

The first floor, with the exception of section B, which accommodates the shipping room and office, constitutes the printing department. The bindery is in section C, cutting room in D, stitching, trimming and type pressroom in E, type pressroom in F, composing room in G, and drying and seasoning room in H.

The second floor is the lithographing department and is divided as follows: B, transfer department, i.e., where the original drawings on stone or aluminum are transferred to other plates in multiplicate; C, plate graining and preparing, and stock rooms; D, layout room, where the work is prepared for the presses; E, F, and G, litho-press rooms.

As before stated B, C and D have third and fourth floors. On the third floor D is divided into a room for chromo-artists and one for the engraving and label department, C is as yet unoccupied and D contains the engineering department, including the office of the consulting engineer and a shop for experimental work, and a limited amount of repairing. On the roof of section G a house has been built to accommodate a restaurant conducted for the benefit of the operatives. The fourth floor section B contains an excellently appointed photographic room and a room for the artists and provers. Sections C and D are not occupied at present.

Mechanical Plant.—An accompanying plan shows the relative location of the component parts of the mechanical plant, including the boiler house, the engine-generator plant furnishing light and power, two engine-fan equipments for the ventilation, and the several pumps for boiler-feed, heating-system returns, sump-pit drainage, house supply and fire service. The ultimate boiler equipment will consist of two double batteries comprising four 213-horse-power Babcock & Wilcox wrought-steel header sectional water-tube boilers. At present three are in place. Each has 2,132½ square feet of heating surface and 59½ square feet of grate surface; two steam and water drums 36 inches in diameter by 23 feet 3 inches long, and 14 sections of tubes, each section consisting of seven tubes 4 inches in diameter and 18 feet long. No. 2 buckwheat coal is burned satisfactorily on herring-bone grates by the provision of an ample natural draft. The chimney is of the Alphons Custodis radial brick construction, 6 feet in diameter on the inside and 150 feet high. At its connection to the base of the stack the smoke breeching contains a Spencer damper regulator.

Coal storing and handling are accomplished conveniently and with little labor. The boiler room is well below the level of the driveway and the ceiling is above, so that the coal may be dumped direct from the carts through short chutes onto the floor in front of the furnaces. Eight of these openings are provided; one in front of each boiler, one in front of the space for a future additional boiler and four in the adjoining coal-storage room. The floor space and the height of the opening allows for each pile a capacity of 100 tons, and by hand trimming it is calculated that the storage room will hold 500 tons. The intention is to replenish the piles in the fire room frequently and to fall back on the coal in the storage room only in case the outside supply should be interrupted by a strike or other cause. The ashes are removed in cans and elevated to the street on an ash lift at the front of the boiler house. This is at present hand-operated, but is to be provided with a 3-horse-power motor. Near the ash lift there is an elevated room containing a shower bath and toilet for the men employed in the boiler and engine rooms.

Steam is generated at a pressure of 130 pounds and delivered from the boilers through an underground tunnel to the main building, branching after entering it with a 4-inch supply to the fire pump, and from this with a 2-inch supply to the return and boiler-feed pumps. The fire pump is a Knowles duplex 18x10x12-inch underwriters' pump, having a capacity of 1,000 gallons per minute. It is ready to operate instantly if needed and is connected to discharge into the sprinkler system. Beyond the tunnel the 12-inch main rises to the ceiling of the engine room where it runs as shown on the plan. The first branch is a 6-inch line to the heating apparatus, and in the opposite direction a 10-inch line is continued to a 10x10x 5x5-inch cross. One of the 5-inch outlets of this connects to a tee from which a 4-inch line supplies a 25-kilowatt set. The other 5-inch outlet of the cross is stopped with a blank flange leaving a supply available for an additional 100-kilowatt set at some future time. The 10-inch side connects with a cross, from which are supplied two 100-kilowatt engine-sets, with the third opening stopped off for another extra engine.

The pipes are taken from the top side of the main to obtain steam as dry as possible, and in addition each engine main contains a Cochrane steam separator. All of the steam mains in the engine room are supported on stanchions of 2½-inch pipe instead of being suspended from the ceiling, to avoid causing vibration in the office on the floor above.

The engine-generator sets consist of Ball & Wood engines direct-connected to General Electric generators. The two of 100-kilowatt size are driven by 160-horse-power horizontal tandem-compound engines with cylinders 12 and 18 by 14 inches, and run at 250 revolutions per minute; the 75-kilowatt set runs at 275 revolutions, driven by a 112-horse-power, 10 and 17 by 12-inch horizontal compound engine; and the 25-kilowatt set is driven at 300 revolutions per minute by a horizontal simple 40-horse-power 8x10-inch engine.

The 6-inch pipe to the heating apparatus, previously mentioned, supplies two engines for the ventilating system and one for the refrigerating system, and it also furnishes live steam to the heating system at a reduced pressure whenever the available exhaust steam is insufficient. The engine-fan sets were built by the Buffalo Forge Company. One is located in Section B and serves the four-story part of the building. It consists of a 134-inch blower direct-connected to an 11x12-inch horizontal side-crank engine and operates at a maximum speed of 145 revolutions per minute. The other set serves the two-story part of the building; it is located in the basement of G and consists of an 8x10-inch engine direct-connected to a 113-inch fan running at a maximum speed of 175 revolutions per minute.

The refrigerating outfit which is also located in the basement G, is employed for cooling the air supply in the summer and making ice for use about the building. On the lithographic presses it is necessary to keep ice in the water with which the stone or aluminum plate is moistened between each impression, otherwise the grease in the ink will have a tendency to spread it over portions of the plate which are not intended to print. At present ice is also used in the drinking water tanks scattered about the building, but the installation of a piped drinking water system is contemplated which will have cooling coils connecting with the refrigerating system. The ammonia compressor is 10½x20 inches in size and is driven by a 14x26-inch engine. The system has a capacity of 30 tons of refrigeration per twenty-four hours and was installed by the De La Vergne Refrigerating Machine Company.

The exhaust steam from all of the engines and pumps in section B is collected into a 12-inch main, which contains a Baldwin oil extractor provided with a by-pass. Beyond the extractor the live steam connection through a by-passed reducing valve is made. The contents of the main is then distributed to the various radiating surfaces of the heating system. When the exhaust steam is in excess of that needed for this purpose it is allowed to escape through a back-pressure valve and passes first through a 1,000-horse-power Berryman feed-water heater, or direct to the exhaust riser to the atmosphere. The exhaust steam from the two engines in section G driving the fan and the ammonia compressor is similarly passed into the heating system through a smaller grease extractor, or vented through an exhaust head on the roof of that section. All piping is dripped and trapped where moisture is likely to accumulate, and the condensation is drained to a sump well.

The returns from the heating system are collected in a main which terminates in a tank 3 feet in diameter by 6 feet long placed in the basement near the feed water heater. Two 7½x 5x6-inch Worthington pumps, cross-connected so that they may be used interchangeably, have their suctions connected to the return tank and are provided with a No. 3 Kieley pump governor on their supplies. They are arranged to deliver through the feed-water heater to a 3-inch feed main leading to the boiler room through the tunnel. If desired the heater may be by-passed and the boiler fed directly from the pumps. As another alternative the boilers may be fed with cold water from the city mains by a Metropolitan injector. The make-up boiler-feed to replace that lost in the wasted exhaust steam and when the boilers are blown off, is let into the return tank from the city water supply. The blow-off pipes from the boilers and the greasy drips from the traps are drained into a sump pit in the boiler room, which is emptied to the sewer by a Worthington pump. The water supply for the building is first received from the street into a 5,000-gallon steel suction tank in the basement B and from this is pumped by a Worthington pump through the plumbing system to all parts of the building.

(To be continued.)

AN ANTHRACITE COAL STRAINER for sewage, having 1 foot of buckwheat size coal over gravel underdrains, operated experimentally by the Massachusetts State Board of Health at a rate of 1,400,000 gallons per acre daily for about six months, removed 44 per cent. of the total organic matter and 64 per cent. of the suspended matter.

A Plea for a Committee on Steel-Concrete.

By Ross Francis Tucker, M. Am. Soc. C. E.

The proposition of the American Society of Civil Engineers to appoint a committee on "Concrete and Steel-Concrete" is most timely, and it is eminently desirable that such a committee be selected to go thoroughly into the subject and establish some general rules for the guidance of the engineer in his design and in the conduct of his work in the field. The repeated failures of reinforced concrete structures during the past year, numbering about fifteen reported cases, some of them entailing loss of life and very serious consequences, indicate a grave condition of affairs in this class of construction and the engineer who may contemplate its adoption may well pause and consider. Broadly speaking, the cause of these failures is quickly found. Incompetency and inexperience lie at the root of the trouble.

A dozen years ago, the subject of reinforced concrete was practically unknown save to one or two specialists in widely separated parts of the world. Monier in France and Ransome in California had progressed far into this unknown field and were the chief exponents of the art of reinforcing concrete, works of great magnitude and importance having been designed and constructed under their respective systems. Since then the intervening years have been given to promulgating and demonstrating the value of the reinforced structure for the solution of many problems, and the writer, having also been a pioneer in this work, can testify to the very proper conservatism of the American engineer in his attitude toward an idea which lacks authority or which is theoretical as far as his personal observation or experience is concerned.

A few years since, however, there befell a great scarcity in the supply of steel for structural purposes, and, as by common impulse, engineers and architects sought other solutions for problems in hand, and at once the subject of reinforced concrete took on a new and great importance. Thereupon was created a demand which there was a corresponding rush to supply. There came forth rods and bars, sheared metal and wire mesh, in great variety, each with its mass of formulae, tables of sizes, records of tests, references and authorities, until one was bewildered with data crowded upon him. Firm after firm sprang up, basing its existence on some bar or mesh, in many cases depending upon a young engineer whose experience has been measured by his college course for the "engineering work" and without technical qualification or adequate experience, has plunged in where angels might fear to tread. There is no more justification for a firm of this character being allowed to undertake the construction of such highly technical and responsible work than there is to permit a dentist to perform an intricate and dangerous operation in surgery. Yet they are upon every hand and their eagerness to solve the problem of the long span seems to be in inverse ratio to their ability and the value of the material they offer for reinforcement.

This matter of building long slabs with reinforced concrete and placing upon it burdens that one would hesitate to call upon steel to bear, indicates what a reckless disregard for fundamental principles exists in the minds of many exploiters of reinforcing fabrics, particularly of wire mesh. The tensile reinforcement is ridiculously out of proportion to the compressive area, and as for shearing resistance, that is omitted entirely. The bearings are in most cases entirely insufficient, and little care is given to either the selection of the materials or their putting in place. One sees cinder concrete mixed helter-skelter, "in any old way," then thrown on to the centers and tamped with a shovel, and the embedded metal tied together with single bits of No. 16 tie wire. There is nothing correctly done in the whole process and yet it "passes." It is really marvelous that so much of this work does stay in place.

The making of concrete may be thought to be a simple matter, but that does not warrant the unskilled in assuming that he may safely and properly build a concrete beam. As a matter of fact, however, the making of concrete is not a simple matter at all, but a very complex and subtle matter of which years of experience will hardly give mastery. To some this may appear amusing, but a knowledge of the qualities of this material would soon justify the statement.

After thoroughly good designs are evolved for a structure failures may occur from many causes. When the weather is very hot, concrete requires shade and water. When it is cold, it needs shelter and warmth. It should not be disturbed during its initial set. It should have sufficient air. It can be frozen or stifled or drowned. These are but the elements of successful "handling" and are the mere incidentals of the problem, yet how many "steel-concrete experts" understand and provide for them.

It is a fairly just commentary on the lack of material progress in the design of reinforced structures to observe that during the past decade, while some details have been developed and perfected, there has been no general advance beyond the limits marked by Ransome in his constructions on the Pacific coast. There have sprung up many rivals to the twisted bar, but the material gain in practical design over that demonstrated in the work done in the '80s is very small indeed. We have data and theory enough at hand. What we need is skilful and responsible application of the data in the actual construction. It is shameful that a concrete beam should fail, whatever may be the type of bar used in its construction. It is shameful that such an excellent material as expanded metal should be subjected to the disgrace of a collapse, because of the endeavor of some "agent" to outspan his competitor.

And yet the busy engineer is to a large extent at the mercy of these irresponsible people. He has neither time nor opportunity to study their comparative merits from actual experiment. He must rely upon data presented, in regard to design, tests and work already accomplished. But there is one thing he can do, and that is insist that skilled and experienced firms shall do his work. He would not use an unknown or untried cement if he were wise. No more will he wisely employ those of uncertain knowledge or skill.

We need, however, the data and regulations that a competent and impartial committee might promulgate for the guidance of engineers in the essentials of the design and execution of steel-concrete structures. The province of the bar and the province of the mesh should be studied and defined, for each has its limits as well as [illegible]-Wheeler [illegible] of every design.

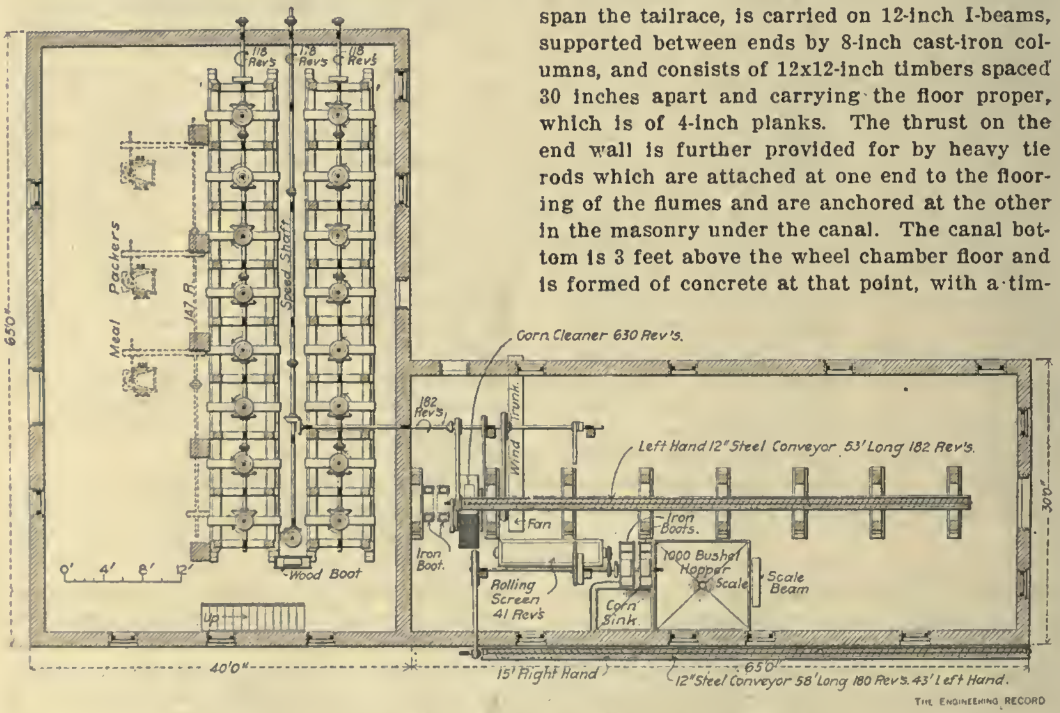
horse-power in capacity are used, th[illegible] of gate rating being about 350 horse-power.

Building.—The building occupies a trapezoidal area of about 55,070 square feet, with a frontage of 261 feet on Grand Street, 330 feet on Morgan Avenue, and 232 feet on Metropolitan Avenue. It is of slow-burning, mill-type construction, and is divided by fire walls into eight sections, enclosing three sides of a court wherein is located a 25x50-foot covered reservoir, having a capacity of 125,000 gallons, and a store-house for the automobile delivery wagons. The designation of the several sec-

A Low-Head Mill Power at Juliette, Ga.

A water power of 14 feet head has recently been improved at Juliette, Ga., on the Ocmulgee River, for the direct driving of a corn mill. A timber dam extends across the river at the head of a shoal, a short canal runs from one end of the dam, and at the end of the canal vertical water turbines are submerged in a flume continuous with the canal and supported directly over the tail-race into which the turbines discharge. By means of bevel gears the wheels drive horizontal shafts extending into the mill building, which stands on the bank of the river opposite the flume. The mill building, which has a capacity of 5,000 bushels of corn meal per day of 24 hours, is largely a timber structure of unusually heavy members.

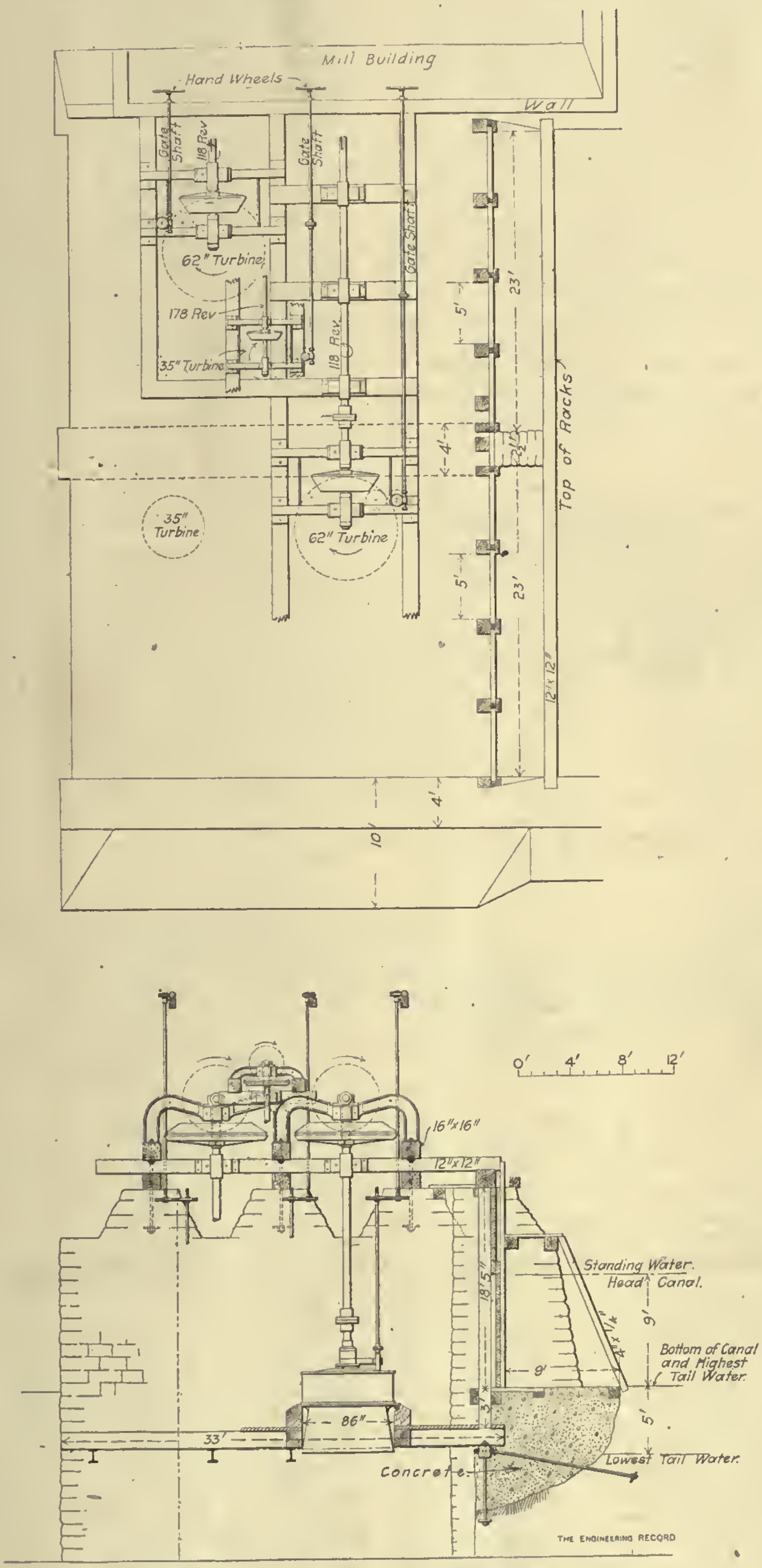
The new mill is located at Juliette, Ga., on a site that has been used for mill purposes since 1845. The river at this point is divided into two channels by an island and at the head of the island a timber dam or bulkhead has long been in use to impound the waters above that point. This bulkhead, on account of the width of the river at this point, is quite long, but is not high. According to a publication made some time ago by the State Geologist of Georgia, the Ocmulgee River at this point has a shoal some 4,000 feet long, which gives a total fall of 16 feet. The river has a low-water flow at Juliette of probably 400 cubic feet per second, so that the power available there is 325 horse-power, which is only one-fifteenth of the power accorded by early authorities. The freshet waters probably amount to some seventy times the stated minimum volume. The desirability of enlarging the old plant, as well as of securing the advantage of a better development and the economy of modern machinery, led to the abandonment of the old mill, which was kept running so far as possible during the construction work. The mill is the property of the Juliette Milling Company, of which Dr. J. P. Glover is the general mill manager and the owner. Water power is utilized on the op[illegible] bank of the river, largely for a cotton [illegible] which is the property of the Glover Manu[illegible]ring Company.



Plan of the Corn Mill and Elevator at Juliette, Georgia.

[illegible] new water-power installation is designed [illegible] maximum head of 14 feet. The canal has [illegible] cut off from the river by erecting a heavy type [illegible]ry wall between what is now the canal [illegible] river channel, and from the upper end of the wall a timber dam has been run across the inner or nearer channel of the river. This consists of heavy timber cribwork carrying 8x12-inch timbers inclined 40 degrees with the horizontal and giving the stream an upward inclination leading to the crest. This is about 8 feet above the stream bed. The canal has a slope so that the head water is normally 9 feet deep at the flumes. There are two of these wheel chambers, each guarded by racks and a pair of timber gates. They are formed with heavy masonry side walls, one being the outside canal wall raised a few feet above the highest head-water level, another the wall at the bank carrying the outer end of the mill, and the third, the partition wall between the chambers. This is 4 feet thick and is carried to the same height as the others, and is provided with an opening which may be uncovered for the sake of stability, whenever there is danger of collapsing the wall, owing to any difference of pressure on the two sides. The back wall of the flumes is of timber, of which the main members are 12x6-inch beams supported vertically on 30-inch centers and braced by horizontal beams and by tie rods carried into the masonry. The flooring of the wheel chambers, which, as explained, span the tailrace, is carried on 12-inch I-beams, supported between ends by 8-inch cast-iron columns, and consists of 12x12-inch timbers spaced 30 inches apart and carrying the floor proper, which is of 4-inch planks. The thrust on the end wall is further provided for by heavy tie rods which are attached at one end to the flooring of the flumes and are anchored at the other in the masonry under the canal. The canal bottom is 3 feet above the wheel chamber floor and is formed of concrete at that point, with a timber flooring at the extreme end to protect the concrete against wear.

The water-wheel installation consists of two 62-inch Samson turbines and one 35-inch Samson turbine, all built by James Leffel & Company, of Springfield, O. They are set on the floor, with short draft tubes extending through holes in it, the normal level of the tail-water being immediately below that elevation. They are of a vertical type, and the shafts carry large bevel gears which are meshed into gearing on horizontal shafts. They are all controlled by hand and the rods for controlling the gates are similarly meshed into light horizontal shafts which allow for placing the controller wheel within the mill building. The highest head-water rises to a level of about 14 feet above the wheel chamber floors and the height of the tail-water is slightly above the center of the wheels. Each of the larger turbines is designed to run at about 78 revolutions per minute, and to develop under the 14 feet of head, 407 horse-power. The 35-inch wheel is rated to develop 129 horse-power at a speed of 136 revolutions per minute. The shafting and gearing are carried by the usual form of yokes, which are fixed to heavy timbers, as indicated in the accompanying drawing. During a recent flood, when the tail-water rose so there was but 5 feet of head, the wheels proved capable of driving all of the machinery, though located below tail-water level.



Plan and Elevation of Water-Wheel Plant at Juliette.

The mill building comprises two adjoining structures, forming a letter L, in communication with each other. One of these is the grinding department, containing two runs of eight buhr stones each, and the other is the corn storage building or elevator, containining eight bins of a total capacity of 26,880 bushels. The buildings have masonry foundations, the first story has brick walls and the structure above is housed in clapboards. The structural work consists entirely of heavy timbers, formed into trusses to carry the roof and floors. To explain the character and amount of machinery installed in the building, the passage of the corn through the mill may be briefly followed. Alongside of the storage building there is a railroad siding on which the grain is dumped from cars into a screw-conveyor. This is partly right-hand and partly left-hand, and delivers the corn in a chute to a corn sink. From this it is elevated a short distance and delivered into a weighing hopper of 1,000 bushels capacity. From this it is again elevated and discharged through a revolving screen for removing large foreign matter, such as cobs, stones, etc., and is elevated to a longitudinal conveyor above the storage bins. These are emptied on a longitudinal screw-conveyor underneath the bins, and the corn then passes in turn through an Invincible cleaner and an elevator leading to conveyors over the stock bins in the grinding house. The corn discharged from the stock bins and ground in the buhr stones is conveyed as meal in steel conveyors, from which it is elevated and carried to a conveyor for three meal bins over the packers, passing en-route through a Eureka magnetic separator. The ceiling of the first story of the grinding room carries a number of I-beams, one over each buhr stone and leading in groups to turntables, the I-beams forming a system of supports for a trolley hoist by which any buhr stone may be removed for resurfacing.

Each of the 62-inch turbines is connected to one of the rows of buhr stones and also drives the corresponding meal conveyor, which is a 9-inch screw 48 feet long and turned at 158 revolutions per minute. Two of the buhr stones in each row are 54 inches in diameter and the others 48, but they are all geared to run at the same peripheral speed, which is 2,225 feet per minute. All the other machinery is driven by the 35-inch turbine from the so-called speed shaft and comprises the following: Four bucket corn elevators, three of 1,000 bushels capacity per hour and one of 530 bushels capacity; one meal elevator; three steel-screw corn conveyors, 12 inches in diameter, one 53 feet long, running at 182 revolutions per minute, one 58 feet long, running at 180 revolutions per minute, and the third, 50 feet long, running at 176 revolutions; two 9-inch screw meal conveyors, running at 123 revolutions, one 12 feet long and the other 35 feet; the rolling screen; the cleaner, the magnetic separator, and three meal packers.

The general features of the water-power development were designed by James Leffel & Company, and those of the mill by the Richmond City Mill Works, Richmond, Ind. The details of the work, particularly the building, were designed by Dr. Glover, and the whole was constructed under his immediate direction.

Two Transporter Bridges in France.

A large and high bridge with a suspended movable platform has recently been completed to carry highway traffic across the Loire at the harbor of Nantes, France. The principle of the bridge is similar to that of a few other well-known European bridges, and has been proposed for some American structures. The dimensions are unusually large and the design has some special features of arrangement and detail which were illustrated in "Le Génie Civil," Paris, November 28. Transporter bridges previously constructed have been built with a suspension bridge span of the ordinary type having the cables anchored at a considerable distance from the towers and having continuous stiffening trusses between the towers. In this case it was impracticable to extend the anchorages more than about 80 feet beyond the towers, and, in order to provide for the minimum obstruction, a modification of the ordinary overhead span was designed. The structure has two steel towers 248 feet high on masonry piers 462 feet apart on centers. Each tower supports, at a height of 164 feet above the water, an unequal-armed double cantilever trussed platform having an anchor arm of 82 feet and a channel arm of 174½ feet. These trusses have not sufficient strength to act as independent cantilevers, but are additionally supported by back stays from the tops of the towers to points about 15 feet apart on the lower chords. The shore ends of the short arms are anchored by vertical ropes to masses of masonry sufficient to provide reaction for all the live and dead load of the bridge. This arrangement makes each tower and cantilever resemble the type of derrick with counter-guyed horizontal boom which is often used for heavy work in large dry-docks. The river ends of the long arms of the cantilevers support and are connected by an ordinary trussed span 113½ feet long.

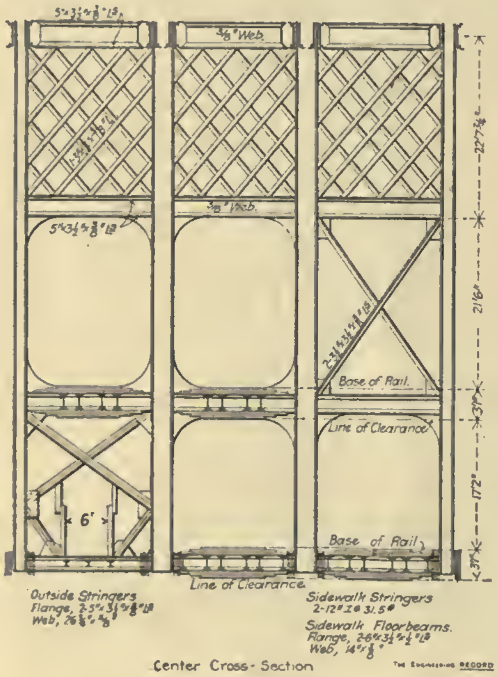
A horizontal platform is thus provided 164 feet high in the clear above water level and 626 feet long from anchorage to anchorage, which gives clearance for shipping and supports the suspended car which travels back and forth across the river to carry passengers and vehicles. The stiffening trusses are about 26 feet apart on centers, have a lateral system of X-bracing and carry sidewalks for the bridge service. In order to distribute the load of the suspended platform on the shallow stiffening trusses, the trolley has a wheel base 105 feet long and from it the 33x39-foot platform is suspended by vertical ropes and by ropes inclined in both longitudinal directions. The car has a landing at one end of the bridge inside the tower and at the other end on a pile platform just beyond it. Each tower is made with two transverse bents battered longitudinally and braced together by horizontal and diagonal riveted members. Each bent is made of two columns 75½ feet apart at the base and 26¼ feet apart at the top. They are connected together by horizontal and diagonal braces and by a deep portal strut at the top. Each column is tapered from the middle to both ends and is built up of smaller stiff members riveted together. The bases are pivoted to the pedestals. The car with its load weighs about 308,000 pounds.

The towers were erected by a light movable derrick having a braced mast or tower with a double-arm trussed boom pivoted to the top. The arms of the boom are unequal, the shorter one being adjustably anchored to the mast and the longer one carrying the hoisting tackle. By operating the anchorage tackles the boom could be raised or lowered. This derrick was carried up with the steel work, and after erecting half of the tower up to the first cross strut, was moved transversely on falsework and erected the other half and then another story of that side of the tower; then it was moved back again and erected two stories of the other side, and so on until the tower was completed, after which the cantilever arms were erected by overhanging shear legs on a traveling platform. The center span weighing 99,000 pounds, was completely assembled on shore, floated underneath the cantilever arms and lifted into position by tackles suspended from the shear legs. Before the center span was lifted, each of the tackles was tested by lifting a boat-load of sand weighing over 57,000 pounds. The span was lifted at a speed of only about 40 feet an hour.

Another bridge of the same class but of much greater dimensions, and an entirely different type, has been designed to cross the Gironde, at Bordeaux, and was illustrated in "Le Génie Civil," June 20, 1903. In this case the clear span between piers is 1,312 feet and the clear height of the trolley platform above the water is 151 feet. The platform is supported by a peculiar arch with hinges at the crown and at the haunches. The trusses between the crown and the haunches have lune-shaped outlines with vertical and diagonal members. From the haunches to the skewbacks the outlines of the trusses are nearly triangular and support the trolley platform on vertical spandrel posts connected to their top chords. Between the haunches the platform is suspended by vertical members from the bottom chords of the arch trusses. The total rise of the arch is 328 feet and its total height above water level is 333¼ feet. The trolley platform terminates at two 33x112-foot towers 164 feet high and 1,392 feet apart on centers. The platform has no stiffening trusses and its longitudinal girders are spaced 79 feet apart and braced transversely with lateral struts and X-bracing. There are two parallel 33-foot-gauge tracks on each of which there is a trolley with a wheel base about 150 feet long supported by sixteen pairs of wheels. From each pair of wheels there is an inclined suspension rod to the platform which, with the trolley and load, weighs about 100 tons. There will be elevators installed in each tower to give access to the promenade on the trolley platform which will be floored over above the tracks. A foot-walk will also follow the lower chord of the arch truss so that visitors may reach the ground. It is estimated that the suspended platform will travel from end to end of the structure in two minutes and with require a 150-horse-power motor.

Strain Sheet and Specifications for a Four-Truss Double-Deck Railroad Bridge.

The five-span, double-deck, four-track (designed for five tracks) bridge which carries the Pittsburg, Fort Wayne & Chicago Railway across the Allegheny River, at Pittsburg, is a very heavy and important structure presenting special features which have been illustrated in The Engineering Record of October 11 and 18, 1902. In order to accommodate upper and lower tracks the bridge has two decks, the clearance between which is so small that it was necessary to provide four trusses so as to reduce the depth of the floor-beams. This arrangement would have permitted three tracks at each level, but one track is at present omitted and another is replaced by a foot-walk for the public, these two transverse panels being occupied by riveted sway bracing arranged to come at opposite ends of the diagonal of the cross-section of the span. The trusses are slightly unsymmetrical and the stresses and cross-sections of corresponding members differ slightly on opposite sides of the center. The sections and stresses for the heavy end of the center truss are shown in the diagram.



Allegheny River Bridge.

At present the two center trusses carry all the load from two of the tracks and half the load from the other two tracks and one sidewalk, and the outside trusses are equally stressed by the remainder of the live and dead loads except that one truss carries a comparatively trifling larger amount than the other on account of the sidewalk. They were designed, however, so that one of the outside trusses should carry half of the fifth track in addition to what the other outside truss now carries. These differences and irregularities affected only the quantities on the strain sheets, the computations for the outside trusses having been made in the same way as those for the center trusses, and their diagrams corresponding to the one which is given for a heavy truss except that all the stresses are lighter. The materials at the right are for the corresponding symmetrical members at the left, and both ends of the diagram together give data for the heavy end only.

The soft steel floor is proportioned for a track weight of 300 pounds per linear foot, a distributed live load of 5,000 pounds per linear foot and a concentrated load of 50,000 pounds. A concentrated load of 75,000 pounds is used for proportioning floor-beam and stringer connections. The medium steel trusses and braces in the 333-foot span are proportioned for a distributed wind pressure of 30 pounds per square foot for the loaded and 50 pounds for the unloaded structure and 600 pounds per linear foot moving pressure. The vertical loads per linear foot were assumed for the outside trusses at 2,980 pounds dead, 3,750 pounds live, and 37,500 pounds concentrated, and the center trusses at 6,380 pounds dead, 7,500 pounds live and 75,000 pounds concentrated. where the greatest chord or floor-beam stress from lateral force exceeds one-third of the stress from dead and live loads, additional section is provided for such excess. All adjustable rods are proportioned for an initial stress of 10,000 pounds in addition to the computed stress, and all lateral struts are proportioned for their computed stresses plus the sums of all the 10,000-pound initial stresses in the adjustable members connected to them. Each vertical and diagonal member of the trusses is proportioned for the computed stresses plus 50 per cent. of the concentrated load or its oblique component.

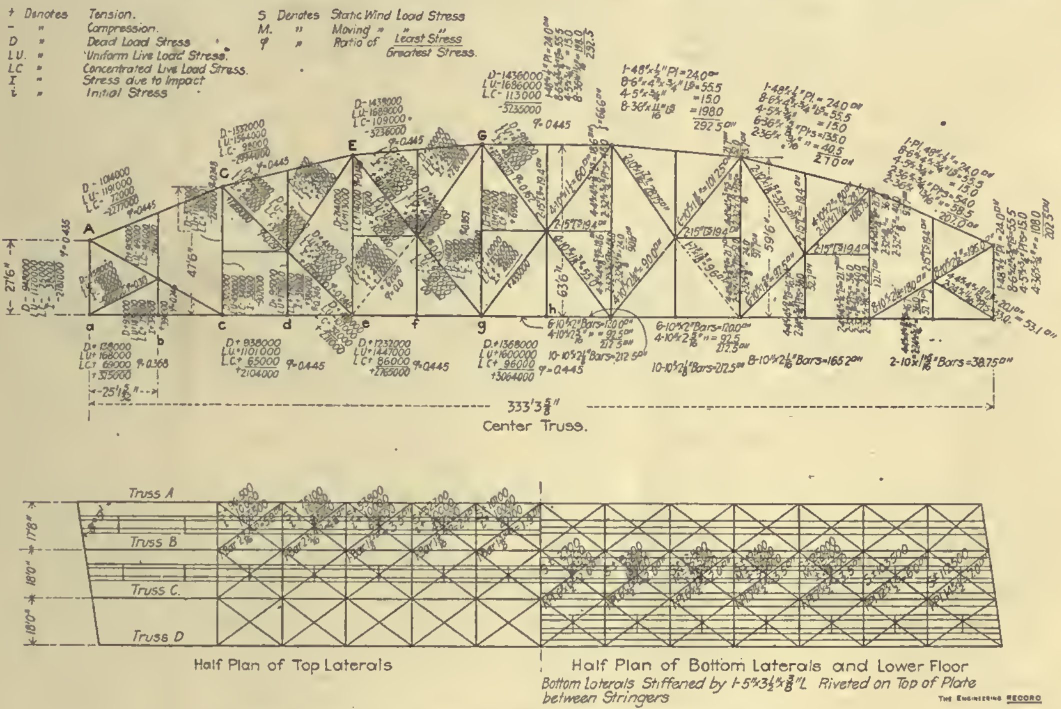
Both maximum and minimum stresses are computed and the working unit stresses derived from them are increased 20 per cent. above the amounts given by the following formulæ: Tension per square inch in plates and shapes, net section = 7,000 [1 + (minimum ÷ maximum)]; tension in rolled bars = 7,500 [1 + (minimum ÷ maximum)]; tension in end suspenders and counters = 6,000 [1 + (minimum ÷ maximum)]; tension in laterals and sway bracing = 9,000 [1 + (minimum ÷ maximum)]. The general formula for compression is: Unit stress = [7,000 — 26 (l ÷ r)] × [1 + (minimum ÷ maximum)] in which l ÷ r is the ratio of the length to the least radius of gyration. Unit compression in lateral struts = [9,000 — 33 (l ÷ r)] × [1 + (minimim ÷ maximum)]. Shearing stress per square inch in the webs of solid girders = 4,000 [1 + (minimum ÷ maximum)]. For members subjected to alternate tension and compression the term 1 — ½ (maximum stress of lesser kind ÷ maximum stress of greater kind) is substituted in the preceding formulæ for the term 1 + (minimum ÷ maximum).

The shearing stress per square inch upon pins or rivets does not exceed 75 per cent. of the allowed tension or compression per square inch in the members they connect, nor is the bearing pressure on the diametrical section more than twice the allowed shearing stress. For hand driven or field rivets these stresses are reduced 20 per cent. Shear in stringer and floor-beam connection angles does not exceed 4,000 pounds per square inch. The bending stress on outer fibers of pins does not exceed 15,000 [1 + (minimum ÷ maximum)] pounds per square inch. The bearing pressure per linear inch upon steel friction rollers does not exceed 400 times the diameter of the roller in inches. The bearing pressure upon masonry does not exceed 250 pounds per square inch.

Rivet spacing in solid-web girders is determined by the shear at the point under consideration, having regard to the kind of shear, thus shearing, one kind, pounds per square inch, 5,000 [1 + (minimum ÷ maximum)]; shearing, opposite kinds, pounds per square inch, 5,000 [1 — ½ (maximum shear, lesser kind ÷ maximum shear, greater kind)].

Flange areas are built up as much as possible with angles. When flange reinforcement plates are used, those next to the angles are made full length of the girder. The minimum thickness of metal is ⅜ inch. The minimum weight of angles is 6 pounds per linear foot. The minimum size of lateral, sway and counter diagonals is 1¼ inches square. No round rods are allowed. The camber is one-thousandth of the span. Provision is made for an expansion of 1 inch in 70 feet. The other requirements conform in general to standard practice for first class railroad bridge work.

The specifications have a number of special provisions among which some are here given which were not applicable to this structure, as well as some which are evident from the previously published details of these spans. Plate girder bridges are generally used for spans up to 80 feet; open web girders for spans from 80 to 120 feet, and single intersection pin-connected Pratt truss bridges for spans over 120 feet. The track gauge is 4 feet 9 inches. For single-track bridges on tangents, clearance is required 21½ feet high, 10 feet wide at the bottom, 6 feet wide at the top, and 14 feet wide for a distance from 4 to 16 feet above the base of rail. Through girders are spaced 13 feet apart on centers when the top chord or flange is not more than 3 feet above the rail base.


+ Denotes Tension.
– " Compression.
D " Dead Load Stress
LU. " Uniform Live Load Stress.
LC " Concentrated Live Load Stress.
I " Stress due to Impact
i " Initial Stress
S Denotes Static Wind Load Stress
M. " Moving " " "
φ " Ratio of Least Stress / Greatest Stress.
A
C
E
G
a
b
c
d
e
f
g
h
276"
476"
636"
333'3⅝"
Center Truss.
Truss A
Truss B
Truss C.
Truss D
Half Plan of Top Laterals
Half Plan of Bottom Laterals and Lower Floor
Bottom Laterals Stiffened by 1-5⅜x3½x⅜"L Riveted on Top of Plate between Stringers
The Engineering Record

Strain Sheet of Center Truss, Allegheny River Bridge.

Stresses and Materials Both Apply to Left-hand Half of Truss, Which Varies Slightly from Other Half.

Bridges on curves have trusses set parallel with the chord connecting the centers of track at the ends of the span, the center line of the bridge bisecting the versed sine at the center of the span. When the bridge is on a curve there is added to the maximum lateral forces a moving lateral force equal to 3 per cent. of the live load on all tracks (acting in the direction of centrifugal force), for each degree of curvature. Stringers are braced laterally to resist the same force. The connections between the lateral bracing and the chords or flanges are made of greater strength than the lateral braces. No portions of the webs of beams or girders are used in computing flange areas. Provision is made for the effect of the weights of horizontal and inclined compressive members in reducing their strength as columns.

In calculating the shearing or bearing stresses of plate-girder rivets the whole shear acting on the outside of any section is considered to be transferred to the flange angles in a distance equal to the depth of the girder. Plate girder flanges generally have 14-inch plates and 6x6-inch angles.

Whenever the unsupported distance between flange angles exceeds 50 times the thickness of the web plate, vertical angle stiffeners are placed on each side of the web. They are generally symmetrically arranged with spaces equal, in the center, to the height of the girder and one-half as great at the ends. Stiffeners are placed at all web splices and over both ends of bearing plates. The stiffeners are wide enough to fully support the flange angles and are provided with fillers as thick as the flange angles.

At the shore ends of through girders the top flanges are curved, on the center line of rivets through the web, to a radius of 18 inches for spans up to 50 feet, 21 inches up to 60 feet and 24 inches for greater spans. The pier ends of girders are finished square and separated 6 inches except on curves. In through girders the floor-beam webs are riveted to the vertical web stiffeners of the main girders and form gusset plates and braces to the top flanges. When the inclined edge of the gusset plate is longer than 96 times its thickness it is stiffened by angles. When the floor-beams are near the middle of the height of the girders their gusset plates extend to both top and bottom flanges.

In the top chords of pin-connected bridges, the distance between the centers of gravity of the channels is not less than the depth of the channel. Splices do not come at pin points. Lower chord eye-bars are not allowed to diverge more than ⅛ inch per foot. Counters, laterals, and sway diagonals are adjustable. Turn-buckles are made with open sides and loop eyes have a minimum length of three pin diameters from back of pin to apex of loop. All lateral systems have adjustable diagonals intersecting in each panel. Struts are of the full depth of the unloaded chord and diagonals there are in the planes of the pin centers.

When two stringers are used under each track they are 6½ feet apart on centers; when four are used one pair is 7 feet apart and the other pair is 3 feet apart. Cross frames are used between stringers at center of panel whenever the length of stringers exceeds twelve times their flange width or whenever the alignment is on a curve. In double-track bridges the upper angle of the intermediate cross frame is continuous over the top flanges of all stringers in each panel, on curves.

All bed plates have sheet lead plates ⅛ inch or more in thickness interposed between them and the masonry. On piers one continuous bed plate receives the ends of adjacent spans. The lengths of rivet grips are limited to five times their diameters. All girder and riveted truss spans must be fully assembled, fitted up and reamed in the bridge shop. All riveted field connections must be assembled and reamed in the shop or the rivet holes must be reamed to an iron template. Rivets above ⅞ inch diameter must not be hand driven. Bridges erected alongside to replace an existing structure must be erected on the down-stream side. These specifications were issued in April, 1897, by the engineering department of the Pennsylvania Lines West of Pittsburg, Mr. Thomas Rodd, chief engineer, and Mr. J. C. Bland, engineer of bridges.

Saving a Sinking Concrete Arch Bridge.

An island landing for pleasure yachts at Mamaroneck, New York, was connected with the owner's residence on the mainland by a concrete arch bridge about 140 feet long which, when nearly finished, was threatened with immediate destruction. It was saved by prompt action and the building of an unusual kind of protection and reinforcement for its foundations. A footwalk and driveway leading to the dock were designed by the landscape architect and two abutments and four piers of stone masonry were built by the general contractor across an exposed channel where the tide of about 7 feet washed the sand back and forth, leaving it usually a foot above low water and often scouring it deeply in storms.

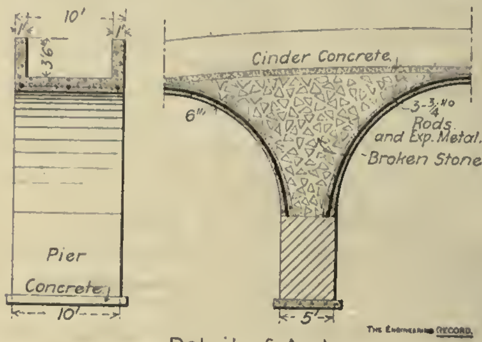
The 5x10-foot piers were about 8 feet high with concrete footings 6 inches thick extended 6 inches beyond the masonry and seated on the sand a foot below low water. The contract for the superstructure was awarded to Messrs. Tucker & Vinton, of New York, who accepted, without special investigation, the assurance that the piers were fully competent to sustain together the 600 or 700 tons weight of their own masonry and superstructure. On the piers and abutments five full centered arches were built, as shown in the sectional elevation, and the large spaces over the piers and haunches were filled up to sub-grade with broken stone.

During the construction of the arches a severe storm scoured the bottom and destroyed all of the falsework. It was renewed and the concrete work was completed and the stone filling over the piers and haunches had been nearly finished when vertical V-shaped cracks appeared above the crowns of two of the arches.

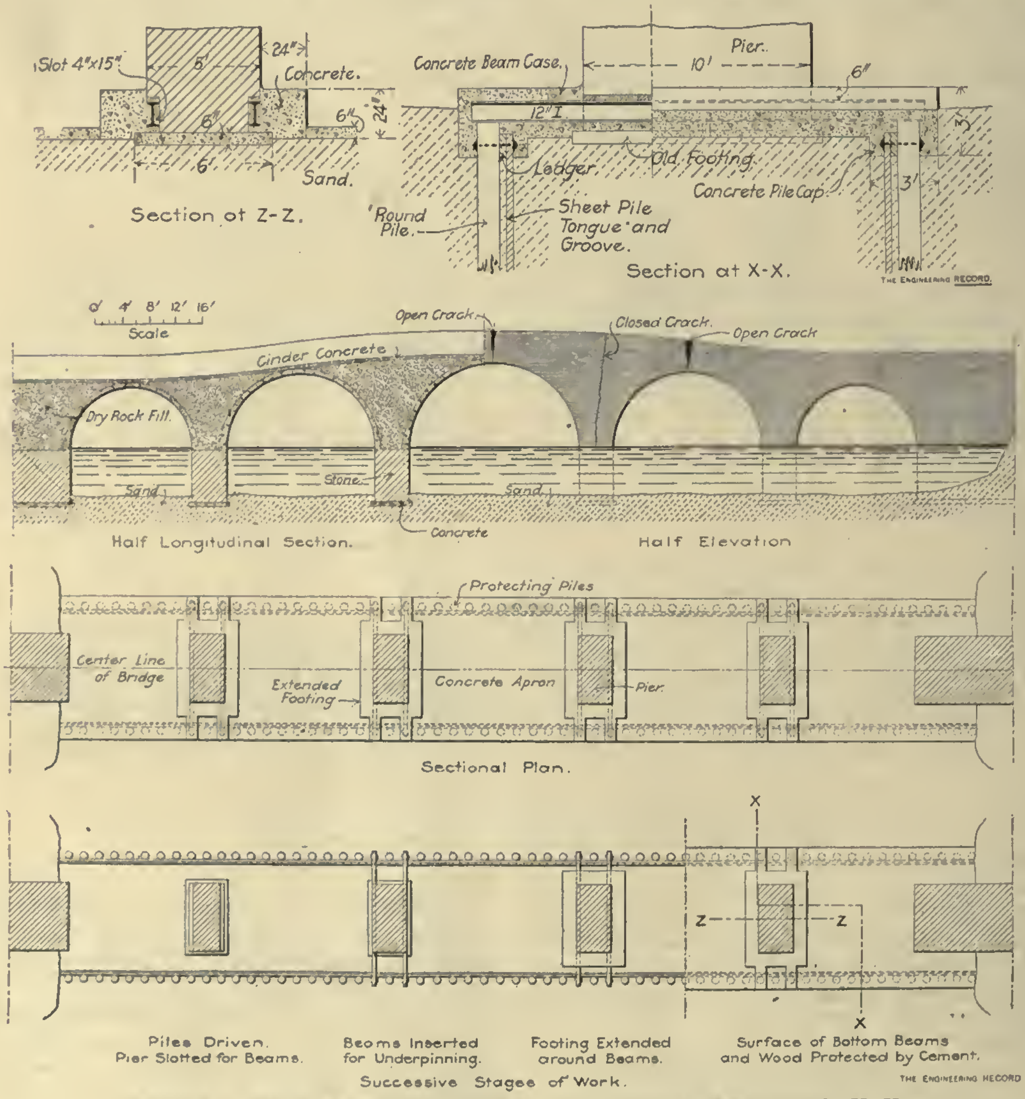
One of them opened about ¾ inch, and the other about ½ inch at the top. A vertical crack was also developed on the center line of the pier between them and on each side of it the face concrete was crushed. Observations on the water marks showed that this pier had settled about 4 inches and the others had settled from 1 to 2 inches. The broken stone which had been placed on the arches was immediately removed and piles 3 feet apart were driven in parallel rows about 9 feet each side of the bridge axis. Waling pieces were bolted to the insides of these piles and against them were driven 3-inch tongued and grooved sheet piles 15 feet long, thus enclosing, between side walls and the dry land on both sides of the channel, a portion of the sandy bottom which sustained the piers.

It was not deemed safe to undermine the piers so as to underpin them, but slots were cut on each side of each pier as low as could be reached at extreme low water and in them were seated single 12-inch, 32-pound transverse I-beams which took bearing on the round piles and were wedged up against the top of the slot in the pier masonry, thus affording some support against further settlement. The beams were encased in solid masses of concrete, which were extended around all sides of the piers to a width and depth of 2 feet. The tops of the piles and the waling pieces were enclosed in a mass of concrete about 3 feet wide and 2 feet high, except where it also enclosed the ends of the I-beams and was 3 feet high. This concrete extended about 2 feet below low water mark and was embedded a foot below the average surface of the sand. The space around the piers and cross-beams between the piles was covered with a 6-inch layer of concrete forming a continuous floor over the whole area which served as an apron to protect it from scour. By this means resistance to further settlement of the piers was provided by the transverse beams, and the bearing capacity of the soil and its stability were greatly increased by confining it between the sheet piles and protecting its upper surface.

The results of the work were satisfactory, and the bridge was successfully completed and put in service and showed no further signs of irregular settlement. The repairs occupied about one month and cost in the neighborhood of $3,000. The concrete in the new footings and apron was made 1:3:6 with Alsens brand of Portland cement and beach gravel up to 2 inches in diameter. The concrete for the arches was made 1:2:5 with Alsen's cement and gravel from ¼ inch to 1½ inches in diameter. The arch rings were reinforced by full width sheets of No. 10 expanded metal with 3-inch mesh, extending continuously from one springing line of the crown to the other springing line and stiffened with three semi-circular longitudinal steel rods ¾ inch in diameter.



Detail of Arch.



Method of Saving a Sinking Concrete Arch Bridge at Mamaroneck, N. Y.

Letters to the Editor.

The Union Engineering Building.

Sir:—With regard to the acceptance by the American Society of Civil Engineers of assistance from persons not members of the Society it may be said that the Society has had for some thirty years a class of Fellows, some of whom are characterized parenthetically in the catalogue as not members. Their qualifications are: "Fellows shall be contributors to the permanent funds of the Society" and "persons elected as Fellows shall become such upon the payment of Two Hundred and Fifty Dollars." The Society has also been publishing with its list of members for twenty years a list of "Subscribers to the Building Fund," including commercial firms or bodies and individuals not belonging to the Society, as, for example, the Boston Gas Light Co. A few years ago many more names used to be printed than now, and among them was Andrew Carnegie.

With regard to the feasibility of having several societies under one roof, I am somewhat influenced by the fact that a common room is used for the libraries of the Boston Society of Civil Engineers, the New England Water Works Association and the Society of Gas Engineers, while an adjacent room is sublet to a manufacturing company. This arrangement has been found mutually advantageous, and has allowed the divers organizations to maintain their distinctive peculiarities. In other respects besides magnitude this experience may differ from the project for a union engineers' building. I am still so hopeful as to perceive no need of quarrels between neighboring engineering societies greater than the quarrels that arise between members in one engineering society.

Respectfully, Fred. Brooks.

Boston, Jan. 26.

Sir:—An argument advanced to me by a prominent member of the American Society of Civil Engineers against the acceptance of Mr. Carnegie's offer to erect a union building for the four national engineering societies is that it will be another "Carnegie Monument"; that Mr. Carnegie will receive all the credit and the building will be known by his name, while as a matter of fact the real success of the venture is dependent, not upon the building, but upon the subsequent efforts of the constituent societies, which will be called upon to raise not only a large amount of money to buy the ground upon which the building is to be placed but also will be responsible for its maintenance.

There is, unquestionably, room for argument as to the benefit derived from some of Mr. Carnegie's gifts, the efforts and sacrifices of the people being overshadowed by the ever present name of "Carnegie" engraved in large letters upon the front of the building in which he bears a part. This it is feared will be the fate of the societies; that the building will be known to the public as a "Carnegie building" and the societies as "some of Carnegie's engineering societies." When we realize that the success of any venture is not assured by the completion of a building, that the man or men who with signal success direct the affairs of the organization for which Mr. Carnegie furnishes a house are as worthy of praise and acknowledgment as he who furnishes the building, is it any wonder that there are men, not so rich perhaps as Mr. Carnegie, but who have worked faithfully for the welfare of these societies individually, who do not wish to see their work and their names buried under the weight of this one man's name no matter how generous his gift?

Mr. Carnegie has had unusual facilities for amassing a fortune and many men have contributed to that fortune their brains and energies, and perhaps to no other factor is Mr. Carnegie more indebted than to engineering science. None knows this better than Mr. Carnegie himself. Mr. Carnegie, therefore, influenced by a broad spirit of philanthropy and generous recognition of the debt which modern commercialism and vast fortunes owe to engineering science, should be more interested in presenting this gift to the engineering societies of the United States that the constituent societies are in receiving it, and upon the completion of the building the knowledge of an act well performed will be Mr. Carnegie's sufficient reward. While I have seen no authoritative statement concerning the relation Mr. Carnegie's name is to bear to the completed project, it still seems to me, in thinking over the arguments used to me against this project, that if assurances were sought from and given by Mr. Carnegie or those who represent him, that this building when completed will in truth be a union engineering society building, known and read of all men upon its face as such, and not, as is now reported, "only another Carnegie monument," then one of the most potent arguments against the acceptance of this gift will have been overcome.

Another argument used among the societies themselves is the inequalities which at present exist among them. The American Society of Civil engineers is at present admittedly in a position superior to any of the other national engineering societies, both as to numbers and finances. This is due, perhaps, to the fact that those branches of engineering science coming more particularly under the caption of "civil engineering" are more advanced than the other branches of the profession. Whether this will remain so in time to come no one knows. It may be that electrical or mechanical engineering is destined by invention or otherwise to eclipse in importance civil engineering. In this age of discovery and progress he who is on the top to-day may be last in the race to-morrow. Jealousies, then, among the societies are petty, too petty to have a place in this argument, and too petty to influence broad-minded and thinking men. Adjustment and reciprocity are to be the keynote of the future, and none should more readily adopt these measures than engineers among themselves.

It is true that the American Society of Civil Engineers seems to have less to gain by the proposed alliance than the other organizations, but this may be only a temporary and surface indication, and I cannot conceive a probable condition in which it can lose anything by the affiliation. It seems to me on the other hand that this society with its present admitted superiority, is afforded an opportunity to manifest the magnanimity which should pervade a scientific body of this kind, and to do that which unquestionably will tend to raise the standard of engineering as a profession.

Very truly, Alexander Potter,
Assoc. M. Am. Soc. C. E.
New York, Feb. 1.

Who is a Civil Engineer?

Sir:—Your interesting editorial on "Who is a Civil Engineer," reminds me that a few years ago you published my suggested definition of the modern civil engineer as "one who skilfully designs and constructs stationary economic structures." In discussing this definition, an English technical journal misunderstood "economic" to mean "economical." Therefore, for "economic" it may be better to substitute "industrial," which, however, the aforesaid journal may interpret as "diligent." Similarly, we may define the mechanical engineer as "one who skilfully designs and constructs movable industrial structures." These definitions would make civil engineering include hydraulics, sanitary works and mining; and would class electrical works and possibly naval architecture as branches of mechanical engineering. The two would include all industrial structures ashore or afloat, and therefore all engineering except military.

Although in the complex relations of modern industrial forces it is difficult to separate distinctly the various professions at all points, in the above definitions the boundary line between civil and mechanical engineering is generally sharp. But it may occasionally blur. For example, a drawbridge, though movable, would commonly be the work of the civil engineer, except the propelling and locking mechanisms, which would be more skilfully built by the mechanical engineer. Mechanical engineering would include not only all machinery and instruments but ships, elevators, cars and other vehicles.

The definition would make civil engineering include some architectural work. I think this inclusion is defensible. The so-called architecture of many industrial structures is practically part of civil engineering. But beyond the utilitarian and into the domain of art, the engineer, as such, cannot go. Embellishment is mine, says the architect. The engineer is essentially a scientist, and the architect an artist. Yet it is probable that, contrary to the popular notion, the work of the civil engineer merges oftener with that of the architect than with that of the mechanical engineer.

However the different works may be apportioned among the branches of the great profession of engineering, who is an engineer? "One who skilfully designs and constructs." The word "skilful" has for engineers a profound significance. They have ceased to think of it as conveying merely the ordinary idea of dexterity or precision, but see in it a profusion of intelligence, study, experience and good judgment. This kind of skill applied to engineering work is what "makes a dollar earn the most interest." To get the best results and to do the most skilful work the engineer must be the chief director and manager of construction, and subordinate to no one in the conduct of his work. Such of his own subordinates as can skilfully design and construct are of course engineers also. It can be demonstrated that no man is made an engineer by schools alone. The C. E. title given by colleges to the inexperienced is at least a misnomer.

Do not these definitions roughly describe the modern engineer? And is it not better for all that the grand divisions be few and logical, and that the specialties be recognized as branches of these grand divisions? Is it not generally true that to be a successful specialist one must have the complete training of the civil engineer or of the mechanical engineer as herein defined? And is it not probable that the recent inclination to specialties among educated engineers has proceeded nearly to its limit and may soon react permanently? Of course, no man can be skilled in all the various works comprised in either civil or mechanical engineering, but to be an engineer he must be able skilfully to design and build some important class of structures; his skill involving the economical use of materials, labor and machinery, and sufficient of the common legal and business principles to safeguard his work and his client under all ordinary conditions of construction.

Very truly yours, John W. Burke.
New York, Feb. 2.

Cost of Running a Union Engineering Building.

Sir:—Inasmuch as the fullest knowledge of all phases of the United Engineering Building project is to be desired, that all members of the American Society of Civil Engineers may vote with the greatest intelligence on the question, the writer having seen no statement of the probable cost of maintenance of such a building, sought and obtained from the largest operator in that line of business in New York City a detailed statement, the items of which foot up a round total of $30,000 per annum, which sum when assessed upon the associated societies in proportion to the space occupied would evidently make the amount to be assumed by the American Society of Civil Engineers about $12,000.

The annual cost of maintenance of the present Society House with ample accommodations for all uses of the Society except the annual meetings (which has recently been provided for most satisfactorily in an adjacent building) is less than $4,000.

The difference will go a long way toward advancing the interests of the American Society of Civil Engineers and the engineering profession in other channels.

Very truly yours, F. S. Odell,
M. Am. Soc. C. E.
Port Chester, N. Y., Feb. 2.

Steel-Core Dams.

Sir:—Noticing in your issue of January 16, 1904, Mr. Babcock's letter relative to "steel core dams," I wish to say that I believe I was the first to suggest such a type of construction. In April, 1891, while constructing a stone-filled, timber-crib dam in the San Francisco River, Arizona, I conceived the idea of building a much higher dam at the same place to develop about five times the horse-power of the smaller structure; and made sketches for a dam of this type, and submitted them to the manager of the mining company for which I was then constructing the smaller one. Also, in this connection, in May, 1891, I wrote a letter to Mr. J. A. L. Waddell, the eminent bridge engineer of Kansas City, Mo., roughly outlining the method I had in mind, and asking his opinion as to the merits of such construction. The plan did not receive his endorsement, as such materials as the steel plates and I-beams were at a high figure; and taking it all together, I seemed to be a good many years ahead of the time. As the mining company did not construct this second dam, I had no opportunity to carry forward my invention; and after discussing the matter with several other engineers, and in no case receiving encouragement, I let the matter drop.

So far as I know up to the present time, I am the bona fide original inventor of this type of construction, and still retain the above-mentioned letter from Prof. Waddell as a memento of that occasion.

Respectfully, A. McL. Hawks.
Tacoma, Jan. 27.

Common-Sense in Engineering.

Sir:—It is the desire of the writer to impress upon his readers the necessity of more of what should be a very common attribute, common sense, in engineering practice. For one example, in the common, but very necessary, work of measuring we see one engineer compelling his men to read the steel tape to hundredths on a farm or railroad survey; while another, to go to the other extreme, will be satisfied to the nearest foot on a base-line, upon which all other calculated distances depend. Truly some do "strain at a gnat and swallow a camel." It is obvious that it is a lack of common sense and a fitness of things which is the cause of this incongruity.

Again we see others, with a like disregard of the precepts of common sense, insisting upon a vernier or angular survey with the transit on a preliminary railroad or timber-land survey, when the needle of the transit would give as good results for the purpose desired, with a great saving in time and expense.

Or we have the case of the superficial one who insists upon a rod-reading in leveling to thousandths of a foot, when the cross-wire will cover a hundredth at a couple of hundred feet; and they also forget that the bubble in a field instrument cannot be made delicate enough to indicate such a refinement. We all, too, have found men in the field (and some of them of years of experience), who persist in reading the rod to hundredths in place of tenths on the ground.

In this way, we might go on ad infinitum, preaching on this subject, but let this suffice. With Pope we can say:

"Why has not man a microscopic eye?
For this plain reason, man is not a fly.
Say what the use, were finer optics given,
To inspect a mite, not comprehend the heaven?"

Yours, A. E. Duckham, C. E.

Pittsburg, Jan. 23.

A New Double-Acting Automatic Stop-Valve.

An automatic stop-valve for which patents have been granted in several countries is shown in cross-section in the accompanying engraving. Its chief feature is that it closes against a flow in either direction in the event of an accident in the apparatus with which it is connected. If on the one hand a boiler tube should bust, its office is, like the automatic valves on the market, to prevent an escape of steam from the remaining boilers through the disabled boiler; and on the other hand, should a fracture occur, for example, in the steam piping leading to an engine, it is designed to shut off a flow of steam from the boilers. The valve can be operated as an ordinary stop valve.

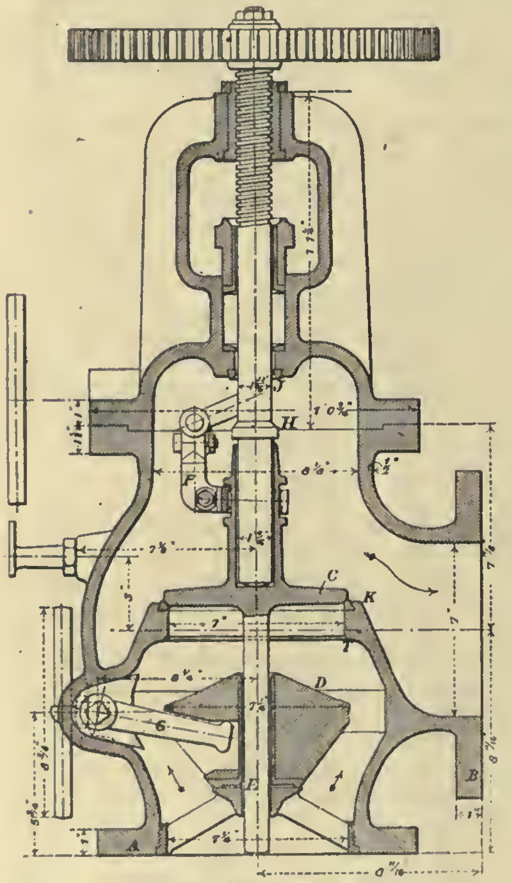
There are two separate valves in the valve body proper, C and D, each loose on the spindle. When valve C is screwed down it acts as the ordinary stop valve; when the spindle is raised and the pressure on the two sides has become equal, the valve is opened and lifted by the flow of steam from the boiler. Being loose on the spindle, as soon as a reverse flow of steam arises it is brought to its seat. The lower valve D operates in the same way only in the opposite direction. This valve is kept in position by its own weight, together with such pressure of steam above it as is caused by partial vacuum formed at point E by the flow of the steam past the valve. According to "Engineering," from which the illustration is taken, the valve can be set to close at any desired difference in pressure, which is generally about 20 per cent., by an adjusting screw and, when once adjusted, a padlock may be applied to prevent anyone tampering with the valve. When D is closed for any reason, it is held in its upper position until the upper valve is screwed down, when it falls, owing to an equalization of pressure above and below it through the space between this valve and the spindle. Hand wheels for testing are connected by means of spindles to levers engaging the valves, as indicated.

The valve, which has been introduced in England by T. Sugden, Limited, Fleet Street, London, is constructed to work at 300 pounds pressure. The body is made of cast steel of 60,000 pounds tensile strength, and the working parts are special gun metal, with the seating for the valves of a special combination of nickel to withstand what action there may be with superheated steam. It will be noted that there is a valve face on the spindle above valve C which, in its upper position, comes in contact with a seat immediately under the stuffing box. This is to protect the packing and to allow for inserting new packing while the valve is under steam. The valve is also made for marine work and in this type valve D is arranged to remain seated by a slight steam pressure, so that the valve may work irrespective of the roll of the ship or location of the valve in a vertical or a horizontal position. The valves are also made with or without spindles, of the angle and straightway patterns and in sizes of 1½ to 20 inches.

Book Notes.

The volume of "Transactions" of the American Society of Mechanical Engineers for 1903 is a book of nearly 1,600 pages. It is particularly noteworthy for the large number of papers it contains on subjects connected with power problems, theoretical and practical. Some of these, like Mr. William Kent's "Heat Resistance," are related rather to refrigeration or other outlying branches of power plant engineering, but as a whole they are of immediate importance. The most important is undoubtedly the final report of the committee appointed to standardize a system of testing steam engines. It is interesting to notice the number and value of the papers on shop and office management and the payment of mechanics, Mr. Fred W. Taylor's now famous paper entitled "Shop Management," being an important contribution to this volume.

The ninth annual report of the Boston Transit Commission is an admirable engineering document. It is largely an account of the construction of the East Boston tunnel, prepared by Mr. Howard Carson, chief engineer of the commission, and fully illustrated. A full description of this difficult undertaking has already appeared in The Engineering Record, but the official explanation of the work gives a number of details which were omitted in the more condensed article in this journal. There are also a number of important tables in the book, which contain data of much value on such important subjects as the strength of concrete-steel beams, the shrinkage of clay and the like.



The Hubner-Mayer Stop Valve.

Earthwork and Its Cost. By H. P. Gillette. New York, Engineering News Publishing Co. Cloth, 244 pages, $2.

The author has collected from scattered sources many valuable data relating to cost and methods of earth excavation and disposal, which forms an important part of nearly all engineering works of construction. Combining these data with results of his own observations, he has presented in a concise and practical manner and in a volume of handy form, information which will be of value in aiding young engineers to make preliminary estimates. The book is valuable in a less degree as an aid to contractors in submitting bids on work of which some of the items and conditions may not be familiar to them. Some severe but just criticism is made of various rules and tables which have been copied from early engineering books without modification to suit modern, wages, cost of materials and up-to-date methods of construction. The common failure of engineers to look to the ultimate financial success of their structures and the too common underestimation of cost of construction by engineers are discussed and the causes pointed out. A chapter is devoted to the shrinkage of earth in embankment, with a summing up of deductions from the great variety of cases cited. Classification of earth is next discussed and the importance of test pits emphasized. Costs of loosening, shoveling, dumping, spreading and rolling are treated in two chapters and the cost of moving earth by wheelbarrows, carts and wagons, with rules for estimating, occupy two more. Methods and costs of excavating with various kinds of scrapers, graders, steam shovels and cars are given in the six following chapters. Tables of cost from which the cheapest method of handling for any given haul can be determined at a glance are given. Cost of trenching and pipe-laying, hydraulic excavation and earth structures are treated in an interesting manner. In the appendix, practical methods of rapid earthwork calculation and overhaul calculation are described.

The Purification of Sewage and Water. By W. J. Dibdin. New York, D. Van Nostrand Co. Cloth, 6x9 ins., 400 pages, $6.50.

This work is devoted chiefly to a description of various methods of sewage disposal and the chemical and bacteriological principles involved, but it contains a few scattered chapters on such related subjects as the ventilation of sewers, screening sewage, discharge of sewage into sea water, pollution of shell-fish by sewage, etc. About seventy-five pages are given to the subject of water purification and to a description of the quality of the London water supply. This third edition differs from preceding editions by giving a more complete account of the anaerobic processes of sewage treatment and by containing summaries of the more recent experiments on sewage disposal made at Manchester and Leeds. In the last chapter abstracts are given of the Interim Reports of the Royal Commission on Sewage Disposal issued on July 12, 1901; July 7, 1902, and Mar. 2, 1903.

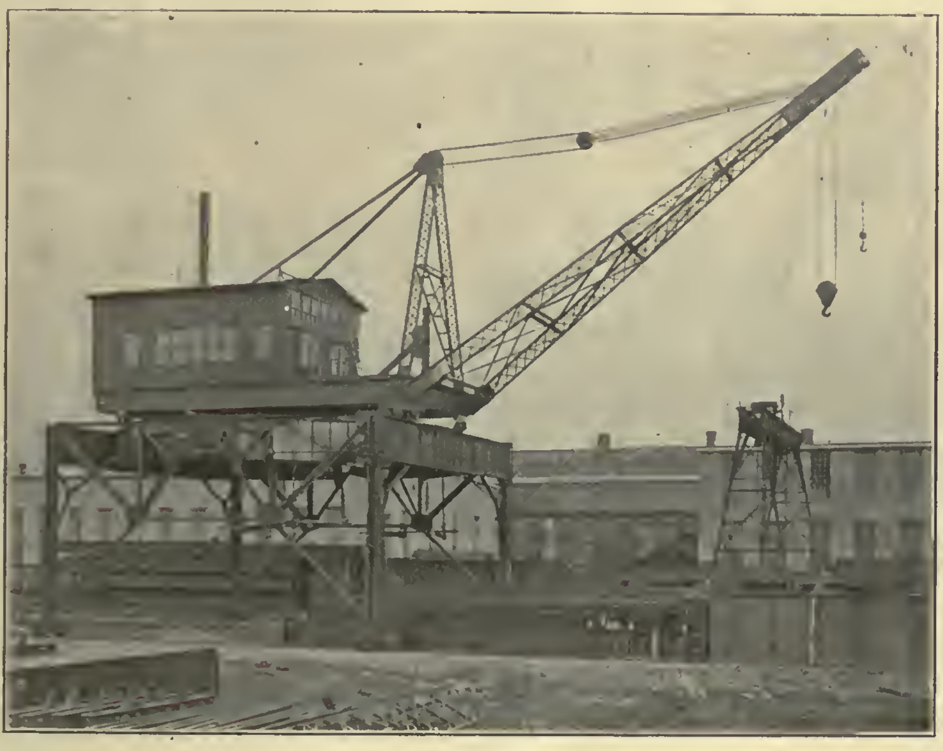
The book contains much information that is valuable and interesting, but as a general treatise upon the subjects named in the title it must be viewed with disappointment. It is fragmentary and incomplete. While describing many of the modern views upon sewage disposal, no mention is made of recent developments in America. The tone of the book is argumentative, and undue emphasis appears to be given to the so-called "bacterial, or contact beds," of which the author is the chief exponent. The aerobic processes are exalted far above the anaerobic methods of treatment. As a check to the septic-tank craze which has of late monopolized the attention of sanitary engineers this may be not without value, but the preface to the book leads one to expect a complete exposition of the chemical and biological principles involved, and in this respect it falls short of other and less expensive treatises. That portion of the work devoted to water purification is particularly superficial.

In emphasizing the importance of frequent systematic biological examinations of water and sewage in connection with purification processes the author is quite right, and the use of his micro-filter is an ingenious, though unpractical, method of determining the amount and character of the suspended matter. It is in striking contrast with the more elaborate methods in use in this country.

The most valuable chapters are those which describe the experiments conducted by the author while chemist of the London County Council, and the accounts of the investigations made at Leeds and Manchester. These and the conclusions reached by the Royal Commission on Sewage Disposal will be found of much interest to those who have not had access to the original reports.

THE DESIGN OF STEEL MILL BUILDINGS, and the Calculation of Stresses in Framed Structures. By M. S. Ketchum. New York, Engineering News Pub. Co. Cloth, 9x6 ins., 380 pages, $4.

Inasmuch as the author states in his preface that his intention in writing this book was to give data not ordinarily available, such tables as are not given in the standard handbooks, including a short course in the calculation of stresses in framed structures and a discussion of mill building construction, it follows that we should expect at least this much of the work. As a matter of fact, while there are some tables and data not ordinarily to be found in the standard handbooks, these are not of enough importance to recommend the work from that standpoint alone. The meager treatment of the subject of bracing and shop details and the omission of a treatment of stresses due to travel of cranes and trolleys is a serious defect. As a theoretical work, it is supplemental to such works as "Roofs and Bridges" by Merriman & Jacoby, and "Theory and Practice of Modern Framed Structures," by Johnson, Bryan & Turneaure. While the omissions stated are serious, there is enough good matter in the course on framed structures, especially in the chapters covering stresses in transverse bents, to make the work a valuable addition to an engineering library; particularly is this true because of the clear and concise way in which the subjects have been treated. The portion of the work on mill building construction details has been fairly well covered, with the exception of going too much into the various manufacturers' specialties and the omission of any mention of mill and shop inspection, both of which are of much importance; this part of the book is perhaps not to be found in any other work of a similar nature. The student and the young engineer will both find the book one of interest and service, and the experienced engineer can certainly afford to have the book on his shelves even though it is prepared on the lines of a text book rather than a scientific treatise.



Derrick for Loading and Erecting in the Dominion Bridge Company's Shipping Yard.

STEAM BOILERS; THEIR THEORY AND DESIGN. By H. de B. Parsons. New York, Longmans, Green & Co. Cloth, 9x6 ins., 387 pages, $4.

Not many years ago, when Mr. Barr's excellent work on steam boilers appeared, one was justified in concluding that the subject was exhaustively and at the same time well covered. The new book on the same subject by Mr. H. de B. Parsons, resembles the earlier one somewhat, yet in many respects it is an improvement on it and other previous works treating of boiler design. The first chapters of Mr. Parsons' book deal with combustion, fuels, furnace temperature, boiler efficiencies and different types of boilers. Marine boilers, with which Mr. Parsons has had considerable experience, are quite fully described. The chapters on materials for boilers and rules for proportioning them are excellent. Mechanical stokers, artificial draft, chimney design, smoke prevention, boiler testing and the use of superheated steam are discussed briefly yet with sufficient thoroughness to afford a good general knowledge of the subjects mentioned, which are closely connected to boiler design and operation. It is to be expected that no man will ever write a book on this subject without expressing opinions at variance with those of other engineers, yet the author's comments are unusually sound, sensible and cleverly stated. The book is well arranged and contains a large number of well executed cuts. Trade catalogue illustrations are omitted entirely, a practice that many others could follow to advantage.

The value of this book to students in engineering schools is emphasized by the clearness of the author's explanations of theoretical topics as well as details of construction. One explanation of this merit may be found in his experience as a lecturer on power plant subjects before the students of the Rensselaer Polytechnic Institute. Such experience is an admirable training for scientific writing.

An Efficient Bridge Shop Yard Traveling Derrick.

There has recently been installed in the storage and shipping yards of the Dominion Bridge Company, at Lachine near Montreal, Canada, a special yard traveler which serves a large area for loading, unloading, shipment and for the yard erection of heavy structures. It consists essentially of a steel tower about 27 feet high, with four vertical posts thoroughly braced both ways which support transverse plate-girders carrying sixteen-sided plate-girder framework on which there is a circular track about 45 feet in diameter. On this track a platform is mounted on four pairs of wheels, so as to revolve 360 degrees, and carries an A-shaped mast and boom, as shown.

The hoisting and topping-lift tackles are operated by a three-drum Beatty hoisting engine in the platform house, which also revolves the platform on the turntable and drives the locomotive gear by which the traveler is propelled on the 45-foot-gauge surface track. The main fall has a capacity of 25 tons and a radius of 81 feet; the auxiliary fall has a radius of 85 feet, and a capacity of 5 tons. Additional tackles can, of course, be suspended from other points on the boom, if necessary, for handling light pieces. Each of the tower posts is provided with two double-flanged wheels running on a single rail, and the tower has sufficient clearance through the longitudinal and transverse sides to prevent interference with ordinary yard operations and to allow trains to pass through it.

The base of the derrick is a 20x47-foot horizontal platform made up of longitudinal and transverse I-beams and girders and is mounted on a two-wheel truck set diagonally across each corner. The turntable is a circular plate girder braced by sixteen radial struts. A vertical shaft through the center of the turntable is driven at the upper end and operates two sets of miter gears, one in the middle and one at the lower end. The middle gears drive a pair of horizontal longitudinal shafts which operate the turntable wheels. The lower gear drives a pair of transverse shafts which, at the outer ends, have miter gears driving longitudinal shafts that are again geared at their extremities to vertical shafts on the front posts of the tower. These shafts have miter gears at the bottom which drive the wheels in the forward trucks. The boom tackle is proportioned for a maximum load of 100,000 pounds and the backstay for 113,000 pounds. The maximum compressive stresses in the boom and mast respectively are 96,000 pounds and 97,000 pounds. The maximum load on each of the derrick trucks is 80,450 pounds. The estimated weight of the lower turntable is 103,000 pounds and the maximum loads on the forward tower trucks are 128,250 pounds. The plate girders in the tops of the tower are 5 feet deep and the tower columns have H-shaped cross-sections made with two channels, a center I-beam and cover-plates on the outer flanges of the channels.

The construction is very simple; and the operation is considered efficient and satisfactory. This crane was designed and built by the Dominion Bridge Company.

THE WASTE OF TIME that occurs in a large manufacturing establishment through trivial causes is sometimes astonishing. A few years ago the superintendent of an establishment made some careful observations, by means of his foreman, of the time lost by men looking out of the windows at steamboats passing along the river on which the works are located. As a result opaque glass was at once inserted in the lower part of each window.

The Allis-Chalmers-Nurnberg Gas Engine.

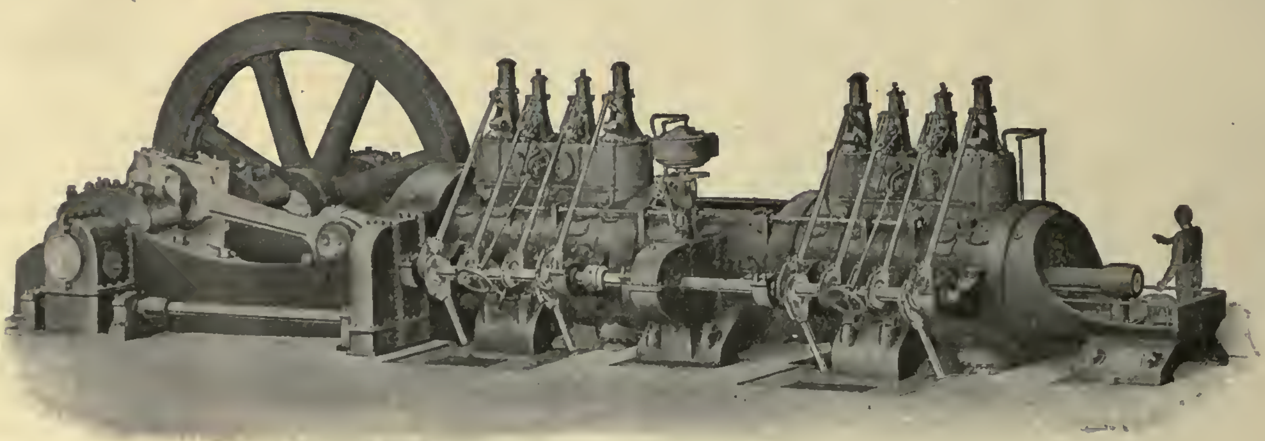
The prevalence of foreign designs for large gas engines will be a pronounced feature of the exhibit of such motors at the Louisiana Purchase Exposition, for with the exception of the Westinghouse Machine Company and the Snow Steam Pump Works, there are no American builders of gas engines of one thousand horse-power or more which have not gone abroad for their general designs, either wholly or in part. The reason for this is not difficult to find. It was recognized many years ago that, theoretically speaking, the fuel consumption in gas engines was marked by remarkable economy, but it was also held that practical difficulties made the steady operation of an engine of even 150 horse-power a questionable feat. Industrial conditions in Europe have long made it necessary to utilize all by-products to the utmost extent, even at a considerable first cost for plant. Large engines were accordingly built to run on blast-furnace gas, and after the initial difficulties were overcome they proved satisfactory. It was accordingly an entirely natural business step for American builders who had not already undertaken designs for large gas engines to arrange with foreign companies for the rights to those European engines which had proved their worth by running satisfactorily under service conditions. The fact that the first of these large engines ran on blast-furnace gas is of course merely an incident, for the character of the fuel supply has little influence on the general design.

Among the German builders who investigated large gas engines very thoroughly was the United Augsburg & Nuremberg Machine Works Company of Nuremberg, of which Dr. A. Rieppel is the director. The type this company developed is a four-cycle, double-acting engine which runs under such careful regulation that the operation of alternating-current generators in parallel has been carried on successfully for some time. It is this engine which the Allis-Chalmers Company is now building at its Edward P. Allis Works, in sizes ranging from 130 to 6,000 horse-power, and for all kinds of gas.

The illustration shows the heavy character of the engine as a whole. By reason of its being double-acting, its cylinder capacity is only about half of that of a single-acting engine of the same power. The pistons are supported by outside cross-heads running on cool slides so that the walls of the cylinder are not called on to bear any weight; this precaution is intended to ensure efficient lubrication and permanent tightness, conditions which are particularly difficult of attainment in these cylinders on account of their high temperatures. The crank shaft has bearings of special shape and great care has been exercised in the general design to prevent any disturbance of alignment by the expansion which occurs during operation.

The inlet and regulating valves and their operating gearing are in plain sight and readily accessible, while the exhaust valves are placed at the lowest point of the cylinder so that any solid particles resulting from the carbonization of the lubricant or other cause, will be surely expelled. The regulation is accomplished by a fly-ball governor and a special construction for combining close governing with high efficiency under light loads. The design has been prepared with an evident intention of making inspection and repairs as easy as possible. All parts of one cylinder are interchangeable with the corresponding parts of the other cylinder. The cylinder heads can be removed and replaced without deranging any of the valve gear, and the pistons can be withdrawn and fitted with new rings without disturbing the valve mechanism or the metallic packing of the piston rods.

This type of engine is in no sense an experiment, for it was developed and tested by its German originators before the Allis-Chalmers Company took it up. Its introduction in this country by these engine builders assures that it will be constructed with the same care in design and skill in workmanship that characterizes the steam engines from the Allis works.



Allis-Chalmers Gas Engine.

The Erection of the Girna Bridge, India.

The bridge across the Girna River, about 260 miles from Bombay, India, is in the line of communication between Surat and Central India. It has nine 175-foot through spans and ten piers each consisting of two unbraced cast-iron cylinders filled with concrete. The lower parts of the cylinders are 11 feet in diameter and a conical section at the surface of the ground reduces them to a diameter of 9 feet for the upper four sections. The cylinders were sunk from about 38 to 63 feet deep to foundations on rock, shingle and clay. Wide platforms were built across the tops of the cylinders overhanging them on opposite sides and loaded with as much as 350 tons of old rails. Two-thirds of the core was excavated by dry excavation and by a submerged grab, and an aggregate length of 992 feet of cylinders was sunk in 697 days. Observations made on the total weight of a cylinder and its frictional area gave a skin friction of about 640 pounds per square foot.

The last third of the excavation, about 350 feet in all, was accomplished by divers who roughly leveled the bottom. Afterwards 600 cubic feet of small stones and 146 cubic feet of cement were lowered in flap-bottom buckets, apparently in separate quantities, and the mass was rammed and leveled by divers. After the cement had set, this concrete sufficed to seal the bottoms of the cylinders to a height of about 10 feet, and the water was dipped out with primitive bags made of the entire skins of oxen. The cylinders were filled nearly to the top with concrete made with 100 cubic feet of stone, 66 feet of sand and 37½ feet of cement, all mixed together dry and then wet and dumped into the cylinders from heights of 40 feet to 5 feet and rammed only for the upper 4 feet. Above this the concrete cylinders were filled for a height of 21 inches, to the top, with equal parts of sand and cement mixed and placed dry and afterwards wet and mixed in place. This formed a cap hard enough to be dressed with a chisel after 48 hours.

The superstructure was erected on a falsework built chiefly of 68-pound double-headed old rails spliced together with scrap plate from locomotive boilers, braced with discarded pot-sleeper tie-bars and riveted and bolted together. The falsework for each span consisted of four short deck truss spans supported on three trestle bents. Each trestle bent had two double vertical posts, and was braced transversely, but not longitudinally. They were 60 feet high, and weighed about 20 tons each. The falsework was erected by a pair of 75-foot riveted steel gin poles. These had a rectangular cross-section 3 feet square, and were made with four vertical angles latticed together on all sides and stiffened by horizontal diaphragms. The base had a cast-iron ball and socket joint, and was seated on a framework of cross girders resting on a 3½-foot drum made of a bent rail. At the top of the gin pole there was a double cantilever bent arm receiving the hoisting tackle at the horizontal end and anchorage connection at the inclined end. The center of the arm was pin-connected to the gudgeon, which received the spider for the guy ropes. The permanent spans were erected on the falsework by traveling gantries, which cleared both trusses and carried hand windlasses. The work is illustrated in a recent issue of "The Engineer," London.

The Air-Cleansing Apparatus at the Royal Victoria Hospital at Belfast, Ireland, is constructed as follows, according to Mr. Henry Lea, of Birmingham, designer of the ventilating plant. In a timber framing, reinforced with tee bars, are removable panels, each having two strong wooden rollers, one at the top and the other at the bottom. Cocoanut fiber in the form of a yarn is wound from one roller to the other, over and under; the fibers are stitched together close to each roller to prevent them from moving and the rollers are held apart to keep the screens in tension. The subdivision in panels is partly due to the fact that one portion of such a filter, as the upper, will rot quicker than another and panels can be kept in stock. The screens are kept wet by means of horizontal perforated sprinkler pipes. These are fixed near the top of the screens, about 12 inches away in a horizontal direction. They are supplied with water from a series of automatic flushing tanks, set to discharge the requisite quantity of water about once every ten minutes. The water strikes the tops of the screens and runs down the yarns to the bottom.

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The Baltimore Fire.

Many valuable lessons will, doubtless, be learned from the results of the great conflagration which so thoroughly devastated a large area of the wholesale, commercial and financial districts of the city of Baltimore, the first of the week. Not only will fire department men and insurance people study with deep interest the various phases of this fire, which is without question one of the greatest of modern times, but architects and engineers will be especially concerned because on the area burned over stood many buildings of modern construction, including a number of tall office buildings of the type popularly called fireproof. At this writing, of course, it is impossible to present the fruits of a careful expert examination of the ruins, but this journal expects to give its readers promptly such detailed facts and deductions as can be of service to those engaged in the design of buildings which may be exposed to fire and to those others who are responsible for the care and protection of existing structures. With the general narrative of the catastrophe the reader has, of course, already been made familiar by the daily press, but from direct and reliable sources this journal has information which is ground for the belief that the newspaper accounts are hardly suitable to be used as the basis of opinion regarding the value of so-called fireproof construction and other matters of technical interest. This statement is not intended to be in any way derogatory to the reporters whose duties were performed under unusually difficult conditions, and whose points of view are entirely different from those of the technical men, but rather for the purpose of suggesting that judgment should be withheld until statements shall have been made by persons competent to present the facts on which more accurate conclusions as to the merits of various forms of construction and different kinds of building materials can be based.

In examining the ruins on the ground or in studying photographs, it will be important to remember constantly the effects of the explosives used to destroy buildings in the attempts to arrest the progress of the flames and to raze walls left in a dangerous condition by the fire. That some buildings commonly regarded as fireproof suffered severely is evident. Instead, however, of all such buildings going down in the common ruin, as at first reported, a number of the modern buildings of fire-resisting construction withstood the attack of the flames remarkably well, especially considering the intense heat to which some of them were exposed. Even when gutted, the walls of buildings of this class acted to some extent as barriers which aided in retarding the spread of the fire. Windows seem to have been the vulnerable points, and throughout the city almost no window protection had been used. According to the best information which this journal has obtained, extremely few buildings were fitted with fire shutters, and very few windows were glazed with wire-glass. A striking example of the benefit of fire shutters seems to be afforded by the United States store-house, a structure about seventy years old, and not of fireproof construction, the windows of which were protected with iron shutters. It stood through the fire while buildings all about it succumbed. On the other hand a tall office building of a modern type is reported to have caught fire in the fourteenth story, evidently through the windows, and the interior burned downwards. The steel framework was badly warped and twisted, and although the walls were standing at the close of the fire, they were said to be so unsafe that it would be necessary to raze them.

The burned district, embracing most of the wholesale, financial and office-building sections of the city, included a large number of old dwellings converted to business uses, which were in no sense of fire-resisting construction. Probably it may be safely stated that approximately half the buildings in this tract were not over four stories in height and had brick walls, with wooden interior construction. Many of the more modern buildings are said to have had cast-iron columns and steel beams without fireproof coverings. The character of the buildings, therefore, and the prevailing high winds were largely the cause of the extensive spread of the flames. The wind carried the fire rapidly in its path, and in a great many cases the buildings were observed to burn from the upper stories downwards. Early in the progress of the fire the water supply, it is stated, became inadequate to the great demands made upon it, and but for the circumstance that the burning area was bordered by Jones Falls, a small stream flowing through the city, and the Basin, the fire engines would have been almost useless. The city did not own any fire boats.

Two adjoining power plants of the street railway company were exposed to a severe test. The older plant was destroyed, but the newer plant, situated at the edge of the fire area, on the water front, escaped in comparatively good condition. Although subjected to such fierce heat that the steel work of the coal hoists and similar attachments on the exterior of the building were red hot, it is reported that the interior was not seriously damaged. The new boiler house was described in this journal November 2, 1901, and the engine house was yet unfinished, only a part of the power units having been installed. These newer buildings were of a good type of fire-resisting construction, and in contrast with the older plant make apparent the advantages of designing and constructing buildings so as to resist fire.

Ornamental cast-iron columns and other architectural features of this metal once forming parts of the fronts of fine buildings are now to be seen among the ruins in numerous cases cracked and broken as if made of glass, while in many places that were in the midst of the fire, wooden telegraph poles are still standing, some of them having their cross-arms in place, and numbers of tubular iron trolley poles escaped without distortion. Valuable lessons will doubtless be drawn from this costly experience of the Monumental City. Among others, this one seems particularly patent now, namely: that buildings with walls and floors of fire-resisting construction if filled with inflammable finish and furnishings may not protect their contents if the windows are left unguarded. That fireproof, or rather, fire-resisting, construction is not a failure, but of great advantage when intelligently used, seems also plain, and this fact will probably be more strongly emphasized by detailed examination of the fire-swept area. The contents of the vaults of safe deposit companies, banks and business houses are generally reported to have been found in good condition, apparently demonstrating that the construction of such vaults has attained a high degree of excellence. Baltimore has been severely afflicted, but engineers and architects will fall short of the discharge of their duty to the public if they neglect to profit by the results of this great test of structural work.

Municipal Water Softening Plants.

We are told that France has held her supremacy in the silk industry against English competition largely because of her more sunny climate, and that the spring water of Munich is an important element in the superiority of her beer. It may be that a part of the hold which New England has always had upon certain industries and Southern and Western competition seems unable to disturb, is due to the softness and clearness of the waters available for industrial uses. It is certain that for many purposes the softness of the water is of controlling importance, and where competition is close the character of the water may determine the success or failure of an enterprise. There are some industries requiring large volumes of water of a certain quality which will probably always be limited to those localities where such water can be readily obtained, but in other cases artificial treatment of such waters as are available in places otherwise better adapted for the pursuit of the industry will be resorted to.

In the last decade the progress in the art of purifying water has been rapid beyond precedent. The advance has been most striking in the removal of disease-producing qualities and turbidity. The removal of coloring matter from peaty waters and of iron from ground waters has also received attention. The softening of hard waters has not advanced in a corresponding measure; but it is bound to be taken up more actively, for it is a practical process and there are large sections of our country where no naturally soft water, except rain water, can be obtained.

In England a number of municipalities soften their water supplies, Southampton being a well-known representative of these. The need of the process is quite as great in America as in England, but there has been a practical difficulty in the large volumes of water which our cities insist upon wasting. Under these conditions of waste, all the water used or wasted by a city would have to be softened, while the part from which a benefit from softening could be realized would be limited to a fraction of the water actually used, which would be a much smaller part of the whole amount requiring treatment. The advantage is limited to a small part of the water used, because for many purposes the hardness of the water is of no practical importance.

The railroads have done most with softening in this country, because with them the hardness affects practically all the water that they use. While there is occasionally a choice of waters, in general they must use the local water, whatever its quality may be, and railroads pass through many regions where the waters are so hard as to be most destructive to the boilers of their locomotives. It thus happens that the railroads have been the pioneers in this field, while a few industrial establishments have followed.

The old and often cited computation of the amount of soap required by a city with hard water in excess of that which would be required with soft water does not accurately represent the facts, because in the city with hard water the computed additional amount of soap is never used. Some additional soap is used, and as much is done with it as possible; but a stronger argument is based upon the superiority of the results accomplished with the soft water.

The softening of water as carried out by the railroads is a relatively expensive process, because it is done on a small scale at scattered stations along the line. Municipal softening on a large scale can be done at a lower cost per million gallons, and this would be particularly true where the processes were carried out in connection with works to remove bacteria or turbidity or color or iron, and the cost of the combined treatment would be less than the costs of the treatments applied separately.

Softening pays with the railroads because all the water treated is used for purposes for which soft water is important. The question remains as to how hard a water must be so that it will pay a city to soften 80 or 100, or even 200 gallons per capita daily in order to give the advantage of soft water for the few gallons per capita used for purposes where it is advantageous. The answer to this question obviously depends upon the amount of water wasted and upon the facilities for carrying out the softening; but there can be no doubt that there are many cities where softening plants would yield a large return upon their cost, and extensive developments in this direction may be looked for more confidently in the near future.

The process of softening water was invented and patented about the year 1844 by Thomas Clarke, professor of chemistry in the University of Aberdeen. The process is the only successful one now used and the patent has long since expired. There are patents in force upon certain details and auxiliary appliances, but not upon any essential part of the process. The process is remarkable in that lime is added to the water to take out the lime already in solution. Lime is held in solution in water by carbonic acid. One part of lime combined with two parts of carbonic acid is soluble in water, while combined with only one part it is insoluble or nearly so. Lime water, which is lime without any carbonic acid, is added to the water and takes away the extra carbonic acid from the lime in solution, and the lime added and that originally present in the water are precipitated together. This precipitate is easily removed by sedimentation and filtration. The magnesia usually present, which contributes to the hardness, acts in some measure as the lime, and is removed in the same way, but in less degree. This treatment does not remove the lime or magnesia present as sulphate or chlorides, and when these substances are present a solution of soda-ash must be added to the water in advance of the lime treatment to change them into carbonates, which are then removed in the final precipitation.

One of the greatest practical obstacles to carrying out the softening process has been the difficulty of getting the necessary trained supervision, for inferior results are obtained with either too small or too large doses of the reagents, and, badly operated, the treatment may be worse than useless. Such supervision has been almost impossible in the smaller American water works, but with the increased use of filtration, laboratories are being established. These laboratories are necessary to hold the work of filtration up to the best attainable standards, and the number of such laboratories is increasing rapidly. These laboratories can furnish the necessary control of softening operations, and the fact of their existence removes one of the most serious obstacles to its use.

Municipal Testing Bureaus.

The growth of large cities necessitating extended and complicated municipal organization creates many problems closely parallel to those arising in connection with great business corporations. Obviously this view of the matter is wholly divorced from all political considerations. It is probably the conclusion of a great majority if not practically all fair and intelligent students of municipal corporations that politics, at least, so far as they are connected with the great national parties, should not influence to any extent municipal administration. Any such ideal condition, however, as the elimination of national party questions from the administration of municipal affairs is probably impracticable at this time. Even if that be admitted there is a great mass of municipal machinery whose administration deals with the actual working of various branches of the municipal organization and which operates along practically the same lines whatever may be the result of any election. This observation is particularly true of those branches of a city government which deal with public works. Water works must be constructed, maintained and operated; great water front developments must be made involving the construction of such works as docks, piers and bulkhead walls; streets and parks must be laid out, paved or surfaced and maintained with the highest possible degree of efficiency; elevated railroads, subways and bridges, involving the construction of some of the greatest modern public works, must be designed, built and maintained, and the entire municipality must be effectively illuminated, requiring the construction of gas and electric light systems with their corresponding power or manufacturing plants. In large modern cities these works require the consumption of vast quantities of all kinds of materials used in engineering construction and maintenance. It is of the utmost importance not only that the best practicable grade of materials should be found in every public structure and machinery plant, but that in their operation and maintenance the lubricating and other maintaining materials, so to speak, should also be of the best quality available. The same observation applies with no less force to the fuel consumed, whether it be gaseous, liquid or solid. It is of equal importance, as is shown by the great number of complaints made at the present time in the city of New York, that the quality of public illuminants should be under constant inspection.

It matters little whether in some cases the operation of these public works be maintained under private ownership or not. The majority of them, and in some municipalities all, are under municipal ownership, and public economy and convenience require that their administration shall be of the highest order. Probably no fair minded and intelligent student or observer of these matters will contend that they should be administered in such a way as to be affected by constantly changing administrations, and even now in well governed cities the influence of politics is felt less in the service of public works than in any other portion of municipal government. They are conducted chiefly by engineers and that fact is a fortunate one for municipal efficiency.

In private business, as in railroad corporations, such a large consumption of materials of all kinds is invariably guarded by most careful tests and inspection. The steel used in public structures is generally carefully tested, as is also the cement to some extent, and the same observation may occasionally be made concerning some other materials; but this inspection and testing with the single exception of steel is seldom or never as thorough or comprehensive as it should be, and it is usually conducted under conditions which militate against such thoroughness and care as should characterize that class of work. It is scarcely probable, indeed, it is practically certain, that not a city in the country has a well equipped and administered testing laboratory with which to control the purchase and use of all classes of material required by its various departments. The recent investigations of the Commission on Additional Water Supply in the single branch of pumping for New York City showed that efficiency of the machinery, to say nothing of money wasted in the purchase of indifferent material, is so low as to produce an annual loss measured in many thousands of dollars. While this is not altogether consequent upon the lack of proper testing of materials consumed, that lack is one of the large elements of the problem, if, indeed, it is not a controlling element of the situation.

The value of continuous and careful cement testing for the large quantities of cement annually used by every large city is shown by what has been accomplished in the City of New York in the office of the Chief Engineer of the Rapid Transit Commission. The quality of the material delivered has been controlled by testing so as to secure both uniformity and material improvement, which has resulted not only in advantage to the city but to the manufacturers also. Equally forceful observations can be made in regard to the use of asphalt and other materials for pavements. There are probably no products consumed by a great city which need more careful or more nearly continuous examination and inspection than the mastics and other material used for pavements. The manufacturers are in reality equally interested with the city. It is to their interest to have the best quality of product and probably no party interested would welcome the inspection and examination afforded by a properly conducted testing bureau more than the contractors for such works.

One of the most elaborately equipped and perhaps the most effectively administered of testing laboratories in the United States is that maintained and operated by the Pennsylvania Railroad, at Altoona, Pa., where all classes of materials consumed by the road have been subjected to careful examination and test in connection with the purchasing department of the company for many years. The results have been no less satisfactory to the railroad company than to the producers. The actual works carried on by a great city are not different in character from those conducted by the Pennsylvania Railroad or any similar corporation. The Altoona laboratory has been a source of great saving to that company in probably every line of purchase made by it, and an efficiently conducted testing bureau would be a source of great saving to any modern city, besides conducing to a higher degree of efficiency and public convenience in a multitude of ways. Such laboratories are already maintained in some departments, but always in an isolated and more or less incomplete manner. A well equipped and efficiently maintained laboratory for all departments of a city conducted in a thoroughly businesslike and progressive manner so as to afford tests and examinations of all classes of materials used by the city would be one of the most effective agencies for improving and maintaining the quality of public works that can possibly be devised.

The mere existence of an efficient testing bureau would have an excellent moral effect and would tend to the offering of a higher grade of material by those who undertook to do public work. It would simplify the duties of, and relieve many heads of departments to be assurred that what they were purchasing and paying for would be the best adapted for public use. The United States government maintains such a bureau at the present time, and it is a matter of satisfaction to observe that some cities, like Baltimore, have already begun the serious consideration of establishing testing bureaus. It is a move in the right direction. It brings into municipal administration a business-like system of conducting business and it is a long step toward securing for the conduct of great public works an efficiency and excellence which engineers always endeavor to secure for the best administered private or semi-public corporations.

The College Graduate as an Engineer.

Most engineers who have achieved positions of any responsibility have heard technical education criticised by men of standing as being without any cultural value. Its importance as a sort of glorified trade education is acknowledged but the possibility that it is anything more is often denied by those unacquainted with the courses of instructions in some of the leading engineering schools of to-day. President Humphreys, of Stevens Institute, has accordingly rendered no small service to education and to the engineering profession as a whole by making a detailed protest against such views in an address before the College of the City of New York. He did not claim that a well-considered technical course would turn out every student a trained engineer and cultivated gentleman, but he insisted that with the right class of students such a result may reasonably be expected. This is not saying that a college course will not be useful to the young engineer, but only that the college is not the only school where the elements of true culture can be secured. This opinion rests in some degree on what culture means, but the majority of people will probably agree with President Humphreys that the statement of the honored head of Harvard University is most in sympathy with modern ideas. In his opinion, "the elements and means of cultivation are much more numerous than they used to be; so that it is not wise to say of any one acquisition or faculty—with it cultivation becomes possible, without it impossible." A good character, the ability to express himself by tongue and pen with some accuracy and elegance, some acquaintance with the store of knowledge which humanity in its progress from barbarism has acquired and laid up, and a constructive imagination are the attributes of a cultured man according to this eminent scholar. President Humphreys claims that all these are taught in a true school of engineering, and it is well worth the time to look into his statements on the subject.

The study of engineering is the study of scientific truths, accurate and unchanging, and the application of this knowledge to useful ends. If instructors are fully imbued with a sense of the high rank of engineering and the proper place it is playing in the life of to-day, there can be no question that the technical school will exercise a powerful influence on the moulding of character. Moreover the engineer-student should be instructed in the relative rights of labor and capital, a subject of vital importance now and growing more serious every year, and this subject, when thoughtfully considered, will leave a deep impression on the character of any one.

As for language studies, President Humphreys' words are most important as an expression of opinion from a man of the highest position in engineering circles and in the business world. He distinctly urges the study of one or two modern languages and as much as possible of the mother tongue and literature. The study of English should be kept in mind in each of the other departments in such a school, and a student should not be graduated until he has given proof in his thesis of the thoroughness and breadth of his training and of his ability, to express himself clearly and explicitly.

Engineering implies a knowledge of the sciences and the time spent in acquiring this knowledge may certainly be ranked as equivalent to that spent in studying general history or philosophy. In Germany, where "bildung" is respected as it is nowhere else, the degree of doctor of philosophy, the universities' indication that the man carrying it has enough information to be considered cultured if his character will support the intellectual polish, is given without much regard to what branches of the wide field of human interests are studied. In this connection, President Humphreys points out that the contest is not yet ended between those who contend that to be practical one must not be theoretical and those who hold that to be scientific one must not be practical. Both these views are wrong, of course, for the engineer must be capable of practically applying scientific knowledge. Discredit has been brought on the engineering profession because some of its members have not been sure of their theories before they commenced to apply them; because others have been credited with a scientific training while they were weak in the very fundamentals of science; because others with a fairly complete scientific knowledge have been deficient in practical ability and experience; and because others have been unable or unwilling to appreciate that engineering practice must conform to commercial conditions and requirements.

The fourth great requirement of a cultured man, a trained constructive imagination, is surely formed as well in an engineering school as a college. Imagination does not imply merely the ability to evolve the plot of a novel or the conception of a picture. President Eliot himself has expressed in striking words this idea: "Contrast this kind of constructive imagination (that of a realistic novelist) with the kind which conceived the great wells sunk in solid rock below Niagara that contain the turbines that drive the dynamos that generate the electric force that turns thousands of wheels and lights thousands of lamps over hundreds of square miles of adjoining territory; or with the kind that conceives the sending of human thoughts across three thousand miles of stormy sea instantaneously on nothing more substantial than etheral waves. There is no crime, cruelty or lust about these last two sorts of imagining. No lurid fire of hell or human passion illumines their scene. They are calm, accurate, just and responsible, and nothing but beneficence and increased human well-being results from them."

While, therefore, the technical school has sound claims to be something more elevating than a mere training school for a calling, it does not follow that it is relieved from the responsibility of turning out young men with a knowledge of business conditions which will make them of immediate value to their employers. President Humphreys contends that even the man who is to stick closely to the technical side of his profession must know the limitations and conditions under which his technical knowledge is to be made available for those who wish to buy this knowledge. He must know how to prepare correct estimates, and must be able to guide investors safely through the pitfalls set by the promoter. He must become thoroughly impressed with the knowledge that it is dishonest to accept and quote any statement of opinion unless it is as carefully conditioned and safeguarded by the context as in the original expression. Finally, while such an engineering course of study is of a high character, every student taking it should be given full opportunity to learn that for true success in his profession he must after graduation take up a post-graduate course of study, and that probably the best course of this sort will be followed in connection with his work as a wage earner in some one part of the field of civil engineering. There are certain necessary things only to be learned by contact with the working world.

Drafting Room Apprentices will be received hereafter at the Schenectady works of the General Electric Company. Candidates must pass a satisfactory examination concerning which Mr. J. W. Upp, engineer in charge of the drafting office, will furnish information on application. The Engineering Record believes that this move will result in considerable gain to the company and will afford just the training some young men will find useful. Every mechanical engineer or mill architect has noticed that there is a certain class of excellent young men who apparently amount to little except in actual design, but in such work display a natural aptitude which often enables them to do more and better work than their associates with more theoretical information. The course of instruction which the General Electric Company can afford such young men is just what they need, and this paper is glad to know that it has been established.

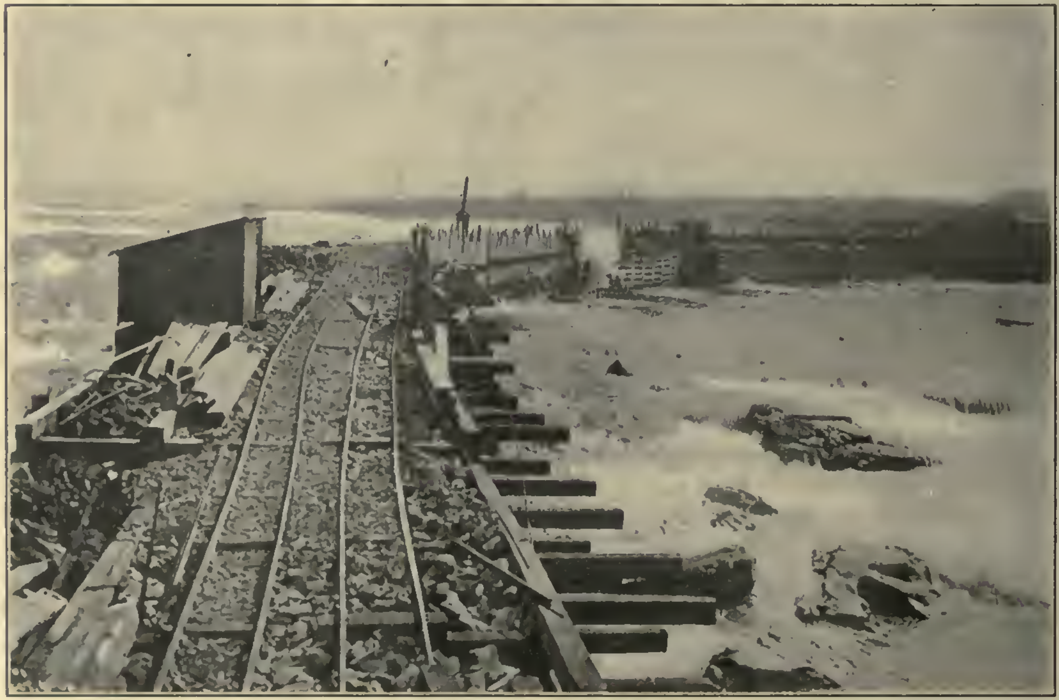
Power Development of the Toronto & Niagara Power Company.

An official progress report of the power development on the Niagara River by the Toronto & Niagara Power Company, near Niagara Falls, Ontario, has just been made to the holders of securities, and through it, the opportunity is afforded of describing with authority the general features and construction methods of this interesting engineering work. It will be remembered that in January of last year, Messrs. William Mackenzie, Henry M. Pellatt and Frederic Nicholls, of Toronto, as the Toronto and Niagara Power Company, secured rights to take water from the river at Tempest Point on the Canadian side for the purpose of generating electricity to the extent of 125,000 electrical horse-power. In March the rights were transferred to the Electrical Development Company, of Ontario, Ltd., with Mr. Pellatt, president; Mr. Nicholls, vice-president and general manager; and Mr. Mackenzie, second vice-president. Dr. F. S. Pearson was at that time appointed chief consulting engineer, Mr. Hugh L. Cooper, chief hydraulic engineer and Mr. Beverly R. Value, resident engineer.

The character of the development is similar in general lines to that of the Niagara Falls power plant recently described in these columns, in that the water is diverted into penstocks located in a rock-excavated wheelpit and discharged through turbines in the bottom of the wheelpit into a tail-race tunnel leading to the river below the falls. There are, however, several distinct departures, some requiring daring methods of construction. In the first place, the tail-race at the wheelpit consists of two lateral tunnels, one on each side of the pit, so that all the wheel pit machinery can be supported on solid rock foundations, with draft tubes from the turbines into the one or the other of the lateral tunnels. Another departure lies in the provision of concrete intermediate supports for the bearings of the vertical shafts from the turbines in the bottom of the wheelpit to the generators in the power-house above the pit, this arrangement, together with the solid support for the turbines, as explained, being adopted to minimize any vibration in the heavy revolving machinery.

The wheelpit is located at the shore line, about parallel with the direction of the flow of the river and the tail-race tunnel is planned to run in a straight line to a point back of the Horseshoe Falls. For diverting the water to the forebay and equalizing the water level across the forebay, which will be constructed on the river side of the wheelpit, a gathering dam standing out in the river and pointing upstream is to be built. This dam will change the original rapids in front of the site into a pond condition and raise the old water level approximately 18 feet under normal conditions. Connecting to this dam will be a system of masonry diverting booms, the office of which will be to divert approaching ice and debris to suction weirs. To present the least obstruction possible to ice, the gathering dams and diverting booms will be nearly parallel with the direction of river flow. Having designed the gathering dam to separate from the main current several times the amount of water required for the ultimate development of power, the use of the weirs provides for the disposal of the extra amount, creating surface currents by which ice and debris can be carried beyond the intakes.

It was originally assumed that the depth of water in the rapids where the gathering dam is to be located would be about 8 feet as a maximum. As a matter of fact the coffer dam by which the river site was uncovered shows that there was 26 feet of water. It is calculated that the water as naturally flowing was at least 150 per cent. greater in depth over the territory that will be occupied, than was first estimated, and now it is the opinion of Mr. Cooper, in the report, that the dam under the most adverse conditions will seize at least 1,800,000 cubic feet per minute, instead of the 700,000 cubic feet which will be needed for the 125,000 horse-power, on the basis of 75 per cent. efficiency in the turbines. He estimates, further, that the amount of flow on the Canadian side of the river is probably 65 per cent. of the total flow, and gives 9,000,000 cubic feet per minute as the low-water discharge of the river, as indicated by U. S. Government gaugings.


Main Coffer Dam for Toronto & Niagara Power Company, Showing Arched Form of Construction.

The differences of level provided by the design are such that, after deducting losses from friction and the velocity of approach and discharge, there will remain an operating head of 143 feet to be utilized by the turbines. There are to be eleven generators, of 12,500 horse-power each, and the connection between the generators and the turbines will be made by the use of a hollow vertical shaft, having a total length of approximately 115 feet supported at three intermediate points by concrete bearings, as already explained. The branching of the tail-race tunnel takes place at a point 165 feet from the lower end of the wheelpit and the intervening rock between either lateral tunnel and the adjacent side of the wheelpit is pierced by the draft tubes, which enter the lateral tunnels through an invert. A water seal is thus preserved at all stages of operation. Single draft tubes are used, each alternate wheel discharging into the same tunnel, six draft-tubes entering the north tunnel and five the south. Gate chambers are provided for each side tunnel, so that by closing the gate in either tunnel and shutting down the wheels discharging into this side, an inspection can be made while the other half of the station is in operation. The branched tunnels are connected by a passageway leading from the wheelpit, and by means of a steel gallery suspended from the top of the tail-race tunnel, and lighted by electricity, it will be possible for one entering at the wheelpit to traverse the length of the tunnel to the portal under the falls. The separation of the machinery in practically two stations is important as allowing for frequent examinations of the machinery in order that the beginnings of trouble may be discovered before serious expense results. A chamber is to be excavated at the level of the turbine deck for oil pumps and other auxiliary machinery.

The tail-race tunnel from the branch tunnels to the discharge portal will be about 1,935 feet long. It will have a grade of 5½ feet in a thousand and is straight to avoid any erosion to its lining due to a change in direction of the rapidly moving water. The cross-sections of the tunnel are shown in accompanying illustrations, that at the left being the cross-section for the major part of its length and that at the right for the last 300 feet from the face of the cliff. Here the tunnel will have a permanent lining of concrete, divided by vertical joints into rings 6 feet in length, in order that, as the falls recede, these rings will break away as a whole, leaving a finished surface at the new end of the tunnel. For the rest of the distance, the permanent lining will consist of two rings of hydraulic pressed brick, backed solid to the rock with concrete.

For the utilization of the power the company has purchased some 530 acres of land fronting on the Chippewa River about 2 miles from the town of Niagara Falls, 3 miles from the confluence of Chippewa and Niagara rivers and about 3½ miles from the point at which the Chippewa River has entrance into the Welland Canal, this to provide for manufacturing sites for those who may become purchasers from the company of power for industrial or electro-chemical uses. In addition to this, a right of way having a minimum width of 80 feet has been nearly all purchased between Toronto and Niagara Falls, 75½ miles in length, on which the pole line for the transmission of 30,000 horse-power is to be constructed. The right of way has been located in such manner that a double-track railway may be run, should future development warrant its use for such an enterprise. This work has been conducted under the direction of Mr. W. T. Jennings, M. Inst. C. E.

The beginning of the actual construction on the power development may be said to date from April 2, when the first timbers for the crib coffer dam were laid down in the Niagara River by Messrs. Barry & McMordie, of Niagara Falls, Ont. The crib work was started from the original shore line 415 feet above the upper end of the wheel pit. For the first 416 feet the construction was comparatively simple, the cribs being built in place. The flow had been largely diverted from this portion of the river bed, by the coffer dam of the Ontario Power Company, next above the Toronto and Niagara development, and the small amount of water intercepted on this stretch was allowed to flow through culverts left in the crib work near the shore end. Between the second and third angles of the crib a heavy flow was intercepted, the water becoming deeper and the flow more rapid. The cribs were then built in the river, upstream from the coffer dam, and by means of cables from the shore were floated into place with the current.

It was found that the extension of the crib into the river, beyond the second angle, was causing a backing up of the water and to prevent a flooding of a portion of the forebay unwatered by the Ontario Power Company, a spur crib was constructed from this angle, leading upstream along the edge of the heavy flow.

At a point 576 feet from the shore, measured along the face of the crib, a decided fall in the elevation of the river bed was encountered. In three crib lengths, 48 feet, the river bed dropped from elevation 522 to elevation 515, giving a depth of water of 24 feet. This deep channel continued for about 50 feet and then gradually shoaled to a depth of 19 feet. Because of this depth of water, the width of the crib work was increased to 24 feet. The puddle space was also increased in width and re-inforced by additional crib work, as shown.

River Bed at the Cascade Rapids, Indicating Difficulty in Securing Foundation for Coffer Dam.

On farther side of coffer dam is the most turbulent rapid in the Upper Niagara River. Depth of water at this part of coffer dam was 14 to 15 feet.

The placing of the cribs in this deep water, flowing at right angles to the end of the crib and at a high velocity, was an operation of very great difficulty. In order to break the force of the current, a fender was constructed of heavy timber, which rested against the upstream side of the crib-work and was projected beyond the last crib in place. The fender was held in position by three steel cables passing along the upstream face to the spur, where a winch was established to control the lines used in paying it out. The cribs were framed in the slack water below the coffer dam and brought into position in the lee of the fender by means of stout tackle, operated from a traveling derrick at the end of the crib-work. On June 9, at a distance of 690 feet from the shore, the strain on the fender was so great, from the impact of water, that the cross-bracing, to which the cables were attached, parted and the fender was carried away, passing out over the cascade and grounding about 150 feet off shore.

A new fender of heavier design was constructed, which served its purpose until the cascade was reached. In attempting to move the fender over the cascade, it was broken to pieces by the force of the water and ultimately carried away. At this point, however, the crib-work was running nearly parallel to the heavy flow and no great difficulty was experienced from there on in placing the cribs without its assistance. The depth of the water actually found has averaged over 13 feet.

While the building of the coffer dam has been a work of considerable hazard, it has been singularly free from serious accidents. On October 5, one of the timbermen, employed on the advance work, lost his footing and fell into the river, on the instream side of the coffer dam. The river currents at that point were not strong, but being unable to swim he was carried out before assistance could be given and his body washed over the falls. On November 11, one of the divers employed in closing openings in the sheeting of the clay space, was drawn by the suction of the water against an opening, in which his foot and leg were caught and held by the force of the water. He remained in this position for over three hours before he was liberated.

The contract of the tail-race tunnel was awarded to Mr. Anthony C. Douglass, of Niagara Falls, N. Y. As the tail-race tunnel lies under the river bed for its entire length, provision was made in the contract for a construction shaft to be sunk on the west shore of the river above the falls, and a small working tunnel or drift to be driven under the river out to the tail-race tunnel, the excavated material to be disposed of either by hoisting vertically through the shaft, and wasting over the bluff, or by dumping under the falls through openings from the drift to the cliff back of the curtain of water. The excavation of the tail-race tunnel will proceed from the falls up grade to the wheel pit, in the most favorable manner for drainage, should water be encountered. Provision was also made for a shaft at the upper end, should it be required for the purpose of expediting the work of construction.

The drift was planned to intersect the tail-race tunnel at a point about 100 feet from the portal, and will have a length of 670.9 feet, measured from the shaft. Work on the construction shaft was begun on May 18, 1903. For a depth of 16½ feet the shaft penetrated loose material, which admitted water from the river very freely. A pit, approximately 46 by 39 feet, was excavated in the loose material and carried to a depth of 2 feet below the level of the water in the river. In this excavation a coffer dam was constructed, surrounding the mouth of the shaft. The seamy surface rock was removed for a depth of 4 feet to an impervious stratum of limestone, and the final shaft timbering placed and surrounded by a wall of Portland cement beton, which effectually cut off the water entering the shaft.

From this point to sub-grade rapid progress was made. During August the shaft was sunk through a depth of 101.5 feet, and in addition 15 feet of the drift was excavated. The dimensions of the shaft are 15 by 7 feet, in clear of all timbering.

The dimensions of the drift are, approximately, 14 feet in width by 7 feet high, an area sufficient for two construction tracks. The drift leaves the shaft at elevation 366 and, with a slight fall in grade, will intersect the tail-race tunnel at about spring line or 23 feet above normal high water in the gorge.

On October 7, at a distance of 385 feet from the shaft, the cross-drift, leading out to the cliff under the falls, was begun. Up to this time the drift had been very dry, and the small amount of water entering the shaft was easily controlled by a No. 5 Cameron mining pump, working only at intervals. On October 9, when within an estimated distance of 14 feet from the cliff, a fissure was developed in the roof by a round of holes fired in the cross-drift, through which water came in considerable volume, flooding the drift and causing a suspension of work. Pumps, of a capacity sufficient to handle the flow, were at once installed and the water lowered so that a resumption of work was possible. Preparations for drilling were under way when a fall of rock occurred near the face of the cross-drift, and a large increase in the flow took place, again flooding the drift.

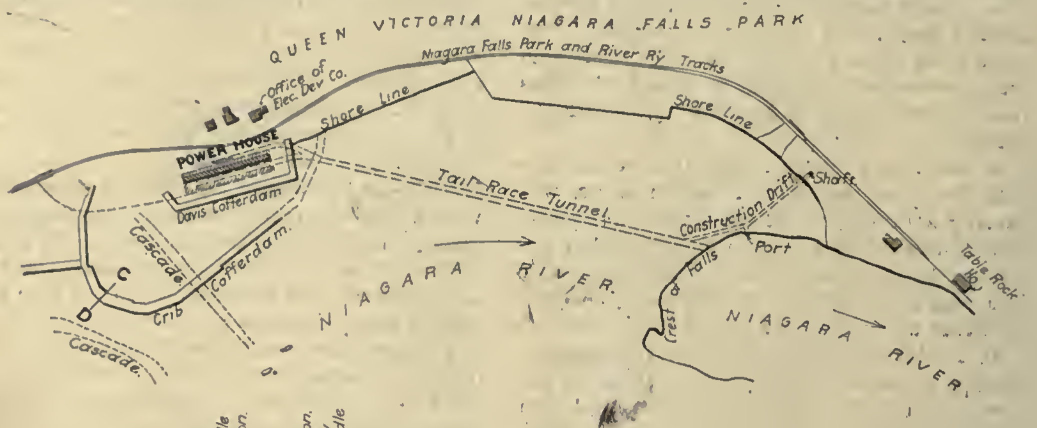
It was found that the water rose in the shaft to a height of 16 feet above the grade of the drift, before finding its level, thus indicating that the water came from the heavy spray under the falls, striking the cliff, and finding its way through fissures, whose openings were, approximately, at this elevation. This inference was completely borne out by subsequent events.

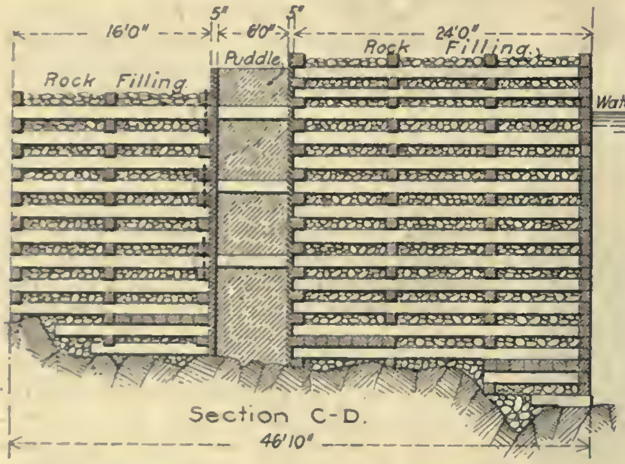
A heavier pumping plant was installed, and the water was lowered and work resumed in the cross-drift. Holes were drilled in the face, varying in length from 18 to 22 feet, indicating a barrier of solid rock of about 12 feet in thickness, and beyond this a softer rock somewhat disintegrated, but of unknown thickness, none of the holes penetrating to the face of the cliff. In all, eighteen holes were drilled, and as the flow into the drift was increasing in volume and gaining on the pumps, it was decided to load the holes and blast away the barrier. In addition to the dynamite used in the holes, ten cases of 60 per cent. dynamite were placed at the face of the cross-drift, and the drift was allowed to flood before firing. The blast broke down the solid rock barrier and opened a thorough cut through the disintegrated rock and talus, out to the sheet of water, and down to an elevation about 12 inches below the drift roof.

The water in the drift fell to this level, and several efforts were made to reach the opening, by means of a boat through the drift, in order to blast away the remaining barrier and allow the water to flow out. Failing in this attempt, two of the foremen successfully made the trip around behind the falls, to the mouth of the drift. These men, roped together, crept along the top of the talus to the mouth of the drift, 450 feet from the Canadian side of the falls, and demonstrated the feasibility, though not unattended with danger, of a passage over the talus.

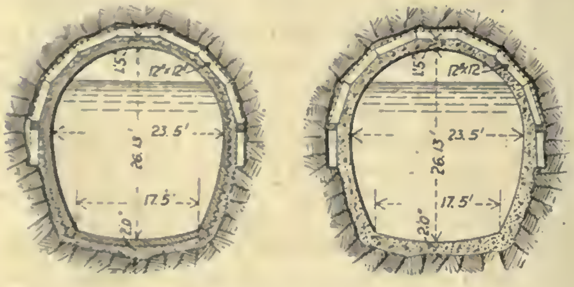
A number of trips were made in this way and a large amount of dynamite was carried out back of the falls and used in open blasts, to scatter the talus and loose rock obstructing the mouth of the drift. By this means a trench was made down to grade, through which the water flowed out, and complete drainage was established and the pumps removed. A timber shield was constructed out from the opening to within about 12 feet of the curtain of water, to protect the men from the heavy spray. In constructing this shield, which was built of 12x12-inch yellow pine timbers, the men working under the heavy fall of spray, which came in gusts of such fierceness and strength as to sweep them frequently from their feet, were roped to the heavy timbers, which in several instances saved them from being swept under the falls. From the end of this shield a chute was constructed, for the disposal of the excavated rock.

The contract for the wheel pit and trail-race branch tunnels was awarded to Mr. M. Davis, of Ottawa, and work was begun August 10. As the site had not been unwatered by the crib coffer dam, under construction by Messrs. Barry & McMordie, provision was made for the construction of an inner coffer dam within a minimum clearance of 35 feet from the head gates. It consists of a double line of crib-work

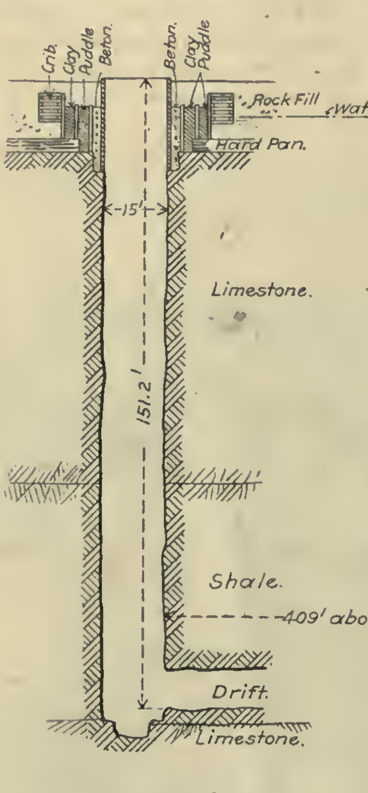




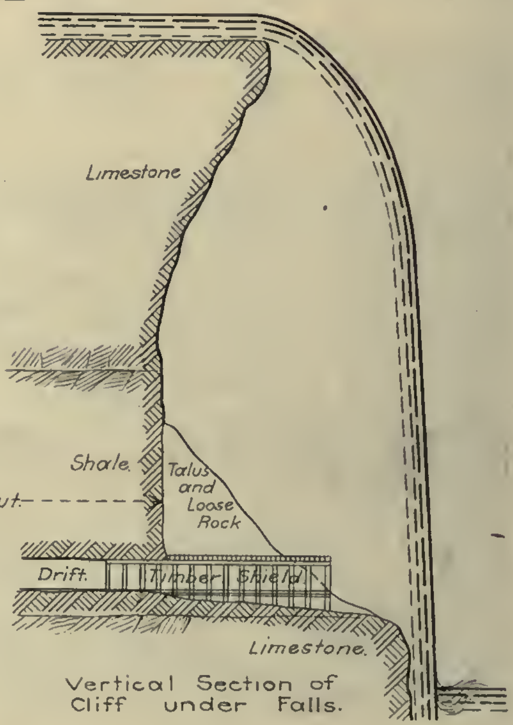
Section C-D.



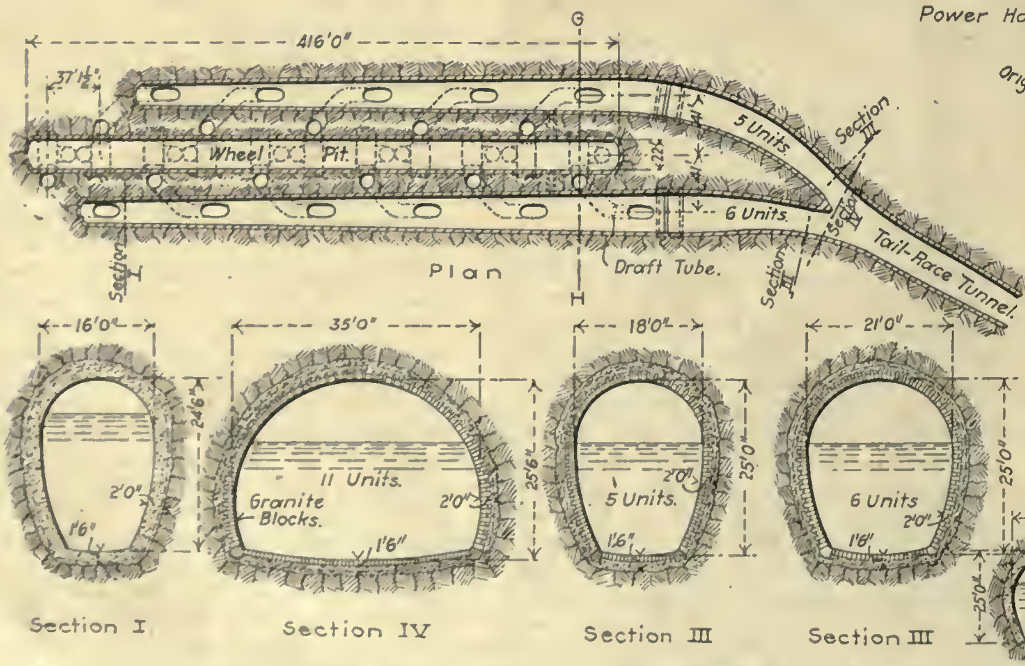
Cross-Sections of Tail-Race Tunnel



Vertical Section of Construction Shaft

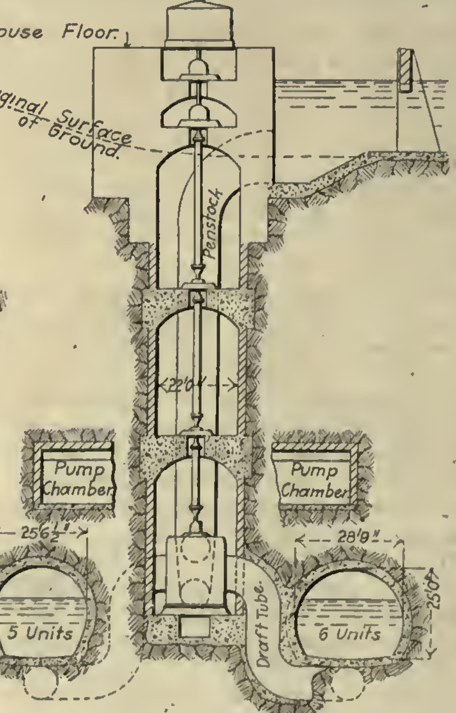


Vertical Section of Cliff under Falls.



Section I Section IV Section III Section III

Plan and Sections of Tail-Race Tunnels



Cross-Section of Wheel Pit and Branch Tail-Race Tunnels at G-H.

MAP, WHEEL PIT, TAIL RACE AND CONSTRUCTION WORKS, TORONTO & NIAGARA POWER DEVELOPMENT, NIAGARA FALLS, ONT.

with a clay space between. The outer crib varies in thickness from 7 to 12 feet, depending on the depth of water encountered. At the lower end a maximum depth of 15 feet of water was recorded. The inner crib has a uniform width of 7 feet and was carried to the level of the water in the river, and above this stout timber bracing was used to hold the sheeting for the clay space. The clay space was sheeted with two thicknesses of one inch plank, breaking joint and carefully scribed so as to fit accurately the river bed. The foundation for the cribs was found to be very irregular, large boulders and detached masses of ledge covering the rock surface, which was also badly fissured.

In accordance with the efforts to preserve as much as possible the natural attractions of the Queen Victoria Niagara Falls park, on the completion of the work, considerable attention is to be paid to the power-house structure. The building will be about 500 feet long, 70 feet wide and 40 feet high. According to Mr. E. J. Lennox, the architect, who has prepared a design, the front elevation will have a center and two end bays, and the portions between center and end bays of the façades will be set back about 6 feet with large windows. In front of the loggia formed will be a colonnade through which the public can pass to view the machinery in the machinery room. It is the intention to form a wide terrace around the building that will lift it above roadway level, and to form ascending steps on all sides.

Launching a Crib at the Cascade during Construction of Coffer Dam, Toronto & Niagara Power Co.

A Water-Power Plant operating under a head of 715 feet has been developed near Klamath Hot Springs in northern California. There is at present installed a 1,000-horse-power Pelton water wheel under the control of a Lombard governor. The pipe line to it is of double riveted 30-inch steel pipe, 2,837 feet long, 30 inches in diameter except the first 37 feet where it tapers from 40 to 30 inches, and ranging in thickness from No. 10 gauge to ⅝ inch. It terminates into a receiver 60 feet long and 30 inches in diameter, built of 7/16-inch steel, from which three 12-inch taps are to be made to three water wheels.

Some Recent Small Sewage Purification Plants.

Extracts from a paper entitled Filters Versus Contact Beds in Sewage Purification, read by Mr. W. S. Shields, of Chicago, before the Indiana Engineering Society.

My own experience and observation with contact beds, though limited, is far from satisfactory, and I have given most attention to filters, principally sand filters, operated intermittently and automatically. Some six of these plants are now in successful operation, the largest being at the county institutions of Milwaukee County, located at Wauwatosa, Wis., within a half hour's ride on an electric car from the city of Milwaukee. This plant is designed to take care of the sewage from a number of separate institutions with a total population of 2,500, including inmates and attendants. They are old and long established institutions from which there is from 300,000 to 450,000 gallons of very strong sewage discharged every day.

Prior to the building of the present plant, a committee of county supervisors made a pilgrimage to Champaign, Ill., and there were convinced that it was only necessary for them to build a similar tank. They purchased a set of their plans and built it. The result was that inside of three months it was overflowing with sludge and was abandoned. The present plant consists of this tank, which is 8x17x54 feet and a new tank 8x20x85 feet. These tanks stand side by side and are covered with low brick buildings. They have a combined fluid capacity of 160,000 gallons, and each is divided by a long central concrete partition into two compartments with all inlets controlled by valves. The outlet in both tanks is over a wide weir into a trough. Both troughs are built of concrete, and the water surfaces of the tanks are protected by deep trap walls. There are no grit chambers to either of these tanks, but both have iron sludge pipes provided with valves, through which the sludge may be drawn off and discharged by gravity into the river during high water.

The plant is located in the valley of the Menominee River, and the most available site for the filter beds was on the opposite side of the river from the septic tanks; consequently the sewage must be carried through an inverted siphon beneath the river, which at this point is some 4 feet deep and 100 feet wide. This siphon is extended on a uniform grade through the filter plant and into the river some 600 feet below the crossing. This pipe with the exception of where it crosses beneath the river, where iron was used, is of vitrified sewer pipe, double strength and deep sockets, carefully cemented; it passes directly under the dosing tank, where a shaft opens up into the bottom of the tank. In this shaft is a sluice valve with a long stem arranged to be operated from the outside of the tank. With the closing of this valve the sewer is closed and the tank effluent is forced to rise into the tank where at the flow or discharge line it is some 9 feet above the main pipe below. By the opening of this valve, the discharge can be turned directly into the river.

The filter plant consists of eight sand filter beds, each having an area of ⅛ acre, arranged in two rows of four beds. The rows are 25 feet apart and the beds 10 feet apart. The four corner beds are each 50x110 feet in dimensions, while the four inner beds are 57.3x95 feet; the latter being shortened in order to provide more room for the controlling chamber and distributing pipes, which are located in the center of the filtering area. The controlling chamber is a concrete basin 12 feet wide and 26 feet long, inside measurements, at the center of which is a brick building 12 feet x12 feet x 11 feet high covered with a tile roof. In the dosing tank are eight 15-inch siphons, one connected with each filter bed, where the water is distributed by two wooden troughs extending the entire length of the beds. The troughs have perforations on each side at the bottom at intervals of 3 feet to allow the water to pass freely and quietly upon the surface of the filter. In the chamber above the tank is a ball device, for automatically putting the siphons into operation at the desired depth of water within the tank.

The filter beds are composed of gravel and sand; the lower 12 inches being built of very coarse gravel, ranging from small cobble stones down to the size of an English walnut, while the next 12 inches is composed of fine gravel similar to roofing gravel. On the top of this is placed 12 inches of coarse clean sand. The partition banks between the beds are of natural soil with sodded slopes leaving a 4-foot walk. The beds are drained with four lines of 4-inch vitrified sewer pipe laid with open joints discharging into 12-inch main drains which lead to a central inspection chamber; four beds draining into one of these chambers. Each bed is provided with an overflow built of concrete, through which water, if for any reason it should not pass down through the filter, finds entrance through the main outlet drain of each bed into the inspection chamber, which is connected with the main sewer, and is discharged into the river through the common outlet. The automatic device is so arranged that one or more of the beds may be cut out of service and the others operated.

The plant has been operating since the first of December in a very satisfactory manner. The final effluent is bright and clear, and the plant has required very little attention, although it has passed through several periods of very cold weather, the temperature being as low as 15 degrees below zero. During this cold weather the temperature of the sewage was reduced only a few degrees in passing the plant.

Similar plants where sand filters are in use, have been operating very successfully for the past two years and this form of construction, where sufficient fall and areas can be obtained, promises to be popular as it has no patented processes connected with it. It is very simple in construction and operation, and where good filtering material can be had at reasonable cost, is not expensive to construct as there is very little concrete or masonry required in the filters. The automatic device used in these plants has been very satisfactory indeed. Experience has shown the necessity of using large siphons which will not only discharge the contents of the dosing tank quickly, but will operate more promptly under an excess flow, which is liable to occur during storms. The only trouble that we have had with these devices, has been that at such times when there is unusually heavy flow, the siphons in some cases could not take the water out fast enough to break their seal when the tank was nearly empty. In the plant above described, the 15-inch siphons were built of vitrified sewer pipe with galvanized iron domes and are not intended to operate automatically without the aid of the controlling device.

Another interesting plant was built for the Allis-Chalmers Company at their new works in West Allis. Early in 1902, the company advertised for propositions for constructing a sewage purification plant with a capacity sufficient to purify the sewage from factories where 3,500 men were to be employed. The requirements so far as purification was concerned, stipulated that "The effluent from the plant shall be without odor and in such condition that no further putrefaction shall occur. In particular, the effluent water shall be at all times unobjectionable in flowing through the course of natural drainage into which it is discharged beyond the limits of the property of the company."

Aerobic Filter Showing Material and Drains.

Milwaukee County Filter Beds.

Aerobic Filter at Allis-Chalmers Plant.

The writer submitted a proposition on plans similar to the one later constructed for the County of Milwaukee in which sand filters were to be used for final treatment. At the suggestion of the consulting engineer, Mr. W. S. MacHarg, of Chicago, the sand filters were discarded. The plant was designed for a capacity of 80,000 gallons of sewage per day, and consists of a septic tank provided with a grit chamber and an anaerobic filter connected with the tank, with final treatment through an open percolating filter. [It was briefly described and illustrated in The Engineering Record August 29, 1903.] The anaerobic filter is composed of lines of 4-inch tile conduit pipe, laid upon a concrete floor, and spaced 4 inches apart with openings at each section of several inches between pieces. The entire floor is covered in this way, the ends of the tiles projecting through beneath the trap wall. On top of this tile are placed large pieces of coal clinkers so laid by hand that the finer material cannot get down to clog the drains; on top of these large pieces there are 30 inches of coarse hard clinkers, 6 inches in diameter; on top of this course is another of 2 feet of 3-inch material; then follow 2 feet of ¾-inch cinders while on top of this are 6 inches of a still finer grade of the same material, leaving a 6-inch depth of water over the entire surface when it is flooded. A by-pass is provided through which the effluent from the septic tank can be carried around this anaerobic filter into the distributing chambers.

The aerobic filter is an open filter constructed on a concrete floor or foundation; this floor is 40x60 feet in dimensions and has a slope of 6 inches from the center to the outside. Along the outside are concrete gutters which collect the effluent and discharge it through tile pipes into an open ditch below the works. On top of the floor are placed parallel lines of 4-inch conduit pipe sloping from the center to the sides, for the purpose of admitting air to the interior of the filter. These tiles are laid a few inches apart over the entire surface and on top of them is placed the filtering material, which in this case is composed of coal cinders and clinkers varying in size from ¾ inch to ¼ inch in diameter. The outside was built of large clinkers laid carefully with a slight batter. The filter has a height of 8 feet at the sides and 7½ feet in the center, and a top area of 30x34 feet.

Across the top of this filter is placed the distributing system composed of three parallel lines of plank troughs 12 inches wide by 10 inches high, constructed of 2-inch pine planks. Into each of these troughs an 8-inch iron pipe leading from the siphons is connected in such a manner that each siphon feeds one-third of the bed. Across and at right angles to these troughs and spaced 3 feet centers, are feed troughs. These are of lumber and are 9 feet long, projecting 4 feet on each side of the main trough. They are built on 12-inch boards 9 feet long resting upon a wall of clinkers and elevated some 12 inches above the top of the bed. These walls were built of selected pieces, are wide at the bottom and narrowed to 16 inches at the top. The troughs are 4 inches wide and 3 inches high, constructed by nailing to a 4x1-inch strip of dressed lumber two side pieces 8 inches wide; then at intervals of 8 inches, notches ¼ inch wide were cut through the lower 2 inches of the sides and half way through the bottom. These boxes were nailed to the 12-inch board and the ends closed; they were then fastened with cleats to the sides of the main trough, in each side of which is a 2x2-inch opening through which the water discharges into the feed troughs. These openings are provided with hand slides so that the amount of water can be regulated in order to get a uniform distribution over the entire area fed by one main trough.

The plant was put into operation about February 1, 1903, and has operated continuously up to the present time, and during this time it has given entire satisfaction. The final effluent is bright, clear and without odor. The operation of this plant has developed the following facts: First, that our estimate of 80,000 gallons per day was far too small as the actual flow ranges during at least 12 hours of the 24 from a rate of 250,000 to 400,000 gallons per day, a fair average probably being 320,000 gallons and contains a large amount of oil and hot water from engines and machinery. Second, that ordinary coal cinders when carefully screened, will disintegrate under conditions here found, indicating that a harder material should be used for constructing filters. Third, that the outside of such filters should be constructed of square open tile laid in mortar or dry rubble masonry instead of the large clinkers which disintegrate under action of the water and allow slides to take place. Fourth, that there is not so much danger from freezing in extreme cold weather as might naturally be expected; consequently the covering might be omitted entirely except in northern latitudes, and then ample provision should be made for opening up doors in the covering whenever the conditions of the weather will allow. Fifth, that with ordinary sewage and a good septic tank effluent a filter of this kind may be depended upon for a capacity of from 750 to 1,000 gallons of effluent per square yard of surface.

This filter has during the past six months been operated continuously at a rate of at least 1,000 gallons per square yard during 12 hours of each day, and as at least part of the plant is operated during the night, it gets but little rest during that period. I have no knowledge of the night flow. Since the plant has been operating, several changes have been made. The aerobic filter has been surrounded with a brick wall laid dry, and the distributing system has been suspended from trusses resting upon brick piers and is now supported independent of the filtering medium and some 15 inches above it. The system, however, proves very satisfactory and the distribution is even throughout the whole surface. The notches in the bottom of the troughs fill up with fine cinder washed from the anaerobic bed and a fungus growth which requires that the slots be raked open once each week.

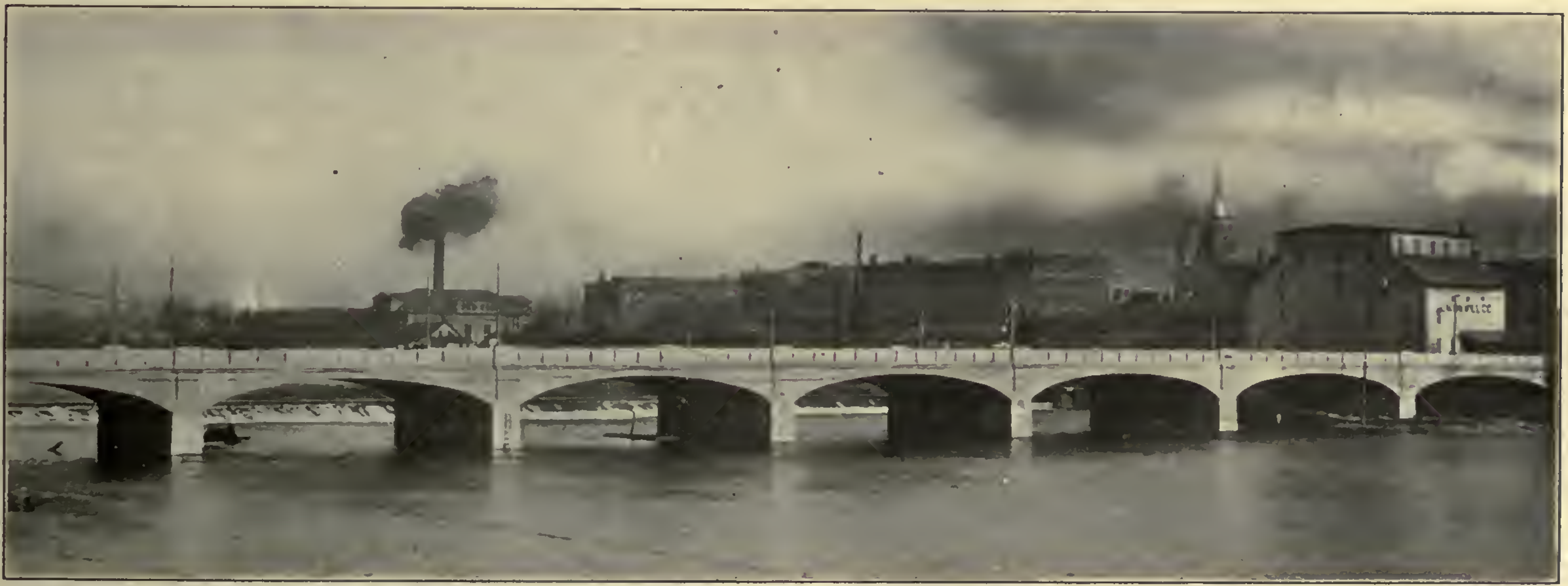
Temperature readings taken at different points through this plant during cold weather indicate very slight changes in the water. A typical set of readings follow: Outside atmosphere, 13; atmosphere inside septic tank with door open, 24; atmosphere over filter bed with winter shutters in place, 44; sewage entering in plant, 60; water leaving septic tank, 60; water in siphon chambers, 54; final effluent below the plant, 52. With outside atmosphere 22, readings show a loss of but 2 degrees in passing the entire plant, and in this as well as a number of other readings the water in leaving the septic tank is 1 degree higher than when it entered.

Fourth Street Bridge, Waterloo, Iowa.

An address delivered by **Mr. M. L. Newton** before the Iowa Engineering Society. Slightly abridged.

Waterloo, in Black Hawk County, Iowa, is a city of 17,000 population, situated on the banks of the Cedar River. An early timber bridge across the river at this place was superseded by a five-span Bow truss, with substantial stone piers and abutments, having an 18-foot roadway and two 6-foot sidewalks outside the trusses which, after more than twenty-five years' constant use in turn became inadequate for the increasing traffic. The old bridge could not be made to serve much longer in its existing condition, and although in later years another highway bridge was in use only one block below, the public demand for better bridge accommodations became such that in the fall of 1901 the matter of a new and more commodious bridge was pretty thoroughly agitated.

Steel plate girder bridges having been recently built at Waverly and Cedar Falls, many Waterloo people favored the plate girder type for the new bridge to be built on Fourth Street. At that time the merits of concrete-steel construction for bridges were beginning to be more or less advertised in the West; and as the result of an investigation along that line, plans of both types of bridges were ordered made. The writer made a plan for a steel girder bridge of 36 feet clear roadway, with 8-foot walks on each side, the bridge to carry 125 pounds live load to the square foot on the roadway and 80 pounds to the square foot on the sidewalks. The bridge was to consist of 7 spans of 79 feet each, or a total clear span length of 546 feet, the girders to be 9 feet deep. Although the plans and bids were for a double oak plank floor with Oregon fir joists, yet the design of the girders and floorbeams was such that at any time in the future, if desired, steel joists, a buckle-plate floor and an ordinary pavement could be put in place of the timber floor system.



General View of the Concrete-Steel Arch Bridge across the Cedar River, at Fourth Street, Waterloo, Iowa.

In competition with this was the plan for a concrete-steel arch, sometimes called the Melan arch bridge, from the Concrete-Steel Bridge Company, of New York, presented by the Marsh Bridge Company, of Des Moines. The Melan arch bridge was to be made up of 7 spans, each 72 feet in clear, piers 7 feet wide, making a total length inside of abutments of 546 feet. The abutments were each 20 feet wide, giving a total length of 586 feet over all. The roadway was to be 36 feet in clear, with 8-foot walks on the sides, or 54 feet wide over all.

Accordingly in February, 1902, bids were received on both styles of bridge. Both plans provided the same roadway and sidewalk privileges, consequently a comparison of the bids would furnish a fair estimate of their relative cost, except that the steel girder bridge would require a new floor every three years, painting every five years, and an entire new system of sidewalk and roadway joists once every ten or twelve years.

To the surprise of the Board the lowest bid for the plate girder was $55,994, by the Chicago Bridge & Iron Company, and the lowest bid for the Melan bridge was only $49,474, by the Marsh Bridge Company; but in the face of even so great a difference in the original cost of construction of the two styles of bridge, as shown by the bids, and the fact that in constructing a plate girder, two-thirds of the cost would go out of town for materials and freight, but for the construction of the concrete-steel bridge only one-third of the cost would leave the city and two-thirds would be spent at home for labor and domestic materials, the Board of Supervisors were not willing to consider the bid for the new style of bridge, and it was only after considerable deliberation, the recommendation of their engineer and the earnest solicitation of some of the business men of the city that the Marsh Bridge Company secured the contract for the construction of the concrete-steel bridge.

According to the interpretation given of the State law, the county could not pay nor contract for an expenditure of more than $25,000 for any one particular bridge without a vote of the people. To obtain a favorable vote for a bridge with which the voters were unacquainted would perhaps jeopardize the scheme for a concrete bridge. The city of Waterloo, having a greater interest in the bridge than the county at large, came to the rescue, and by action of the Council pledged the city to pay all above the sum of $25,000 necessary for the construction of the Fourth Street concrete-steel arch bridge. This action on the part of the city was satisfactory, and the Board of Supervisors thereupon entered into a contract with the Marsh Bridge Company for the new bridge, after which the city, having confidence in the enterprise and believing the new bridge should be wider than called for by the plans and specifications, entered into a special and private contract with the Marsh Bridge Company to add an extra 4 feet in width to the new bridge as already contracted for by the county, thus the bridge would provide a clear roadway of 40 feet instead of but 36 feet as in the plans.

In the spring of 1902 the construction of the foundation for the new bridge was begun. Fortunately the old piers were not in the way of the new ones, and, as the bridge was to be somewhat shorter than the old one the abutments also could be built without disturbing the old ones. Thus the old bridge was allowed to stand until the new foundation was entirely finished, the walks on the bridge serving as a foot-bridge and the street railway tracks being used by the contractor to transport materials to place.

The year 1902, in this section of the county, will be remembered, by contractors especially, as remarkable for its frequent rains and high water, and in Waterloo there were still living many of the early residents of the town who ever and anon spoke of the season of 1858 as one of excessive high water, when most of the business men went barefooted, and generally with their trousers legs rolled up above their knees, the town being simply a group of islands, and boats sailed about in the streets, boots and shoes and stockings being at a discount. Soon after the commencement of work the rains fell and the waters rose as they had not done for many a year before, and the men who had such vivid recollections of those early days seemed suddenly to multiply and with one accord they each expressed their fears that the construction of a concrete-steel arch bridge on Fourth Street would so restrict the waterway of the river that in case of even an ordinary high water, the awful times of 1858 would surely be repeated and dire calamity result. Such talk caused more or less fear and apprehension on the part of some of the best men of the city, and accordingly a meeting of the bridge committee and the engineer was held, which resulted in an elevation of the grade of the bridge. This had the effect of allaying the fears of the people.

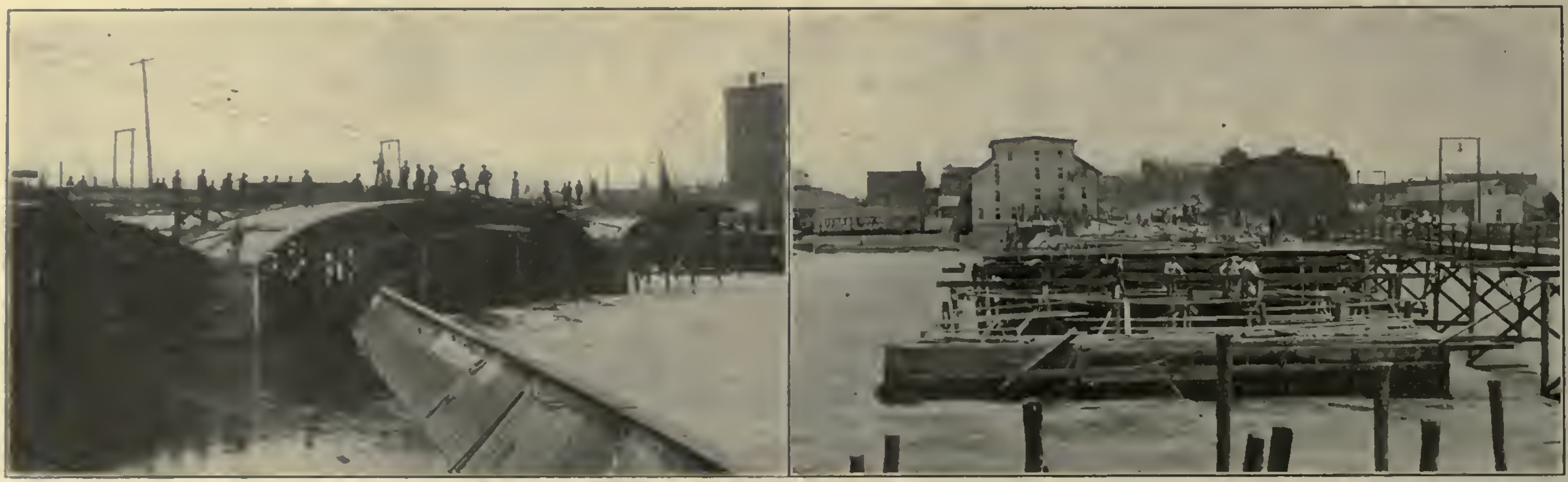
Work was pushed forward as fast as possible under the peculiarly adverse circumstances attending wet weather, operations being entirely suspended four different times during the summer by the complete submergence of the entire work, cofferdams and all. Finally, before freezing weather came, the foundations were all completed and work postponed till the next season, an extension of time for completion of contract being granted till the following year. In tho spring of 1903 work was resumed. The piers and abutments which had been built the season before were found to be in excellent condition. The old bridge was removed, a new foot-bridge made, and the work of constructing the arches was speedily carried forward. The weather being more favorable, there were no serious hindrances, and the entire structure was completed according to plans and specifications in the early fall of 1903, since which time the bridge has been in use, giving excellent satisfaction to all.

The bridge is made up of seven arches, each 72 feet in clear between faces of the piers, with a rise of one-tenth of the span or 7.2 feet above the springing line. The height of the springing line at the abutments is about 14 feet above the bottom of the foundation, or about 11 feet above the surface of the bed of the river. At ordinary low water the average depth of the water is about 2½ feet. The bed of the river is loose limestone rock with an occasional clay pocket. In building the piers one of these clay pockets about 7 feet square and 4 feet deep was encountered. To secure a good and safe foundation it was necessary to excavate from 2 to 3 feet below the surface of the bed of the river, owing to the fact that the rock above the solid ledge was loose and flat and quite irregular in form, and that the interstices were filled with sand and gravel. It became a serious problem at times to keep the water out of the excavation by means of the ordinary cofferdams. The best success was had with a cofferdam frame made of 8x8-inch timbers 4 feet wider and longer than the pier, with two rows of sheet piling from 6 to 10 feet apart outside of the space for the pier. The space between the sheet piling was filled with straw, clay and dirt well rammed, and even then it frequently became necessary to use sacks of sand around the outside to prevent the inrush of the water under and through the loose surface rock of the river's bed.

The frequent and great fluctuations of the river added very much to the difficulties of that part of the work. The removal of the water was effected by a large rotary pump, with 6-inch suction, run by an ordinary thrashing machine traction engine. The excavation being completed and thoroughly cleaned, the concrete foundation of the pier was built as high as the surface of the bed of the river without the use of forms, thus securing a foundation as wide as the excavation, no matter how irregular in outline. Upon this foundation forms were built of the exact size of the required pier, using 6x8-inch timbers for upright studding, held together by four strands of No. 9 wire, to the ends of which were secured a ⅝-inch machine bolt nut by means of a small U-shaped iron clamp. A bolt with square head and a washer was used on each side, passing through the studding and screwing into the nut held by the clamp. If the thread on the bolt was not sufficient to draw the studding to proper place, the wire strands were twisted to secure the result. Inside the studding 2-inch surfaced plank was used to complete the form, and to remove the forms the bolts were screwed out, and upon removal of the bolt the small bolt hole was filled with cement mortar. Small quarter-round fillets of about 1½-inch radius, made of galvanized iron, were used in the vertical corners to give a finished rounded corner to the pier. A depression of about 10 inches in depth was left on top of each pier to secure a better foundation for the arch proper and to allow the ends of the lower line of steel ribs to pass a little below the springing line.

The general upper surface of the finished bridge is a vertical curve, being two feet higher in the center than at the ends, and the arches being all alike necessitated raising the first pier 12 inches above the abutments, the second pier 8 inches above the first and the third or middle piers 4½ inches above the second, which gave a uniform depth of spandrel wall of 3 feet, 4 inches above the crown of the respective arches. The arches were so built that the thickness of the concrete at the skewback was 32 inches, and 14 inches at the crown, with two lines of steel bars, the one 2 inches clear above the soffit of the arch and the other 2 inches in clear below the top surface, so that all steel was thoroughly embedded in concrete, to prevent rust or a scaling off of the concrete below the ribs.

The proper forms for the arches were secured by laying out, on a large flat space, to full size the three-centered arch of the plan, having a radius of 29.5 feet at the ends and 120.5 feet for the central portion. Using the templates thus obtained all the 3x12-inch fir timber ribs for the arch were made, and upon them transversely to the center line of the bridge, were laid the 2x6-inch surfaced lagging. The arches being all alike only timber enough for three arches was cut, and the timber moved forward as the work progressed, leaving each form in place long enough for the concrete to become fully set before removal to the next. Thus the form for the first arch was used for the fourth, the second for the fifth, and so on. To support the forms for the arches piling of native timber was used, a steel pile being first driven to make a hole in the loose rock, into which, after the withdrawal of the steel pile, the timber piles were solidly driven to place so as to guard against any settling of the form during construction. Caps of 8x10-inch timber were used on the piles, and oak wedges on the caps to bring the curved joists to exact grade.



Piers and Falsework for the Concrete-Steel Arch Bridge at Waterloo, Iowa.

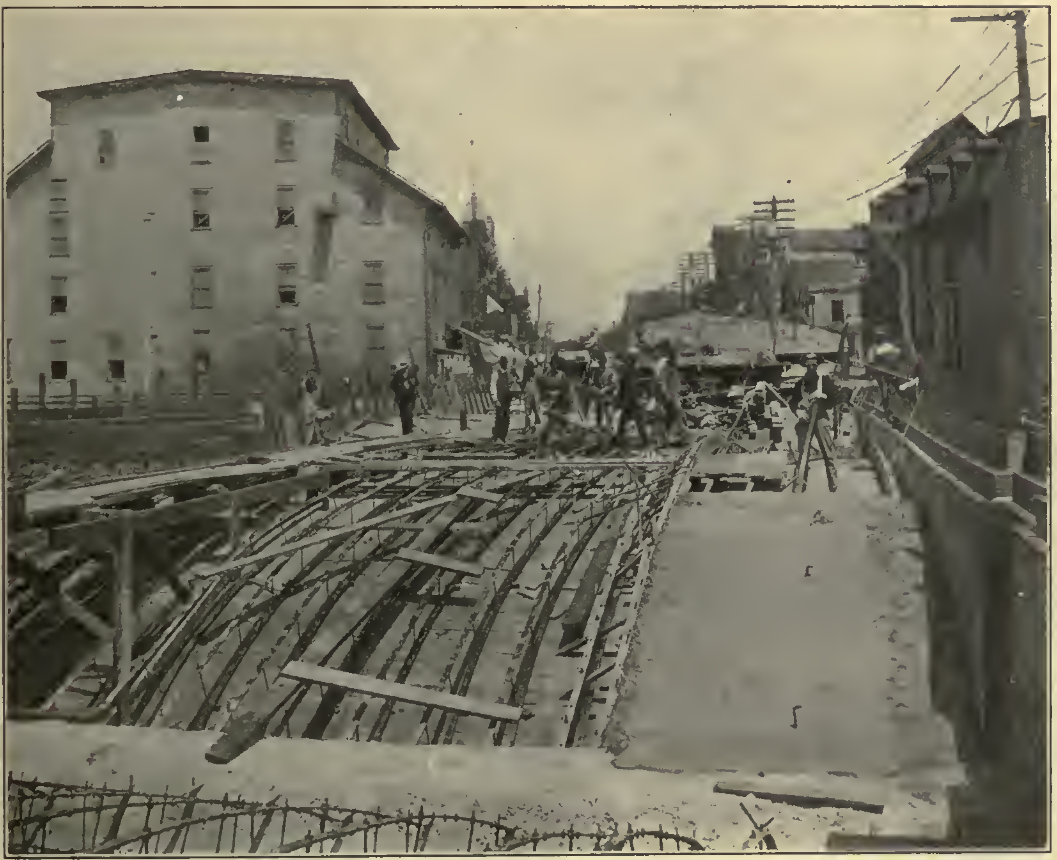
The steel ribs were 2½x⅝ inches with ⅝-inch rivets, cone heads on each side, spaced 8 inches apart and each line was firmly riveted together, giving a continuous rib from one end of the bridge to the other. The upper line of ribs was secured to the lower by bolts with double nuts, spaced 32 inches apart. These double lines of ribs were spaced 24 inches apart transversely to the line of the bridge. The steel ribs are supposed to take care of the tensile strains of the bridge under a moving load, and the better to do so, they are placed as far apart vertically as possible and have sufficient concrete covering for the metal. From the experience had in other bridges of this kind, 2 inches from the outside should be the minimum. Two-inch blocks were laid between the ribs and the lagging at spaces of about 4 feet. As the concrete was laid and tamped under the ribs these blocks were removed. The ribs extended into the abutments about 6 feet.

The concrete of the arches was laid in sections about 15 feet in width, and it was so arranged that each section extending from abutment to pier or from pier to pier constituted one day's work. First, however, the concrete was placed at an abutment and finished in the rough from the springing line on a slope about normal to the arch, a depression having been left in the top of the abutment to receive the ribs. Then at each successive pier the concrete was placed over the piers for the double purpose of holding the ribs steadily in place, and providing suitable skewbacks for the newly constructed arches. On the face of the forms, used to divide the arches into longitudinal sections, pieces of 2x4-inch scantling were nailed parallel with the steel ribs, to provide for a better joining of the fresh work to that of the day before and to guard against any future sliding of one part by the other. In the concrete near the sides of the bridge and inside of the place for the spandrel walls pieces of iron rods were set to give place for securing the inside forms of the spandrel wall, the construction of which immediately followed the completion of the arches. The inside face of the spandrel wall slopes about 3 inches to the foot, being 18 inches thick at the top. The thickness at the bottom varies from 2 to 5 feet in proportion to its height. To provide for expansion and contraction due to changes of temperature, the spandrel walls were built in sections of about 12 feet each, divided by vertical lines over the faces of each pier and the abutments.

During the cold days of the present winter when the temperature was near the zero point, the expansion-joints over the piers were open about an eighth of an inch, with an apparent lowering of the crown of each arch of about

½ or ¾ inch. At the time of construction of the spandrel walls pieces of ⅜-inch rods about 3 feet long were inserted about half their length in the wall along the center line of the cement hand rail, and when the hand rail was completed they served the purpose of securing it safely in position. Owing to the impossibility of preventing contraction cracks in concrete structures of considerable length, the hand rail was built in separate sections about 6 feet long and 3 feet high, with a large and more elaborate section over each abutment and pier.

The spandrel filling is a sand loam, being probably two-thirds pure sand. Upon the filling for a temporary roadbed the city placed 6 inches of finely crushed rock, and common plank for the sidewalk, it being thought best to allow the filling to settle for a year or two before attempting to put on the permanent pavement, which will doubtless be asphalt, with the sidewalks of cement, the upper surface of the walk coinciding with the top of the spandrel wall. The pavement and walks were not included in the contract for the bridge. On the bridge is a double track electric street railway with tracks 5½ feet each side of the center line.



Steel Reinforcement in Concrete-Steel Arch Bridge at Waterloo, Iowa.

The materials used in construction were good sharp sand of excellent quality containing some fine gravel; crushed limestone from Waterloo quarries, that in the abutments and piers not greater than 2 inches in greatest dimension, that in the arches being a much harder rock and not exceeding 1½ inches in size, averaging probably about ¾ inch; crushed in a Gates crusher, with all the finest dust screened out. The cement used was the Northampton Atlas, except to avoid delay on some obscure parts of the work, when a few sacks of the Hannibal Atlas were allowed. All the cement was subjected to tensile, fineness, pat and color tests. Fairbanks apparatus was used for the purpose The specifications required at least 99 per cent. to pass a 50-mesh sieve, 90 per cent. a 100-mesh and 70 per cent. a 200-mesh; briquettes of neat cement to develop a tensile strength of at least 450 pounds per square inch in seven days, and 550 pounds in 28 days; briquettes of one part cement and three parts sand to develop at least 150 pounds in seven days or 220 pounds in 28 days.

The concrete was used in the proportion of 1:4:8 in the abutments, 1:3½:7 in the piers, 1:2½:5 in the arches, and 1:3 in the hand rail. A Smith mixer, propelled by a gasoline engine, was used for all concrete. No soap or other lubricant was used on the inside of the forms; some experiments in using paper proved a failure. The facing of all exposed surfaces was made of mortar, without the crushed rock, and was put in place by using a form made of heavy plate iron about 10 inches wide and 6 feet long, upon which were riveted 1½-inch angles placed vertically about 2 feet apart, while upon the other side and level with the top edge was riveted an angle iron the whole length and to which two handles were fastened.

The amount of materials used by the contractor in the performance of his contract is about as follows: 250,000 feet of pine and fir lumber for the forms, not including the special forms and mill work for the hand railing; 7,200 barrels of Atlas cement; 5,000 cubic yards crushed rock; 3,000 cubic yards sand; 110 tons of the steel ribs, and 6,000 cubic yards of spandrel filling. The entire cost of the bridge, as left by the contractor, including the contract price on the original plan, the special contract by the city for 4 feet additional width, the increase of material and cost of raising the grade and the change of style of hand rail from the common highway bridge steel railing to concrete, amounted to $54,100.

THE WATER USED BY A WATER WHEEL of 340 horse-power, operating under 1,470 feet head in a plant on the Isere River in France, is measured as follows: The discharge is passed into a large funnel-shape vessel the upper part of which is cylindrical and pierced with 80 rectangular openings disposed around the periphery. The water flows out of the openings, 80 in all, and one of these streams is passed through a water meter as a measure of the total volume.

A New Water Power Development at New Milford, Connecticut.—I.

By Walter Scott Morton.

Rising in the western part of Massachusetts, in the romantic region of the Berkshire Hills, the Housatonic wends its way past Pittsfield, Lenox, Great Barrington and other well known summer resorts, enters Connecticut in its northwestern corner, flows substantially parallel with its western border for some distance, and, with an eastern divergence, reaches Long Island Sound between the cities of New Haven and Bridgeport. The Housatonic is the second largest river in the State, with but one important water power developed, that of the Ousatonic Water Company at its confluence with tide water.

Late in the fall of 1900 the writer paid his first visit to its valley in company with Mr. Nicholas Staub, of New Milford, who had acquired the rights of the feasible powers on the River, and had secured a charter from the State under the name of the New Milford Power Company, authorizing their development. The writer had the good fortune finally to interest Mr. Robert N. King, of Dayton, Ohio, whose long connection with the Stilwell-Bierce & Smith-Vaile Company as its president, and his other independent operations has made him one of the foremost water-power men in the country. Through Mr. King's efforts the rights of Mr. Staub in the New Milford Power Company were purchased, and in the fall of 1902 the construction of the Bull's Bridge plant—the subject of this article—was inaugurated.

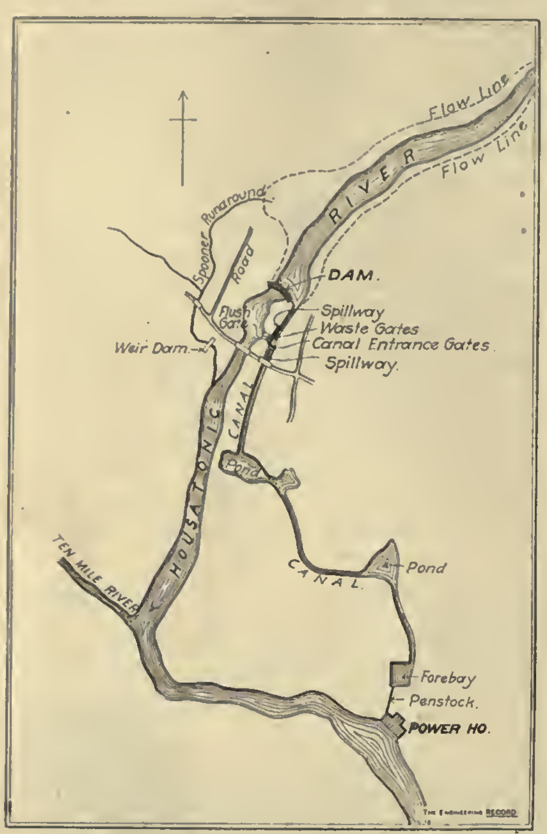
The development at Bull's Bridge was a matter requiring much investigation and careful study. Four miles below Kent the river enters a narrow gorge less than 100 feet in width, and has a drop of some 45 feet in a little over one-quarter mile, which, with a 15-foot dam, gives a head of 60 feet. This head was insufficient for commercial development, and it devolved upon the writer to devise some plan which would embrace the rapid descent of the river in the next two miles. The banks, though high, were many feet below the established flowage line at the head of the gorge. The Housatonic, below the gorge, makes a decided western turning to its junction with the Ten Mile River, where it is but one-half mile from the New York State line. Again it abruptly changes to the east for another mile, where it assumes its normal course. Finally a canal was traced out along the eastern side hills, cutting off the river bend. A suitable place for a forebay was found on a plateau just above the river and a fine power-house location at its foot on the river bank, with deep water at the point of tail-race discharge. A total head of 110 feet is here obtainable, and the removal of some river bars below the power-house further increases this to a total of 115 feet. The river for four miles above the dam being comparatively flat, a fine storage basin is created, materially enhancing the horse-power output.

The development, in general, consists of a concrete dam at the head of Bull's Bridge gorge, thence a canal in a thorough rock cut from 18 to 40 feet deep for 550 feet, where waste gates are constructed, discharging into the river at this point. Here also the entrance chamber for the entrance gates to the canal proper is blasted out of solid rock. Thence for 1,200 feet the canal runs partly in rock, partly in earth, to a valley now converted into a reservoir of some eight acres by two large dykes, one an earth with rock-fill backing, the other, at the inlet to the canal continuation, a rock-fill dam with concrete water tight backing.

From here the canal extends along the side hill, largely through rock cutting, for some 4,000 feet (the down-hill side being an earth embankment with a rock-fill backing) to another valley, dyked off at its lower end, creating a second reservoir of some four acres. The next thousand feet of the canal is carved out of a very steep hill-side, largely rock, a high embankment of loose rock with a heavy earth lining forming the down-hill side, this being the most difficult part of the entire canal construction. Thence for 2,000 feet more the canal is carried along the side hill and through a deep cutting, all in earth, to the forebay.

The forebay, with a superficial area of about one acre, is created by heavy earth banks on top of a level plateau. At its lower end a large entrance basin with heavy concrete walls has been constructed to contain the racks, gates and pipe entrance. A 13-foot, steel riveted pipe, 400 feet long, goes down the steep side hill to the power-house, turns at an angle of 50 degrees and parallels the river side of the power-house, from whence feeder pipes connect with six water-wheel units and two exciter wheels. The pipe, at its extreme end, curves upward into a standpipe of 5 feet diameter with its top level with the crest of the dam. The power-house is located some 50 feet back from the river to insure a solid rock foundation, a large tail-race being excavated to a connection with the river, where the latter is from 12 to 15 feet deep, the bottom of the tail-race being 124 feet below the dam's crest.

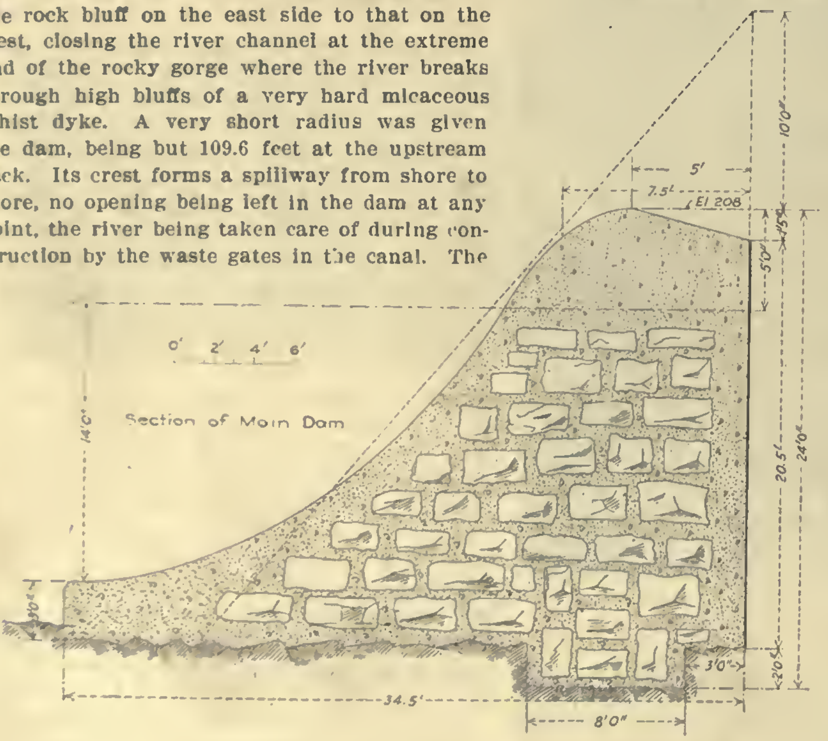
The Dam.—A most favorable location was found for the dam with rock bottom and end anchorages. The dam forms a perfect arc from the rock bluff on the east side to that on the west, closing the river channel at the extreme end of the rocky gorge where the river breaks through high bluffs of a very hard micaceous schist dyke. A very short radius was given the dam, being but 109.6 feet at the upstream back. Its crest forms a spillway from shore to shore, no opening being left in the dam at any point, the river being taken care of during construction by the waste gates in the canal. The concrete was flared at each end to give a stronger anchorage and a better resistance in its arch action.

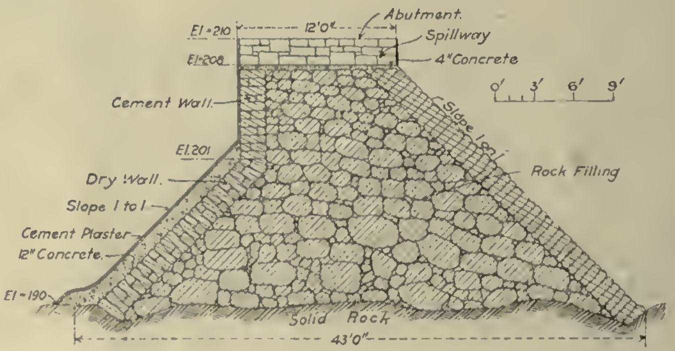


The New Milford Power Development.

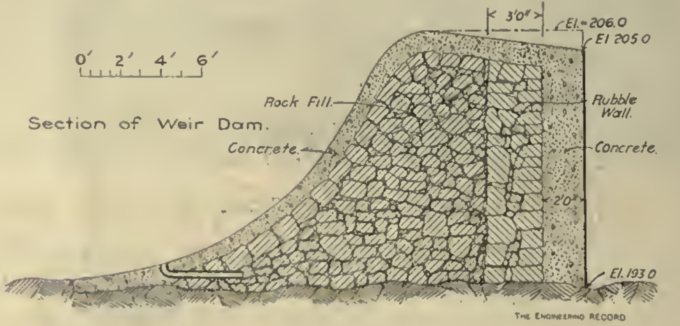
The section of dam consists of a flat top with an incline of 1½ feet in 5 from the upstream edge to the crest. The crest is rounded, the face of the dam at the top being a parabola, calculated on a head of one foot over the crest, an assumed mean head in ordinary floods. The lower part is a cycloidal curve to its junction with the toe where it runs tangential to the river bottom. From the toe proper a concrete apron is laid from 30 to 40 feet wide, inclined from the toe and flattened to a horizontal in its lower ten feet. Still below this concrete apron, rock and boulders are filled in for a short distance downstream. In addition a small, loose rock dam at the head of Bull's Falls impounds a water cushion over the apron, the river between being flat. The above construction entirely eliminates any undermining action. The same section, 16 feet in height, was carried across, resting on an enlarged foundation, thereby giving a much stronger section. It has a total length on its crest of 203 feet.

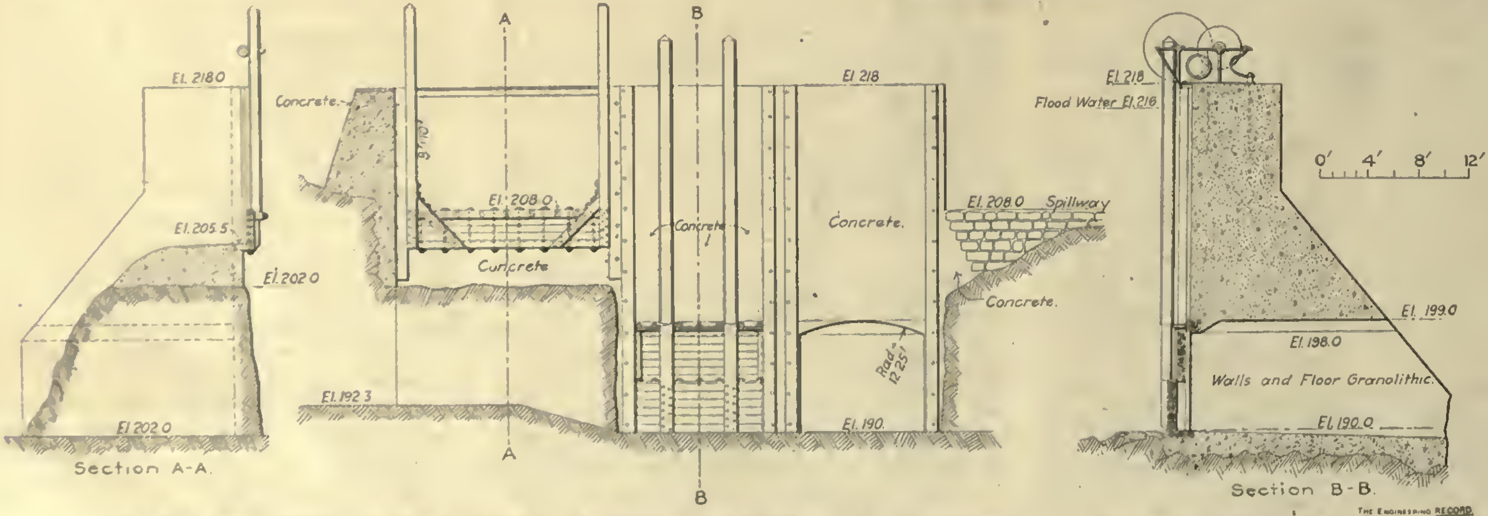
The dam is of concrete construction, interspersed with rocks and boulders ranging in weight from 100 to 5,000 pounds. In all cases a spacing of at least 6 inches was maintained, a clear mass of concrete of at least 2 feet thick being left between the embedded rock and the outer surfaces except at the top, where the concrete is 6 feet thick. A mixture of one part Portland cement, three parts sharp sand and five parts broken stone was used throughout. The top foot and the crest of the dam were made of granolithic, being a mixture of one part Portland cement, 1½ sharp sand and 1½ small, carefully screened pebbles, to make a better wearing surface to resist the erosion of





Section of Dyke.





Section A-A.

Section B-B.

WASTE AND FLUSH GATES AT CANAL ENTRANCE CHAMBER, AND SECTIONS OF DAMS AND RESERVOIR DYKE.

ice and debris. The crest was brought to alignment by intersections (a transit at each end being used), from calculated angles, and checked by measured distances between. Iron pins, 6 inches long, were set in the granolithic at regular intervals, their tops carefully leveled, and by this means the crest was brought to an exact elevation from end to end. The last concrete was placed in the dam just eight days before the advent of a flood that carried the water to within one foot of the crest, giving a hard test of the construction, and at this date not a single crack or seam shows in any part. The back face of the dam was plastered with ½ inch of one part Portland cement and two parts sand, for additional watertightness and wearing surface.

The coffer dam was run across the river above the dam, the waste gates discharging into the river at a point below Bull's Falls at an elevation considerably lower than the base of the dam. It was formed of brush facines made into mats when sunk below the water surface, loaded heavily with stone and in alternate layers of brush and stone. For water-tightening, a filling of earth was placed on the upstream side. The coffer dam withstood the destructive action of several floods without appreciable damage. A temporary connection of earth between the coffer dam and the east anchorage of the concrete dam and around the west end, which was necessarily butted against a sandy shore, washed out in an extreme flood and caused the only delay. The coffer dam, though built on a gravel and boulder river bottom, showed but slight leakage, a 4-inch centrifugal pump being necessary only when the last gap in the foundation was put in.

New Milford Power Development: Fascine Coffer Dam; Concrete Main Dam.

A culvert, 3 feet wide and 5 feet high with an arched top and zigzag sides, was left in the dam to carry the final water. This had a sliding gate at its upper end. When the dam was completed to the top and higher than the water in the pond above the coffer dam, the gate was closed and the culvert entirely filled with concrete.

Storage Basin and Spillways.—The water is impounded for a distance of 23,000 feet above the dam with an average width of 250 feet and a superficial area of 5,750,000 square feet. This gives a storage capacity at 3 feet depth of 17,250,000 cubic feet, or in round numbers 500 cubic feet per second for ten hours in addition to the regular flow of the stream. This represents a fine storage of water and is of great value to the plant.

The Spooner Run Around, so-called, is through a valley, the upper part of which lies about three feet lower than the crest of the dam. By a gradual descent it encompasses the dam site and enters the river again below Bull's Bridge through a narrow, deep gorge. This topographical condition is utilized as an overflow outlet for flood water. At the head of the gorge before mentioned where the rock lies 2 to 3 feet below the surface of the ground a rock fill weir dam was constructed, its crest being 2 feet below the crest of the main dam.

All earth and loose and decomposed rock was carefully removed from the base of the dam. The dam has a backing of a masonry wall 3 feet in thickness, augmented by a concrete wall 2 feet thick. The surface of the rock fill was carefully shaped to the subgrade for each section and paved with stone. Over all this was laid a concrete envelope at the crest of the dam and augmented at the toe where the dam joined the rock ledge. A section of the dam showing the method of construction is herewith given, also a plan showing the Run Around in connection with the dam, entrance gates, waste gates and upper part of the canal. Movable flashboards are placed on the crest of the dam with their top at the elevation of the main dam which can be quickly lowered at the time of floods to increase the flood discharge.

Wherever possible, spillways were put in the canal and reservoirs as safeguards. These represent a total distance, including the Spooner Run Around dam and the flush gate, of 886 linear feet. Of this 200 feet is in the canal above the waste gates, 16 feet in the flush gate, 132 feet in the Run Around dam and 300 feet in the canal immediately below the entrance gates, 240 feet in the first reservoir, the latter including the spillway over a rock fill dyke, an additional spillway of some 60 feet built of masonry being located near the southwestern corner of the reservoir. These amply safeguard the canal against an excessive water elevation as well as relieve the river during floods.

The flood relief afforded by the Run Around weir dam, flush gate, waste gates, spillway above the waste gates and the dam itself is substantial and directly affects the height of flood water over the dam. In computing the discharge Bazin's formula, $Q = (C l h)^{3/2}$ was used. In this C, the coefficient, was taken at 4, l being the length of the weir and h the head. By this formula, assuming the water to be one foot over the crest of the dam, the Spooner Run Around shows a discharge of 2,702 second-feet, the main dam 812, the spillway above the waste gates 229, the flush gate 179, a total of 3,927 second-feet. Added to this should be the discharge of the waste gates, 3,880 second-feet, and the ordinary discharge of the canal 1,000 second-feet, making a total of 8,807 cubic feet per second, which represents a little more than the general spring freshets.

(To be continued.)

Concrete Foundation and Cement Filler for Brick Pavement.

A paper read before the Illinois Society of Civil Engineers and Surveyors, by Mr. O. L. Gearheart.

In this paper it is proposed to discuss the economic relations between concrete foundations of different compositions and cement filler.

The Concrete.—About a year ago the writer made a series of experiments to determine the variation in the strength and cost of concrete due to a variation in the kind of cement and in the proportions of the ingredients. The former practice was to use a natural cement concrete for the pavement foundation, but on one occasion a Portland cement concrete, consisting of 1 part Portland cement and 9 parts fine gravel, was used with excellent results. This led the writer to give the matter of Portland cement concrete further study. The number of specimens made were about as follows: Twenty-five 8-inch cubes, twenty-five 6-inch cubes and twenty-five 6x6x21½-inch beams. Eleven different proportions with Portland cement and one proportion with natural cement were used. One each of the two cubes and one beam were tested at 30 days and 90 days. Owing to other matters that were occupying the writer's attention at that time, the age of breaking for specimens intended for the 90-day tests vary somewhat, but the difference is not enough to materially change the results. The different specimens were made by the writer at the Champaign city laboratory, and through the kindness of Professor A. N. Talbot, tested on the machines belonging to the Department of Applied Mechanics at the University of Illinois. Only details essential to the understanding of the results will be mentioned here.

The materials used were Atlas Portland cement, Clark's Utica cement, gravel from a pit north-east of Urbana, Illinois, sand from a bank in the same locality and broken stone from a quarry at Kankakee, Illinois. The sand was a fair quality of building sand, containing some clay and having about 35 per cent. of voids. Of the gravel, 23 per cent. was retained on a number 4 sieve, 53 per cent. on a number 10 sieve, 71 per cent. on a number 20 sieve, and 29 per cent. passed a number 20 sieve. This material contained 21 per cent. of voids. It will be seen that the gravel contained but little coarse material. The broken stone was a good quality of stratified limestone, crushed so that all the particles would pass a screen of 2-inch mesh. This material contained 47 per cent. voids. The stone is bought by weight, and as the freight is quite an item it is found to be cheaper in Champaign to buy screened stone and fill the voids with a larger amount of gravel than would otherwise be necessary.

The cement was taken from bags shipped to the city for the retail market, and was not a special cement for testing purposes. It will be seen from table below that the Utica cement is a high grade of natural cement, and that the Atlas cement is a good quality of Portland:

	Utica.	Atlas.
Per cent. passing sieve No. 50....	97.4	99.6
Per cent. passing sieve No. 100..	80.5	92.5
Time from mixing to initial set..	32 m.	1 h. 56 m.
Time from mixing to final set...	3 h. 20 m.	5 h. 10 m.

Tensile Strength:

Cement.	Per cent. of water.	24 hrs.	7 days.	30 days.
Utica	31	80	181	230
Atlas	17	263	710	..

The cement and gravel were thoroughly mixed dry, then wetted and mixed into a stiff mortar, after which the dampened stone was added and the whole was turned several times. The mixture was then tamped into the molds by means of an eleven-pound tamper, having a face area of 9 square inches. About 2 or 3 inches of loose material were placed in the molds at a time and tamped. During the operation a square-ended trowel was worked up and down between the concrete and the form, thus bringing the mortar to the sides and corners of the specimen and making it homogenous throughout. In every case only enough water was used to cause a film of water to come to the surface after considerable tamping. The cubes were left in the molds for 24 hours with a damp cloth over them, after which time the molds were carefully removed and the specimens were stored under cloths which were dampened from time to time until the cubes were tested. The concrete beams were made and stored in the same manner as the cubes. In crushing the cubes and breaking the beams, the direction of the force applied was perpendicular to the tamped surface. Immediately before crushing the cubes the two faces to which the force was applied were plastered with a thin coat of plaster of Paris, and a self-adjusting plate was used to distribute the pressure over the entire surface of the cube.

In arriving at the cost of the concrete, gravel and sand were taken at 90 cents per cubic yard, broken stone at $1.40, Utica cement at 65 cents per barrel, Portland cement at $2.00, and labor for measuring, mixing, placing, grading and tamping a 6-inch layer of concrete was taken at 6 cents per square yard.

Table 1 shows the strength of the cubes and beams and also gives the yield of rammed concrete in terms of the sum of the volumes of the gravel and broken stone. This table also shows the cost per square yard of a 6-inch layer of concrete of the different compositions.

From the tests given in Table 1 it is believed that the following conclusions may be drawn: (1). From numbers 2 and 20 we see that the cost of Portland cement concrete is about 4 per cent. more than natural cement concrete, while the former is 50 per cent. stronger. (2). By comparing numbers 2 with 23 and 24 it is seen that the strength of concrete composed of 1 part natural cement, 3 parts gravel, and 3 parts broken stone, and concrete composed of 1 part Portland cement, 10 parts gravel, and 10 parts broken stone, are nearly equal. (3). By comparing experiment number 4 with number 10 it is seen that the addition of broken stone in amount equal to the gravel, without increasing the quantity of cement, materially increases the strength and decreases the cost of the concrete. (4). Numbers 12, 16 and 20 show that the increase of the broken stone from 4 parts to 8 parts does not materially change the strength of the concrete, but reduces the cost. (5). By comparing number 18 with number 26, it is seen that the increase of the broken stone from 8 parts to 16 parts does not materially change the cost of the concrete. (6). About half a mile of pavement having a very lean Portland concrete was laid during the past season under the writer's direction. It was found, much to the surprise of the writer and also of the contractor, not only that the very lean concrete was more easily mixed, but that it was more uniform than the very rich natural cement concrete heretofore used. In all respects the Portland cement concrete is superior to the natural cement concrete.

Brick Beams.—The writer made a number of brick beams by taking paving brick and cementing them together with a cement filler. The beams were 3 bricks long, 3 bricks wide and 4 inches deep. They were formed by laying the brick side by side as in the pavement, and the interstices were filled with grout consisting of 1 part Portland cement and 1 part sand.

Table 1.—Strength and Cost of Concrete of Different Compositions.

	Proportions to 1 part of cement.			Yield in terms of volumes of gravel and broken stone.		Load on cubes, lbs. per sq. in.		Average crushing strength, lbs. per sq. in.	6"x6"x18" beams.		Cost per sq. yd. for depth of 6", cents.
No.	Sand.	Gravel.	Broken stone.	Per cent.	Age, days.	8-in.	6-in.		Load at center, lbs.	Modulus of rupture, lbs. per sq. in.	
Natural Cement.											
1............	..	3	3	..	30	610	540	575	1,280	100	..
2............	..	3	3	77	90	870	470	670	1,270	159	49
Portland Cement.											
3............	..	5	..	80.4	30	1,750	1,565	1,657	2,700	338	77.5
4............	..	5	..	..	90	1,770	1,990	1,880	3,060	382	..
5............	..	4	4	74	30	1,500	1,365	1,432	2,440	305	74.6
6............	..	4	4	..	90	2,210	1,780	1,995	5,360	670	..
7............	..	6	4	70.7	30	1,180	1,170	1,175	1,800	225	68.6
8............	..	6	4	..	90	1,260	1,430	1,343	1,620	203	..
9............	..	5	5	74.4	30	2,250	1,545	1,897	2,800	350	66.1
10............	..	5	5	..	90	1,850	2,050	1,950	3,280	410	..
11............	..	8	4	72.8	30	890	840	865	1,650	206	57
12............	..	8	4	..	105	883	1,230	1,056	2,500	313	..
13............	..	6	6	76	30	1,290	895	1,092	2,550	319	64
14............	..	6	6	..	90	1,510	930	1,220	3,060	383	..
15............	..	8	6	74	30	965	570	767	1,750	219	56.8
16............	..	8	6	..	115	1,425	860	1,142	1,700	213	..
17............	..	7	7	74	30	1,240	1,365	1,302	2,100	263	56.6
18............	..	7	7	..	90	1,190	1,425	1,307	2,820	353	..
19............	..	8	8	73	30	1,010	990	1,000	1,600	200	51.4
20............	..	8	8	..	103	1,050	1,030	1,040	1,930	241	..
21............	..	10	10	71.5	30	530	600	565	1,010	126	50.3
22............	..	10	10	..	118	585	..	..	1,220	153	..
23............	..	10	10	..	102	..	610	..	..	..	..
24............	6	..	6	..	30	1,230	†780	1,230	1,780	223	..
25............	6	..	6	..	107	1,720	1,535	1,627	2,410	301	..
26............	..	8	16	*70	..	..	..	..	..	..	51

*Defective and omitted from average. †Assumed.

New Milford Power Development: Canal Entrance Chamber Showing Gates; Weir Dam under Construction.

The filler cost 8 to 12 cents per square yard. Table 2 shows the results obtained by supporting the beams on knife edges 24 inches apart and applying the load at the center:

II.—Modulus of Rupture of Brick Beams with Cement Filler.

No.	Name of brick.	Age, days.	Breadth of beam, ins.	Load at center, lbs.	Modulus of rupture, lbs. per sq. in.	Beam, 6"x4"x 18" span, load at center, lbs.
1.	Clinton	30	10½	1,640	351	1,248
2.	"	30	10¾	2,160	452	1,607
3.	"	90	10¾	2,660	557	1,981
4.	Culver	30	11	2,570	526	1,870
5.	Poston	122	11	2,210	452	1,607

By comparing number 2 and number 20 in Table I with number 3 in Table II it will be seen that a brick beam 4 inches in depth is 50 per cent. stronger than a concrete beam consisting of 1 part natural cement, 3 parts gravel and 3 parts broken stone, and is also a little stronger than a beam consisting of 1 part Portland cement, 8 parts gravel and 8 parts broken stone. This fact suggests the question whether it may not be more economical to employ the cement as a filler between the bricks rather than to use it in the concrete foundation.

The cost of the cement and labor for a 6-inch layer of concrete composed of 1 part Portland cement, 8 parts gravel and 8 parts broken stone is about 24 cents per square yard more than that of a compacted layer of gravel or broken stone; and the cost of cement filler is about 6 to 10 cents per square yard more than sand filler. Therefore a brick pavement with cement filler on a foundation of broken stone or gravel without any cement in it is from 14 to 18 cents per square yard cheaper than brick pavement with sand filler and with a concrete foundation; and further, the two forms of construction are of equal strength. For a pavement on a street which has been cut up with trenches and where the traffic is heavy, the use of the cement filler adds very much to the strength and to the life of the pavement, and the added expenditure for the filler is money well invested. In residence districts, where the traffic is not so heavy or constant, a brick pavement with cement filler and a gravel foundation may be constructed with advantage, and the cost of the improvement be considerably less than if a concrete foundation and sand filler were used.

As far as the writer knows, attention has not before been called to the strength produced by the cement filler, nor to the fact that the brick thus filled makes the beam 50 per cent. stronger than the use of concrete foundation; and in view of what has been said concerning the merits of the cheapness and strength of the cement filler, to use it in pavement construction is clearly an economical advantage. For several valuable suggestions the writer gratefully acknowledges his indebtedness to Professors A. N. Talbot and I. O. Baker.

The Philadelphia Filtration System.

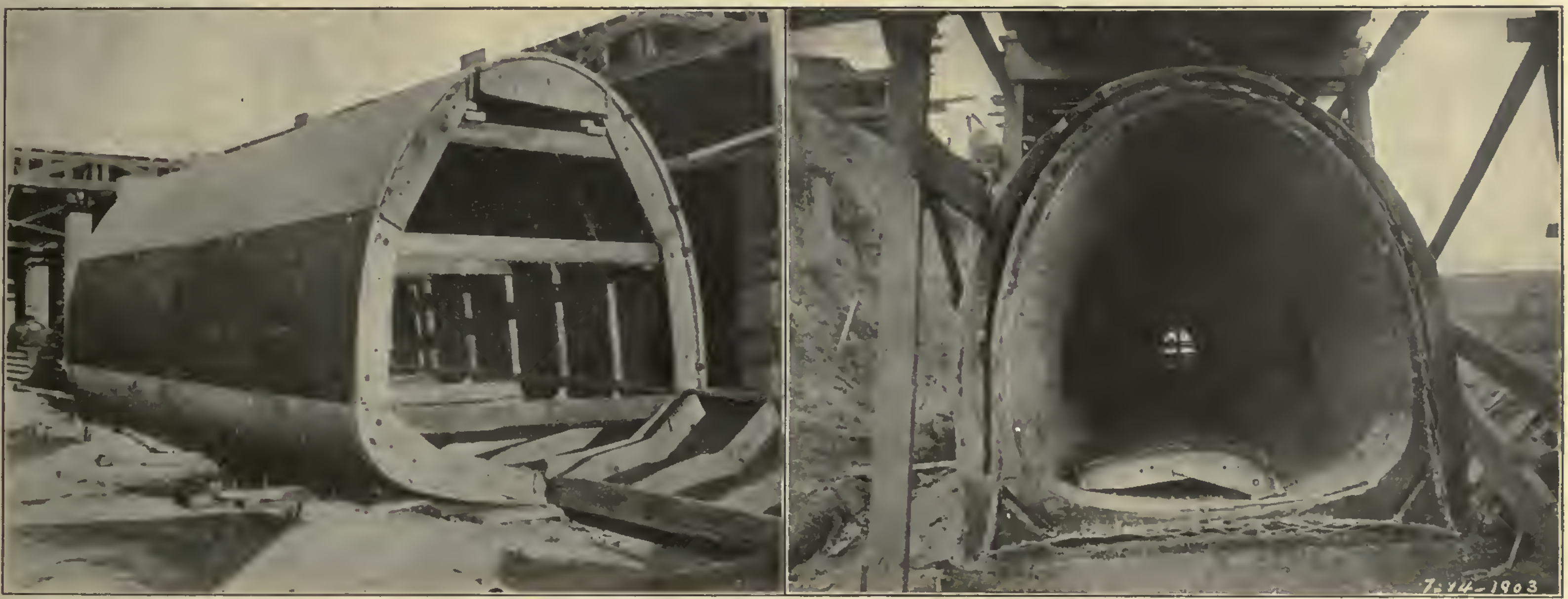
PART VI.—TORRESDALE FILTERS, CONCLUDED.

The pipe and conduit systems required for the Torresdale filters are on a scale commensurate with the magnitude of the plant. Because the quantities of water to be dealt with will be very large, neither cast-iron or steel pipes could be used so economically for the main conduits as reinforced concrete construction, especially as it was imperative to keep the losses of head near a minimum. However, for receiving water from the main collectors of the filters and conveying it to the conduits, and for distributing the raw-water cast-iron pipes were used. The raw-water pipe system was briefly described in the preceding article, accompanying which was a partial plan of the piping and conduit system. The collector pipes increase in diameter from 24 inches at the remotest filter of each row to 60 inches at the filtered-water conduit. One of these compound mains is located on each side of each court, and collects the effluent of eleven filters. All cast-iron pipes and the necessary special castings for the pipe lines and for connections with the regulating houses and other purposes were furnished by Messrs. R. D. Wood & Company and the United States Cast Iron Pipe & Foundry Company, through Messrs. Davies & Thomas, of Philadelphia. The valves of various sizes in the regulating chambers and gatehouses, as well as in the outside pipe lines, were furnished by the Eddy Valve Company, of Waterford, N. Y.

Reinforced Concrete Conduits.—The effluent conduit, 2,200 feet long, has the form of cross-section shown in the drawings, and in successive portions is 7½, 9 and 10 feet in height. The discharge conduit, 850 feet long, which carries the water from the filtered-water basin to shaft No. 1 of the tunnel leading to Lardner's Point pumping station, is 10 feet high. These conduits will be under a pressure head of about 20 feet, and are believed to be the first of such size built of concrete and expanded metal to be used under internal pressure. Other examples of this type of construction are the 5-foot conduits at the Cedar Grove reservoir of the Newark water works, described in this journal December 5 and 12, 1903. Some of the forms and centers used are clearly shown in accompanying drawings and photographs, and, except in special places, were so made that any piece could be passed through a complete form set in place. They were covered with sheet iron and were cleaned and oiled each time before being used. Two of the most difficult and unusual forms, at junctions of conduits, are so clearly shown by accompanying views as to require no detailed description. One is for the dome of the overflow chamber on the discharge conduit, with its manhole and the connection to the sewer, the location of which was shown on the general plan printed last week, and the other is for the junction chamber where the 8-foot circular by-pass conduit meets the 10-foot discharge conduit from the filtered-water basin. As shown in a detailed drawing, this portion of the by-pass is on a steep grade, since it has to overcome a difference of elevation of 11 feet in a distance of about 66 feet.

The straight portions of the conduits were built in monolithic sections 12 to 13 feet long, with a bonding groove in the end of each section and with the expanded metal extending from one section to the next. All conduits have a 1-inch granolithic finish on the interior surfaces. The mortar for the finish was deposited in the forms with the concrete and the surfaces are remarkably smooth. The centers were usually left in place about 60 hours. Sufficient expanded metal was used to resist the computed tensile stresses which will be caused by the water pressure. In the discharge conduit 6-inch mesh No. 4 metal cut double width was employed, but, as this heavy metal could not be obtained rapidly enough, the filtered-water conduit was reinforced with two layers of 6-inch mesh No. 4 expanded metal, wired together as one. The position of the metal is shown in the cross-section; adjacent sheets are lapped not less than 6 inches.

The trench for the discharge conduit was about 34 feet deep and that for the effluent conduit 22 feet; they were dug with the aid of a 2-ton 300-foot span Carson Lidgerwood trench machine, and the placing of the concrete followed the excavating as closely as possible. The concrete for the discharge conduit was mixed in a ½-cubic-yard Municipal portable mixer mounted with its engine on a platform beside the trench, and chuted to a shoveling board in the trench. The concrete for the effluent conduit was mixed by hand. The proportions for the concrete were 1 part Portland cement, 3 parts sand, and 5 parts ¾-inch



Torresdale Filters: Portion of Concrete-Steel Discharge Conduit and One of the Forms Used in Building It.

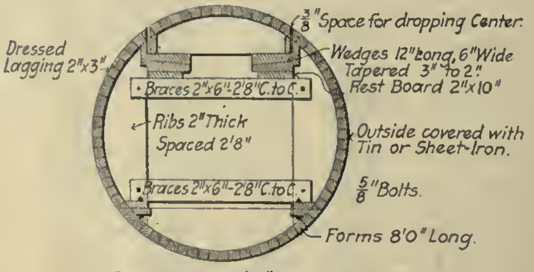
broken stone, mixed wet. The granolithic facing composed of 1 part Portland cement, 1 part sand and 1 part grit, was mixed to the consistency of stiff grout and poured, just in advance of the placing of each layer of concrete, into a 1-inch space between the inside forms and sheets of iron with lugs, which were withdrawn gradually during the placing of the concrete.

Sewers.—The main drainage system of the filtration plant, for the removal of wash water and other sewage, is arranged as shown on the general plan printed last week and comprises 4,600 feet of 24-inch and 850 feet of 30-inch vitrified pipe made by the Blackmer & Post Pipe Company and the Evens & Howard Fire Brick Company, both of St. Louis; 1,000 feet of 3½-foot, 700 feet of 4-foot and 650 feet of 4½-foot circular brick sewer, and 1,800 feet of 6-foot and 300 feet of 8½-foot concrete sewer. The concrete sewer of both sizes is 8 inches thick at the crown and 9 inches at the invert. The 8½-foot sewer is reinforced with expanded metal, and in it two layers of 3-inch mesh No. 10 metal were used, one 2½ inches for the interior surface and the other 2½ inches from the outside. The sewerage system is designed to take care of the drainage from a considerable tributary area in addition to the overflow and waste from the filters and sand washers and the sewage collected from the filter plant. The outfall is in Pennypack Creek, which discharges into the Delaware River at the southerly line of the city's property. In the early studies it was considered probable that a sewage-disposal plant capable of treating the sewage from a semi-urban population of 45,000 would be necessary when the territory draining into Pennypack Creek becomes populous, in order to guard against the discharge of fresh sewage too near the intake for the filters. No definite plans for such a plant have yet been made, and it is believed that it will not be required for a number of years. The sewers and conduits were constructed very early in the course of the work.

Economy of Reinforced Concrete Construction.—Besides the trench machine mentioned above, two traveling stiff-leg derricks with 60-foot booms were used for handling the excavated materials from the large trenches for the sewers, conduits and pipes. On all this work except carpenters and foremen, only ordinary labor was employed. The inside surfaces were so smooth that no finishers were needed. The costs, exclusive of excavation and engineering supervision, per linear foot of the different sizes of conduits and sewers were as follows:

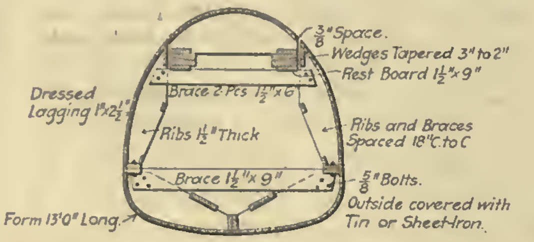
Size.	Cost per linear foot.
6 feet diameter (no expanded metal)	$7.24
7½ " high	19.85
8 " diameter	22.52
8½ " "	21.59
9 " high	23.94
10 " "	26.37

Draining Excavations.—As was natural in low ground so close to the river, intersected by brooks, considerable water came into some of the excavations and necessitated the installation of a large number of pumps for drainage purposes, in all eighteen. To remove the large quantities of water encountered in the excavation for the filtered-water basin two 8x10x12-inch Snow duplex pumps were placed in a house at the location shown on the general plan printed last week. Besides these, twelve Snow, Blake and Burnham steam pumps of various sizes, two Emerson pumps with 4-inch discharge, and one 6-inch and one 8-inch Morrisville centrifugal pump each driven by a vertical engine, were set up and moved from place to place along the trenches and filter excavations as needed from time to time. This drainage water was pumped mostly to Pennypack Creek, making use of the main sewers after these were completed. For running these pumps and for miscellaneous work six-50-horse-

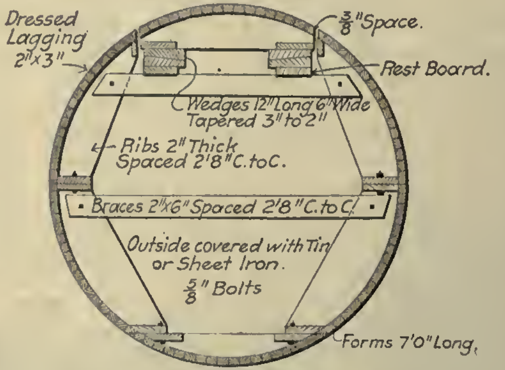


3/8" Space for dropping Center.
Dressed Lagging 2"x3"
Wedges 12" Long, 6" Wide Tapered 3" to 2"
Rest Board 2"x10"
Braces 2"x6"-2'8" C. to C.
Ribs 2" Thick Spaced 2'8"
Outside covered with Tin or Sheet-Iron.
5/8" Bolts.
Forms 8'0" Long.

Form for building 6'0" Concrete Sewer.

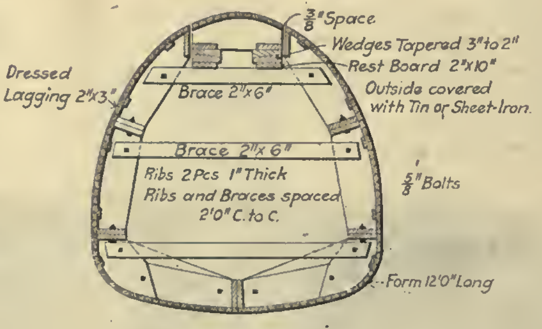


Form for building 7'6" Concrete Conduit.

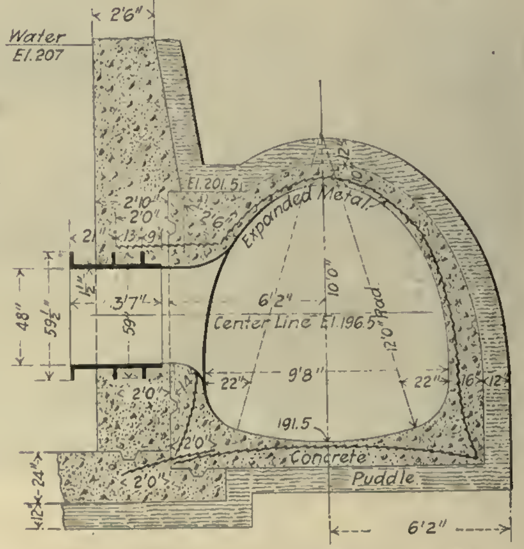


Dressed Lagging 2"x3"
3/8" Space.
Rest Board.
Wedges 12" Long 6" Wide Tapered 3" to 2"
Ribs 2" Thick Spaced 2'8" C. to C.
Braces 2"x6" Spaced 2'8" C. to C.
Outside covered with Tin or Sheet Iron.
5/8" Bolts
Forms 7'0" Long.

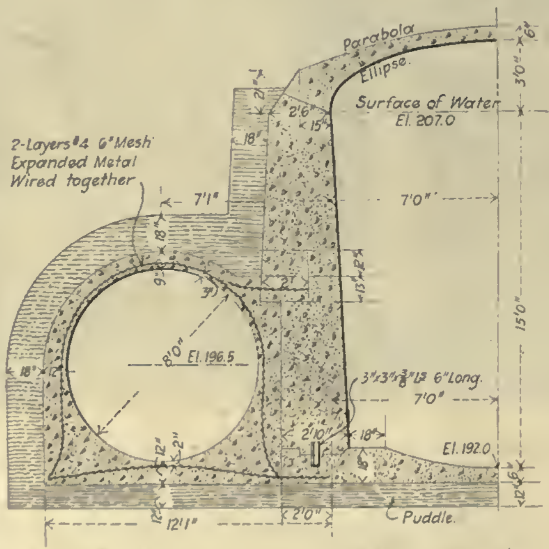
Form for building 8'6" Concrete Sewer.



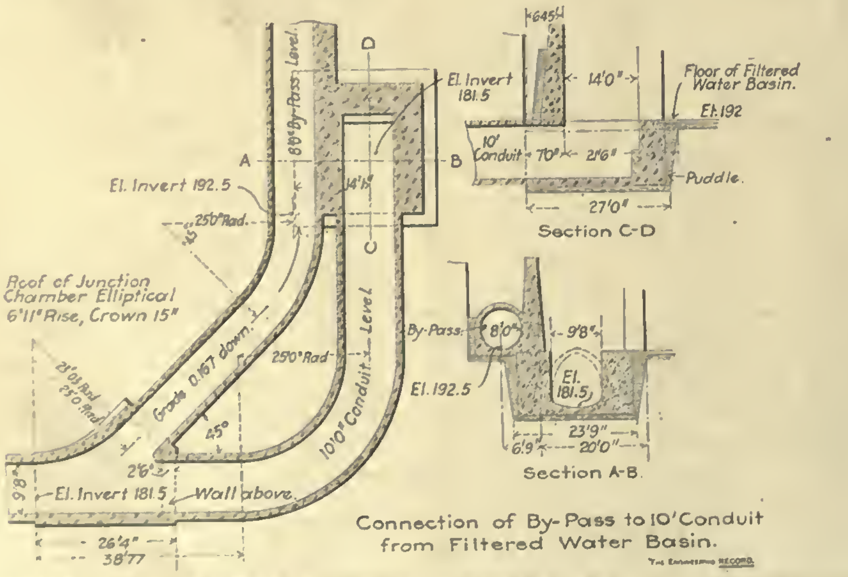
Form for building 10'0" Concrete Conduit.



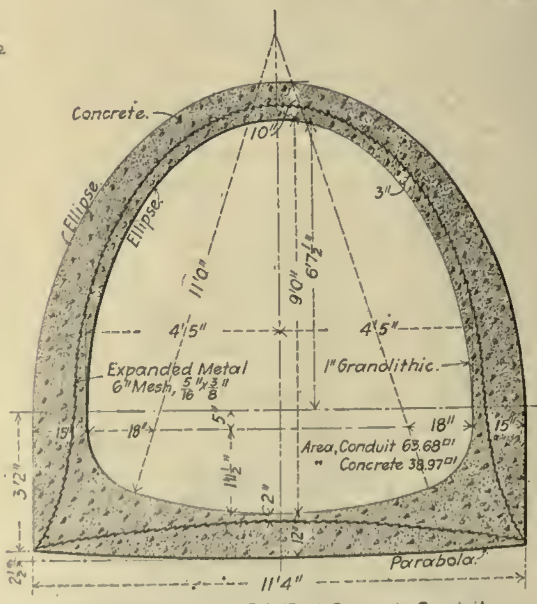
Bonding of 10-Foot Conduit to Inlet Gate House. Filtered Water Basin.



By-Pass Conduit and Wall of Filtered Water Basin.



Connection of By-Pass to 10' Conduit from Filtered Water Basin.



Cross-Section of 9-Foot Concrete Conduit.

TORRESDALE FILTERS: FORMS FOR CONCRETE SEWERS AND CONDUITS, SECTIONS OF CONDUITS AND DETAILS OF CONNECTIONS.

power portable boilers and one 55-horse-power Nagle portable engine were used.

Water Supply.—For mixing concrete and puddle, for steam making, for sprinkling and for practically all other purposes, except drinking, water is drawn from the river by an 8x10x12-inch Snow duplex pump installed in a house on the wharf and pumped to various elevated tanks. A tank for locomotive supply is situated beside the tracks in Pennypack Street, near Delaware Avenue, and a group of three tanks having a combined capacity of 30,000 gallons is supported by a trestle tower close to the central concrete mixing plant. From these tanks water was piped to various points of use, but for supplying a number of boards used for mixing small quantities of concrete by hand and some of the isolated portable boilers eight 400-gallon and six 600-gallon Austin water-tank wagons were found more economical than piping. Potable water for offices, camps, shops and stables was obtained from two wells and from springs, and was pumped by three Rider-Ericsson hot-air engines to elevated tanks, from which it was piped about the grounds.

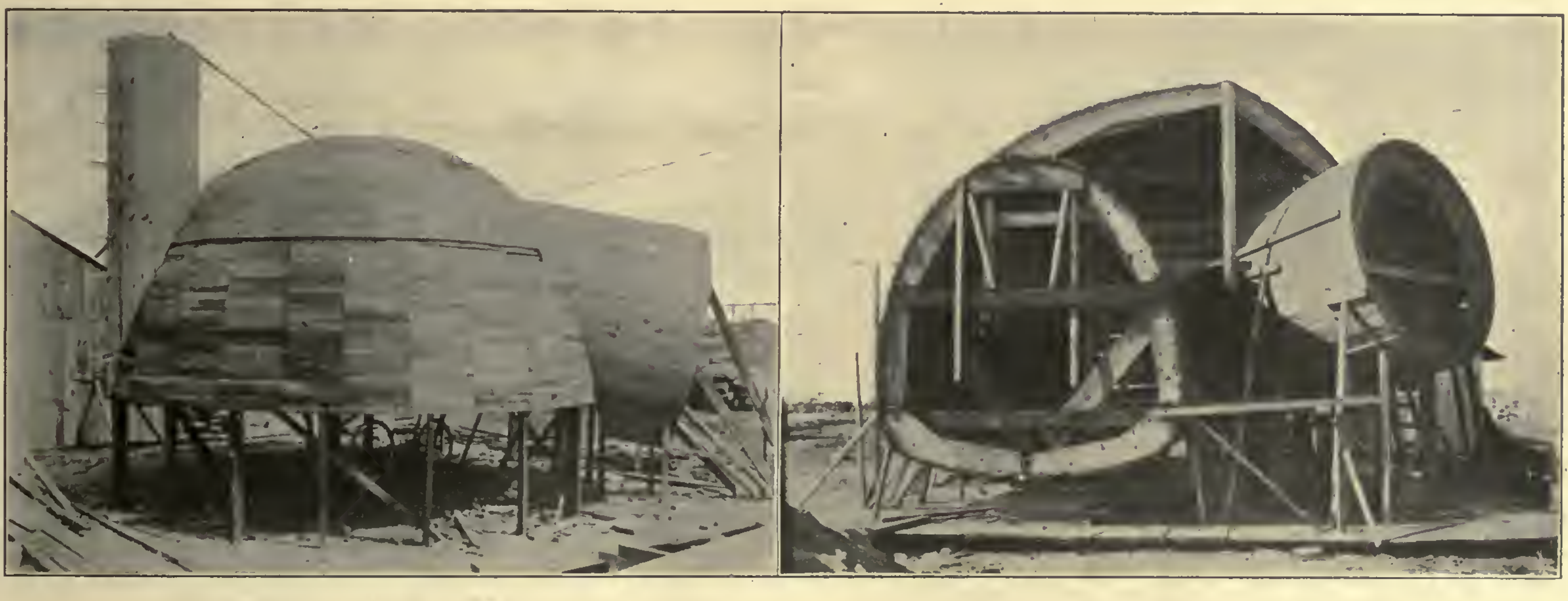
Work of Resident Engineer's Staff.—The resident engineer and his staff developed methods of handling the details of their work which have several interesting features, some of which are commendable, although, perhaps, not essentially novel. Especially valuable was the practice of reducing all detailed instructions and sketches for laying out parts of the work, tables of elevations of bench marks, the base line reticulation, corrections for tapes and similar information to be used by a number of persons to small sheets of convenient size, which could be checked carefully once for all and traced, so that blue-prints could be issued to each person who had occasion to use the data, with the assurance that all parties would be working from exactly the same figures. To be sure, this system is not absolutely infallible, but it is a great improvement over copying data into note-books or slips of paper as needed from day to day. Before any work was laid out a steel tape was sent to the Bureau of Weights and Measures of the Coast and Geodetic Survey to be standardized, and after this was returned, all other tapes used on the work were carefully compared with it. A diagram showing the tensions to be applied to the tapes when supported at two points various distances apart, was prepared, and another diagram gave the corrections for temperature, with the plain reminder lettered on it that for temperatures above the standard, corrections are plus when measuring between fixed points and minus when laying off a given distance, and vice versa, for temperatures below the standard.

Before the field was obstructed in any way by construction operations, a gridiron of base lines was very carefully laid out and checked, all its angles being right angles. At all intersections and at many other convenient and useful places 4x4-inch hubs were driven, in which the exact points were marked by prick punch holes in the heads of copper nails or transit tacks. Lines were established in State Road and Delaware Avenue, and cross lines were run through Pennypack Street and each of the courts; from Pennypack Street a line was run along the location of the main sewer, and two lines were staked to control the remaining two sides of the filtered-water basin. The hubs were designated by letters and their exact positions were given by X and Y co-ordinates.

Accurate record was kept of each cast-iron pipe, special casting and valve, by a designating number, as it was laid and this information has been plotted, during spare time, on the record drawings of the plant. During the severest part of each winter, all concrete work was stopped, but for a short time in November and December concrete was placed between 8 A. M. and 3:30 P. M. Parts of the filters or other concrete structures which were not covered with earth were usually protected with hay during the cold weather.

Mr. John W. Hill, chief engineer of the Bureau of Filtration, has general supervision of the Torresdale filters, as of all the other filtration plants. Mr. Frederick C. Dunlap is resident engineer in charge of construction, and his party is composed of Mr. J. A. Vogleson, first assistant engineer, and Messrs. John S. Ely, Thomas C. Atwood and Andrew S. Hackett, second assistant engineers. All these works fall under the executive direction of Mr. Peter E. Costello, commissioner of public works.

(To be continued.)



Torresdale Filters: Forms for Vault of Overflow Chamber, and for Junction Chamber of Discharge and By-Pass Conduits.

WATER SUPPLY FOR SUBURBS OF CAPE TOWN is being increased by building a reservoir on the slope of Table Mountain 370 feet above sea level. The reservoir has a capacity of 30,000,000 imperial gallons and will be filled from several streams. According to "Engineering," of London, the reservoir has been formed by excavating a solid ledge 960 feet long and 200 feet wide and building a great concrete wall 25 feet high containing 23,000 cubic yards. An earth bank is being formed against the wall 40 feet wide at top and 150 feet at the base, while 180,000 cubic yards of earth will be packed around the inner rim.

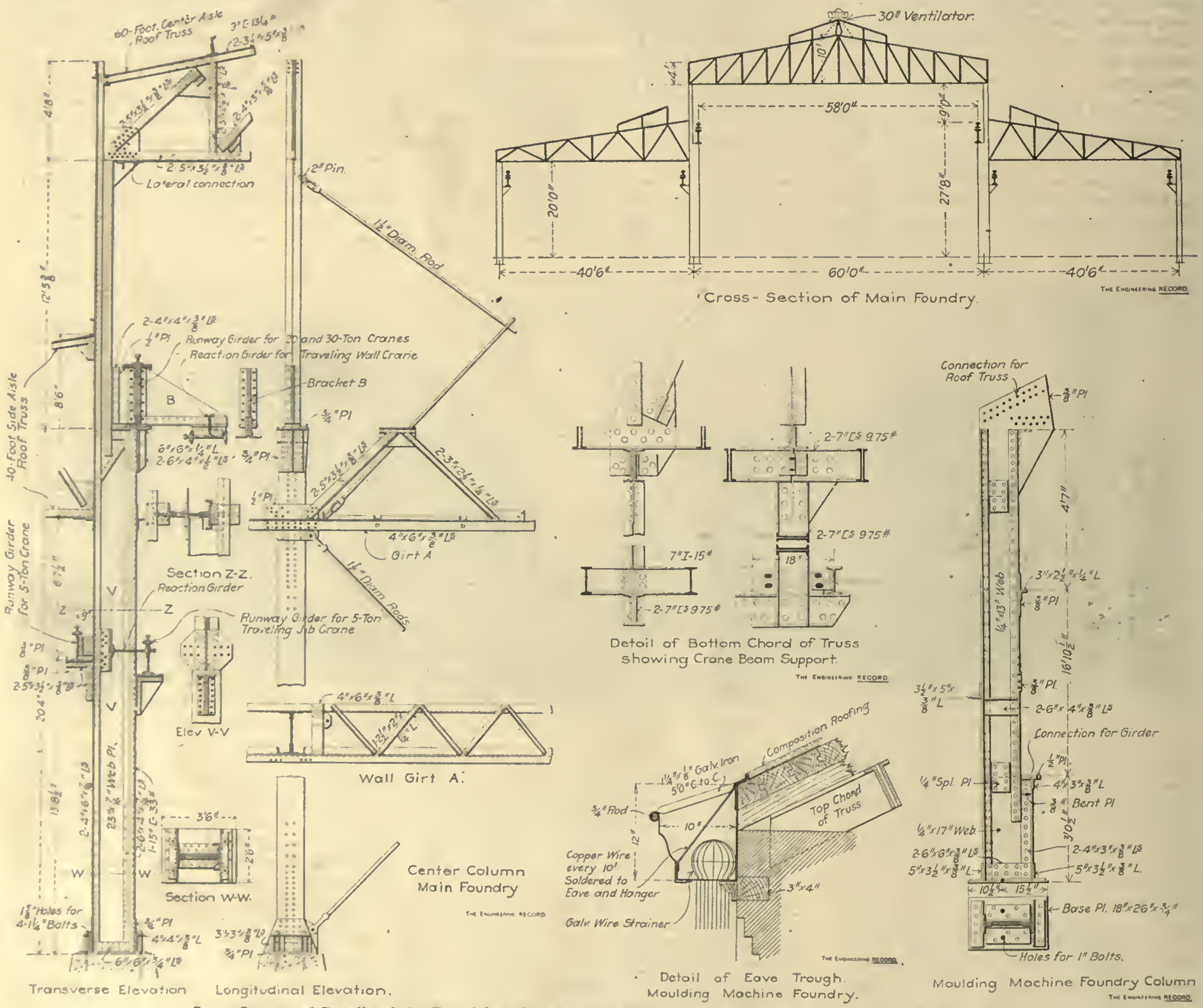
The New Henry R. Worthington Hydraulic Works at Harrison, N. J.

PART II.—FOUNDRIES.

Main Foundry.—The 141x600-foot main foundry has four longitudinal rows of columns dividing it into a 60-foot center aisle and two 40-foot side aisles, and its framework corresponds with that of the machine shop, except that the roof is lower, that there are no gallery floors in the side aisles and that the center columns are arranged for traveling gib wall cranes under the traveling girder cranes. The second and fourth panels between roof trusses at each end and every third succeeding panel has $\frac{7}{8}$-inch lateral brace rods with clevis ends between the eight lines of longitudinal struts. These diagonal rods are also provided in every panel at each end of the trusses. The panels between wall columns are X-braced with 1½-inch clevis rods. The columns have offset seats for the main crane girders, which are field-riveted through their end vertical stiffeners to transverse diaphragm plates connected to the column flanges and projecting beyond the girders to form cantilever brackets supporting upper reaction girders for the traveling wall jib-cranes. These runway girders for the traveling wall cranes are of simple and rigid construction, composed of two deep I-beams riveted together at right angles so as to give both vertical and horizontal stiffness. The upper runway girder does not carry vertical loads and is stiffened by an 18-inch I-beam designed to prevent undue flexure. The lower girder receives both horizontal and vertical loads. The runways for the 30-ton overhead cranes in the center aisle, are plate girders seated on the tops of the flanges of the lower sections of the main columns. These girders are riveted together through the end web stiffener angles and are braced to the upper sections of the columns by transverse vertical diaphragm plates. Their lower flanges have gusset plate projections in the plane of the web, which receive the diagonal members of longitudinal lattice girders bracing the columns just below the runways. The runway girder lower flanges thus serve as top flanges for the longitudinal girders.

The side aisle roof trusses were shipped complete; they are seated at one end on the inner flanges of the wall columns and are field-riveted to their projecting web-plates. At the other end they are flange-riveted to the main columns. The center aisle roof trusses were shipped in two pieces with field-riveted splices at the center. The bottom chords and end diagonals are field-riveted to projecting web plates shop-riveted to the tops of the columns. Both side and center aisle trusses are braced by two lines of longitudinal struts consisting of pairs of 4x4-inch angles with their flanges turned in opposite directions and field-riveted to the horizontal connection plates shop-riveted to the lower chords to receive the clevis pins for the diagonal rods.

The 60x40-foot charging platform for the cupolas is at the center of one long side of the building, 21 feet above the main floor. It is proportioned for a live load of 800 pounds per square foot and has a floor of solid steel plates ⅝ inch thick covering the top flanges of 10-inch I-beams 2 feet apart, which are carried by 24-inch I-beam girders of 20-foot span.

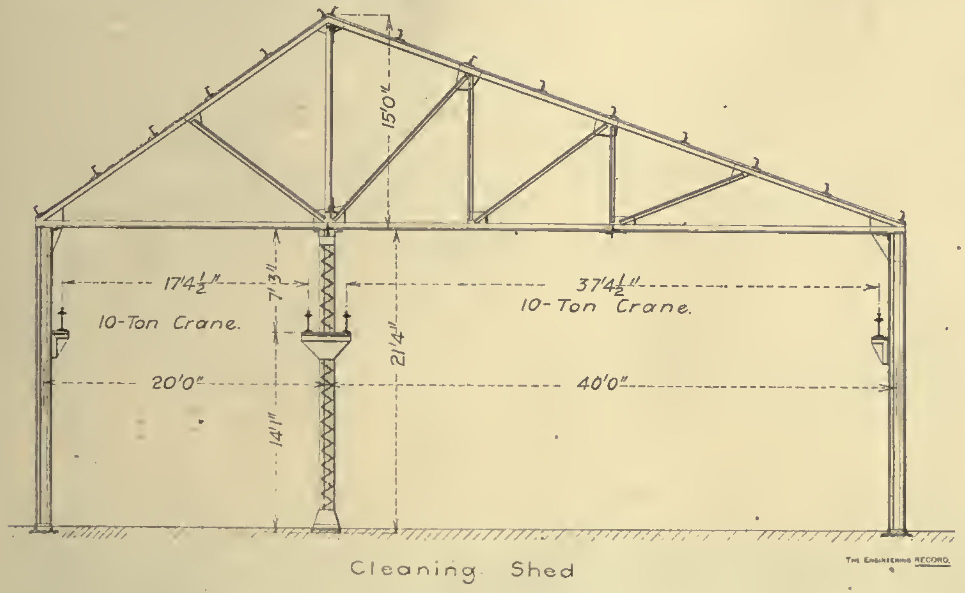

60-Foot Center Aisle Roof Truss
Lateral connection
2" Pin.
1½" Diam. Rod
40-Foot Side Aisle Roof Truss
Runway Girder for 20 and 30-Ton Cranes
Reaction Girder for Traveling Wall Crane
Bracket B
Girt A
Section Z-Z. Reaction Girder
Runway Girder for 5-Ton Traveling Jib Crane
Runway Girder for 5-Ton Crane
1¼" Diam. Rods
Elev V-V
Wall Girt A.
Section W-W.
1⅛" Holes for 4-1¼" Bolts
Center Column Main Foundry
Transverse Elevation
Longitudinal Elevation.
30" Ventilator.
58'0"
20'0"
27'8"
40'6"
60'0"
Cross-Section of Main Foundry.
Detail of Bottom Chord of Truss showing Crane Beam Support.
Composition Roofing
Top Chord of Truss
Copper Wire every 10' Soldered to Eave and Hanger
Galv. Wire Strainer
Detail of Eave Trough. Moulding Machine Foundry.
Connection for Roof Truss
Connection for Girder
Bent Pl
Base Pl. 18"x26"x¾"
Holes for 1" Bolts.
Moulding Machine Foundry Column
The Engineering Record

Some Structural Details of the Foundries of the Henry R. Worthington Hydraulic Works, at Harrison, N. J.

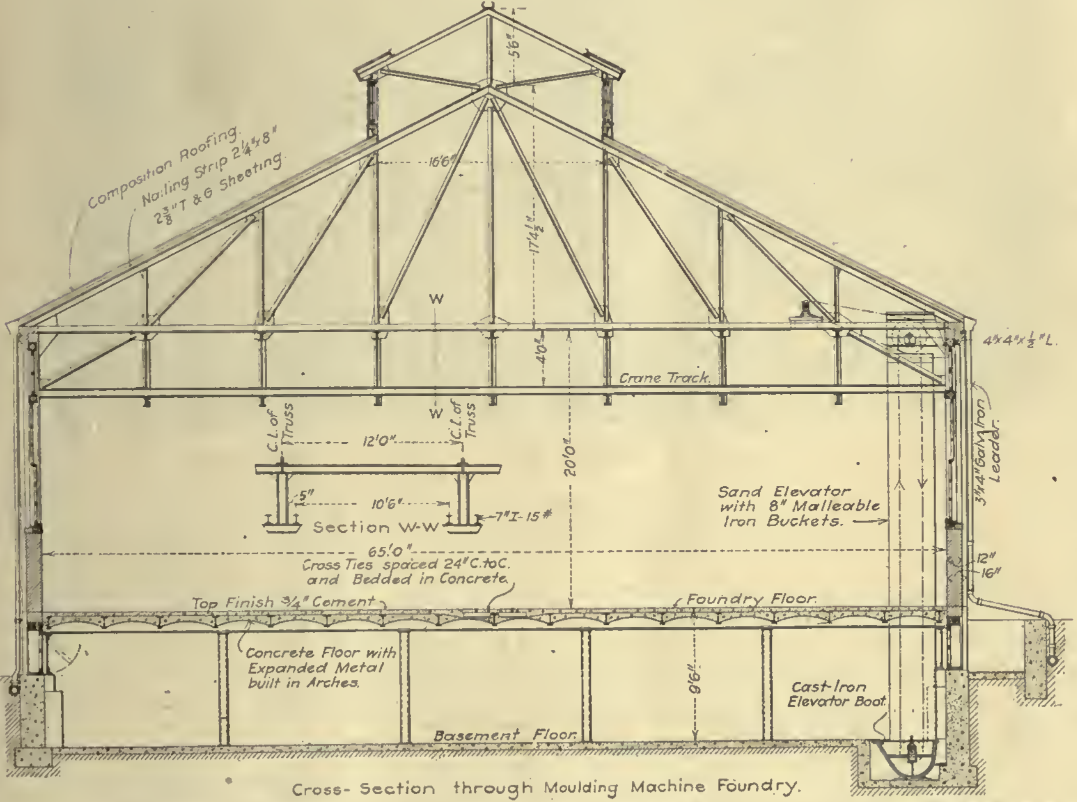
The two 50-ton cupolas will be made by Messrs. J. W. Paxton & Company, Philadelphia, and will have 9x9-foot concrete foundations, 6 feet deep, carried down to a satisfactory footing on hard coarse gravel and boulders. A 60x140-foot space at the west end of the building is reserved for a cleaning floor and is specially designed to avoid the accumulation of sand which in other foundries usually forms an inconvenient obstruction by building up troublesome piles on which the men are obliged to work while emptying flasks until operations are stopped altogether to remove it. Here, as in the moulding machine foundry, the floor is made with open gratings of steel bars set edgeways in frames. The sand falls through the spaces into the basement where it is collected, tempered, mixed with fresh sand and delivered to the elevator, which returns it to the moulding floor.

Small Foundry.—The 66x408-foot machine moulding foundry has only two rows of main longitudinal columns which carry the wall framing and masonry and the full span roof-trusses 65 feet long. The transverse bents of the framework are 12 feet apart and are braced longitudinally by five lines of struts in the planes of the top chords and nine lines in the planes of the bottom chords. The center two panels and the two panels at each end and every third panel between the ends and the center are X-braced with ¾-inch clevis rods in the planes of the top and bottom chords and in the planes of the wall columns at the ends and center of the building. There are no purlins, but the longitudinal sheathing planks are laid directly on nailing strips screwed to the flanges of the top chords. From every panel point of the lower chords of the roof trusses, over the moulding room, there is a vertical suspender carrying a short longitudinal double cantilever beam which supports runways for light bridge cranes 10½ feet long traveling from wall to wall, and carrying pneumatic trolley hoists of 2 tons capacity to serve the Pridmore & Atlas moulding machines on the main floor, one of which is located on the center line of each panel. To provide longitudinal stiffness, the upper ends of the track suspenders are braced by continuous struts composed of pairs of channels, shown in the cross-section. The moulding room floor has a capacity of 400 pounds per square foot and is made with concrete arches supported on 12-inch longitudinal I-beams and 15-inch transverse I-beams carried by one-story cast-iron columns, except in the center panel of the core-room, where there are two rows of riveted columns 13 feet apart carrying 20-inch transverse I-beams that support double lines of 15-inch I-beam stringers under the rails of a standard-gauge track which runs into the core-room on this floor. A third rail is added to form a 3-foot gauge track running the length of the building, and the space adjacent to the rails is floored with a strip of double planking 12 feet 3 inches wide.

Under the center of each roof panel in the moulding room floor there is a 3x20-foot grating of longitudinal steel bars through which the burnt sand falls to the basement when the flasks are emptied. It is periodically collected, screened, mixed and delivered to elevators in alternate panels, which convey it into hoppers above the moulding machines, where it is used again by the moulders. The elevators are operated by independent electric motors. The core ovens will be heated by gas, although built with regular furnaces so that coke can be used. The foundry is lighted by two tiers of windows on each side and by windows in the clere-story of a monitor 16½ feet wide with double pitched skylight roof, extending from end to end of the building. The sills of the lower tier of windows are 6 feet above the floor, so as to avoid danger of breaking the glass. The basement is lighted from a paved area through swinging windows with horizontal pivots at the upper edge. The main floor is calculated for a live load of 400 pounds per square foot. There are two 40-ton J. W. Paxton & Company's cupolas with a charging platform 40 feet long and 26 feet wide in the center of one side of the moulding room. It is 20 feet above the main floor and is served by a hydraulic elevator in a shaft outside the main wall. The floor has a capacity of 800 pounds per square foot, is covered with steel plates and is carried by 12-inch transverse beams 15 feet long and 3½ feet apart, supported on three lines of 20-inch longitudinal beams carried by the wall columns and two lines of interior riveted steel columns.



Cleaning Shed



Cross-Section through Moulding Machine Foundry.

Cross-Sections of the Henry R. Worthington Moulding Machine Foundry and Cleaning Shed.

Adjacent to the cupola room is the men's toilet room, and the blower room is on the opposite side underneath the charging floor. One end of the shop is partitioned off for the core rooms, where women and girls are employed. The standard and narrow-gauge tracks extend through this room and between them there are trap doors in the floor through which the sand bins in the basement are filled. At the end of the core room are four large ovens for baking the cores, and on one side there will be twelve Millet core ovens for small cores. The columns in this building correspond to those in the other buildings, except that they do not carry the walls or any crane girders. They have I-shaped cross-sections with solid webs in the planes of the roof trusses. The upper ends of the webs project beyond the column to form gusset-plates for the roof truss connections.

The main foundry and the moulding machine foundry are connected at one end by the transverse 60x201-foot cleaning shed with a 20-foot and a 40-foot aisle, each of which is commanded by travelling cranes. The roof trusses are continuous over the interior columns and are braced together by X-bracing in the planes of the interior columns and by two lines of longitudinal struts in the plane of the lower chords. This building will contain the rumblers and sand blast machines for cleaning castings in the 20-foot aisle, and the 40-foot aisle will be used as a chipping room.

Throughout the plant the clere-story windows are opened and closed in sections by an attachment devised by Mr. Baldwin. The sashes are swung on horizontal center pivots and at the top of each sash there is pivoted a gas pipe link which engages a crank shaft. This shaft is provided with grooved pulleys suspended from the purlins and receiving two turns of the operating cord, both parts of which are led over snatch blocks in the wall and suspended within reach of the floor so that the windows can be conveniently operated.

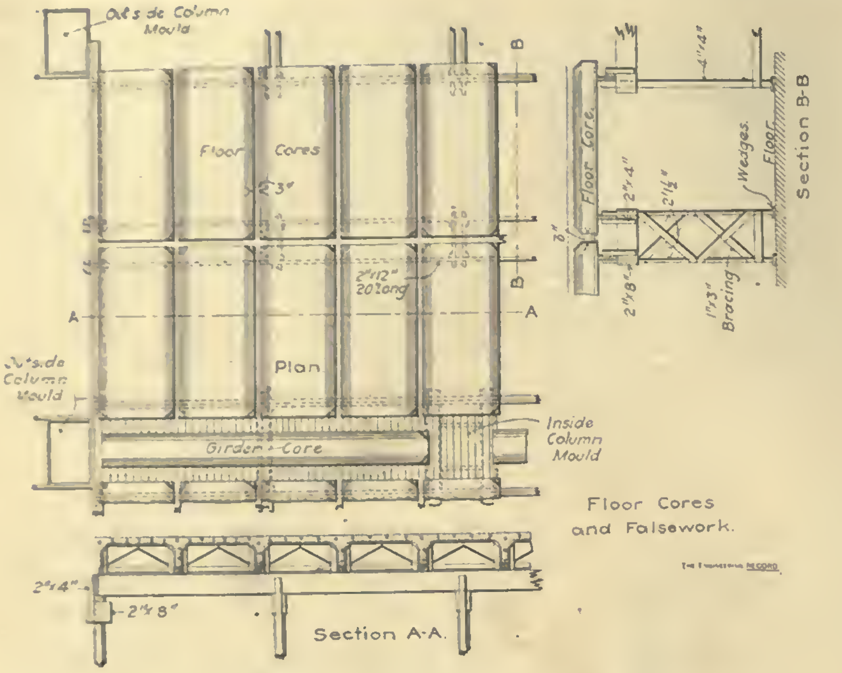
(To be continued.)

The Kelly & Jones Company's Concrete-Steel Factory Building.

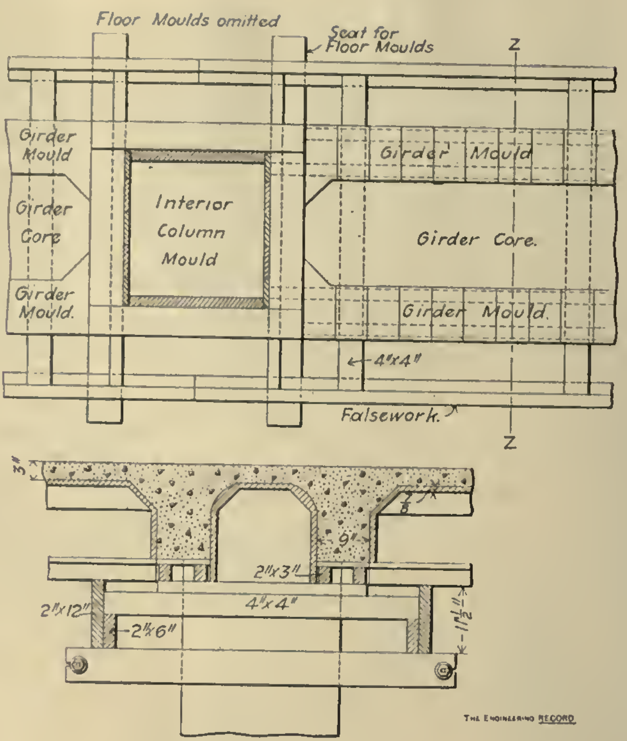
Part II.—Methods and Plant for Construction.

All concrete was mixed very wet, with Vulcanite Portland cement, sand and ¾-inch broken stone, 1:2:4, in a No. 13 Ransome standard drum mixer driven by a 35-horse-power vertical engine. The mixer was set in a pit about 6 feet deep just outside the building near the middle of one long side. The cement and aggregate were filled by hand into a valved hopper, which discharged to the mixer as soon as the latter dumped its contents into the steel bucket in which it was hoisted to the upper floors. This bucket held as much concrete as could be conveniently mixed at once in the machine, and was hoisted by an ordinary drum engine. It was suspended below its center of gravity and was maintained in a vertical position by the three guides of the elevator frame. A section of the front guide could be removed so as to allow the bucket to overturn and discharge its contents at any required point, as illustrated in the descriptions of the concrete plants for the St. James church, Brooklyn, and the fifteen-story Ingalls building, Cincinnati, which were published in The Engineering Record May 5, 1900, and July 18, 1903, respectively. The bucket discharged to a hopper platform elevated about 6 feet from the floor, from which the concrete was raked, whenever convenient, into the hand-barrows by which it was distributed on an outside scaffold and on planks laid across the moulds and finished floor slabs. These barrows were of special construction and consisted of a semi-cylindrical steel bucket with its axis coincident with the axle of a pair of wheels about 4 feet in diameter. The bucket was rigidly secured to the axle and the latter was furnished with a 6-foot U-shaped horizontal handle bar. Each barrow had a capacity of 7½ cubic feet and could be handled by one man. The advantages were that it could be easily dumped by revolving it on the axle of the wheels, and the concrete fell gently to the floor without causing any injurious shocks to the falsework.

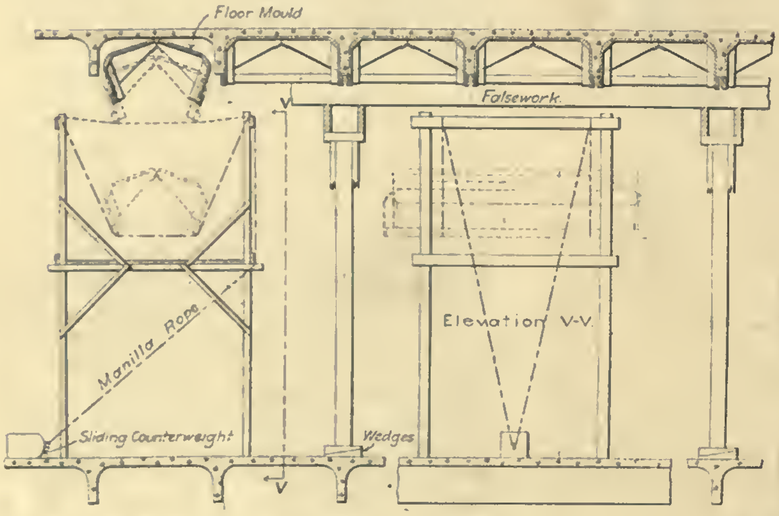
Immediately after being placed, the floor concrete was rolled for several hours, first by a 250-pound wooden roller 3 feet in diameter and 3 feet long, then by a 500-pound iron roller 2½ feet in diameter and 2½ feet long and finally by a 700-pound iron roller of the same dimensions. One man could operate each roller and a force was kept busy rolling all the time that the floor concrete was being laid. This system was found much better than ramming or using heavy rollers at first. The light roller flushed the water to the top and compacted the concrete, making it firm enough to use the second roller, which could not have been applied at first without displacing the concrete. Similarly the second roller prepared the concrete for the heavy third roller, which produced an excellent finish. In the beams and girders the concrete was cut rather than rammed by steel



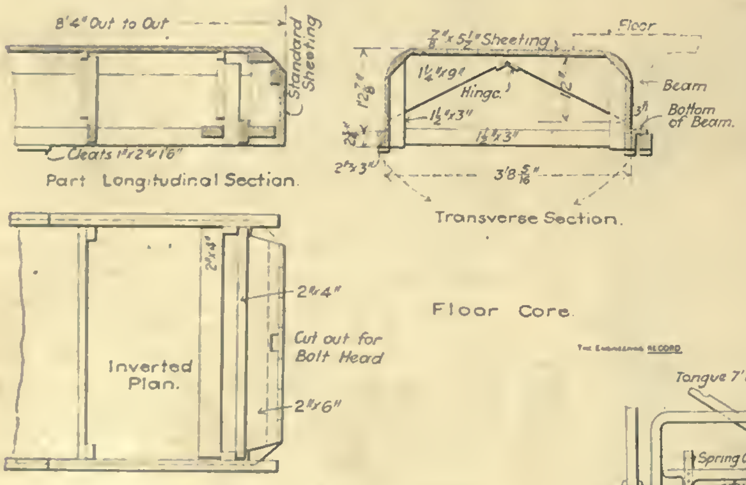
Floor Cores and Falsework.



Sectional Elevation Support of Girder Core



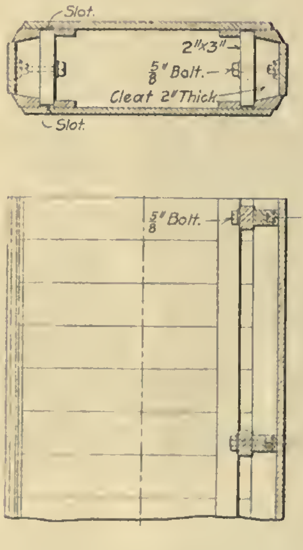
Movable Tower for lowering Floor Moulds and Cores.



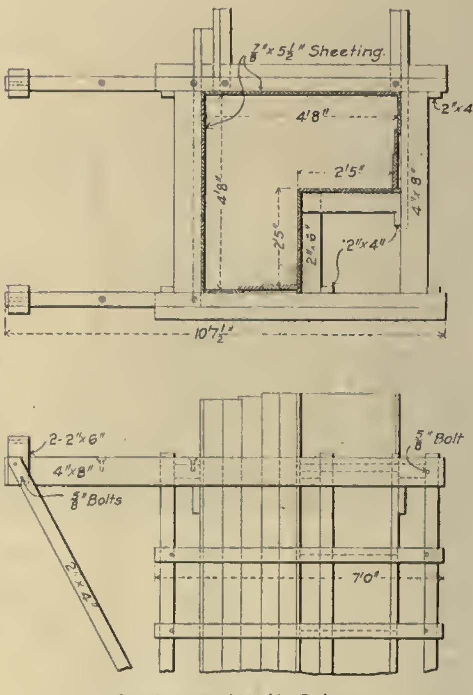
Part Longitudinal Section.

Transverse Section.

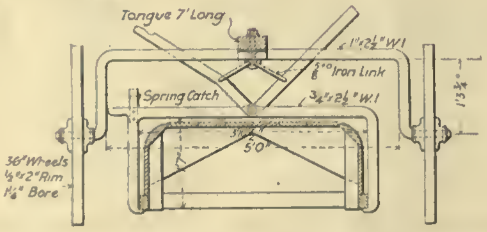
Floor Core.



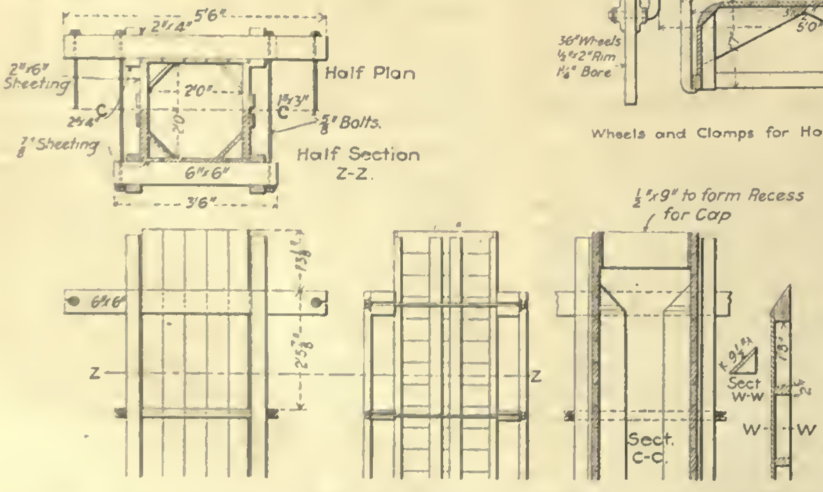
Core for Wall Column.



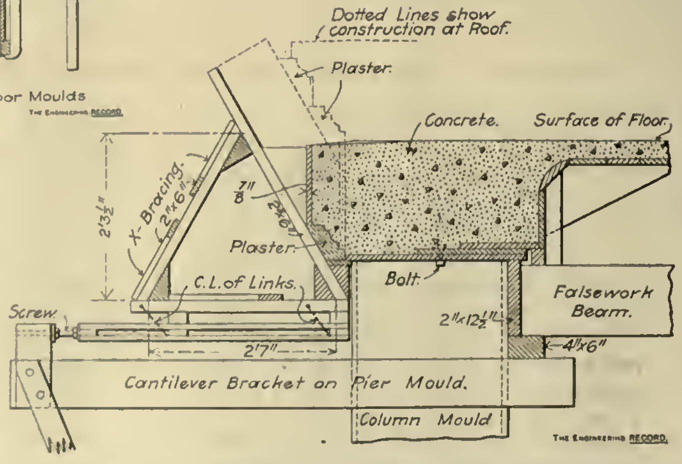
Mould for Corner Wall Column.



Wheels and Clamps for Handling Floor Moulds



Interior Column Mould

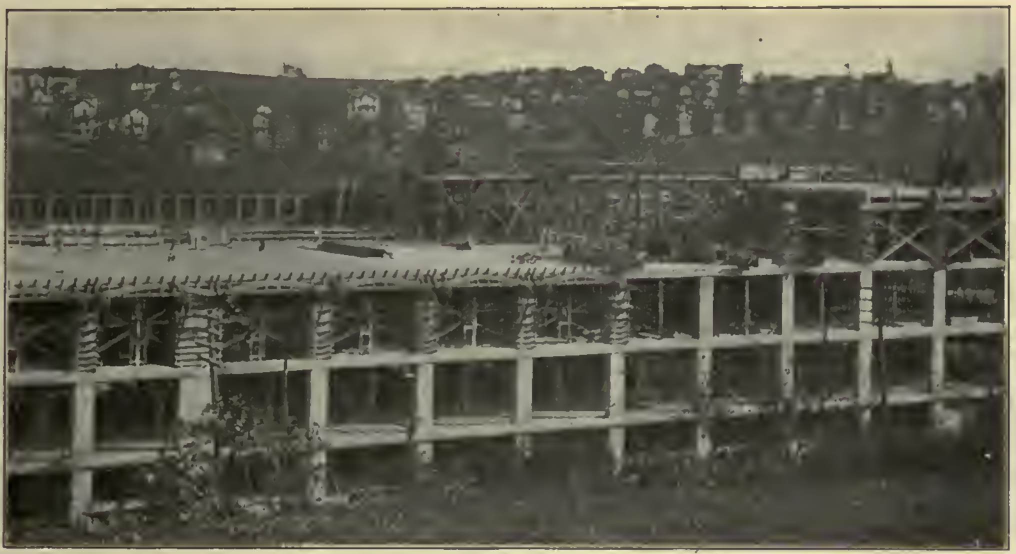


Belt Course Mould.

DETAILS OF FALSEWORK, MOULDS AND CONSTRUCTION PLANT FOR THE KELLY & JONES CONCRETE-STEEL FACTORY BUILDING.

spades each having a blade 6 inches wide, 18 inches long and ⅛ inch thick attached to a ¾-inch gas-pipe handle 5 feet long. The concrete in the column moulds was rammed by a tool somewhat resembling an elongated plumb-bob. The lower end of it was a cone 18 inches long, 1 inch in diameter at the point and 3 inches in diameter at the top with a 5-foot handle. In both cases the blades of the tools were long enough never to sink entirely below the surface of the concrete. The concrete mixer had an hourly capacity of 40 batches of 15 cubic feet each, and the greatest day's product was about 160 cubic yards in 10 hours. The plant was so arranged that the conveying hopper, mixing machine and hoisting bucket were constantly filled, so that no time was lost in waiting, and three different batches were simultaneously in progress.

Samples from every carload of cement were tested for fineness, and were made into briquettes which were subjected to flexure tests when seven days old, thus giving close indications of the character of the cement with little trouble or expense. From each day's run of concrete 6-inch cubes were made, and when tested in compression, after from 7 to 10 days, developed from 80 to 120 pounds ultimate strength per square inch. At the commencement of operations permanent bench marks for alignment and level were established on four 12x12-inch concrete monuments set at the corners of a rectangle concentric with the building and having its length sufficient to give a clearance of 12 inches between the ends of the building and the faces of the monuments. Marks were thus established by which the location of the columns and heights of the floors could be verified at any time without danger of their being disturbed by the workmen. The quantities of material used were about 60,000 cubic feet of concrete and 85 tons of steel, which was all twisted by a machine set up near the concrete mixer and belt-driven together with the bucket elevator, a buzz-saw and a boring machine by a 35-horse-power steam engine.



Kelly & Jones Building: Falsework for Fourth Floor and Completed Concrete in Lower Stories.

The inside column moulds were built as shown in the detail, with four separate side pieces made of 5½x⅞-inch planed wood strips having beveled edges to allow for swelling from moisture. On two opposite sides the strips are vertical and are nailed to the edges of horizontal cleats 20 inches apart, breaking joints on the centers of alternate cleats. The other two sides are made with horizontal strips nailed to a pair of outside vertical cleats. The horizontal cleats project beyond the edges of the mould and their ends are slotted to receive tie bolts, which clamp the four sides of the mould tightly together, but can be quickly slipped out of the ends of the cleats when their nuts are loosened but not removed. The upper cleats project about 2 feet beyond the sides of the mould and are made heavy to serve as beams supporting the beam and floor moulds. Their loads are carried from the floor below by full-length pairs of vertical strips spiked to both sides at both ends and having square bearings on pairs of wooden wedges on the finished floor surface, thus serving as false-work posts. The column moulds made for the lower stories were also used in the higher upper stories and were lengthened as required by splicing extensions on the lower ends of the vertical cleats and posts and adding the necessary side pieces. The moulds for the columns below the first floor were similar to those above described except that they had no inside corner pieces and no outside falsework posts, but were supported by the upper horizontal cleats which took bearing on horizontal sills laid on the ground on opposite sides of the foundation pits.

The moulds for the outside columns, or wall piers, were made with vertical boards on all sides and were offset to form the window casings. The clamp bolts passed through round holes instead of slots in the ends of the horizontal cleats and they also passed through the vertical falsework posts. The upper horizontal cleats extended about 5 feet beyond the moulds on the outside to form cantilever brackets for the working platform. The moulds for the intermediate piers were similar to those for the corner piers except that they were smaller and rectangular in cross-section. The hollows in all piers were made with collapsible cores having the beveled vertical edges of the narrow sides movable inwards on horizontal bearing wedges, from 12 to 30 inches apart, on the inner faces of the wide sides. The movable sides were set and held in place by horizontal bolts, shown in the detail, which engaged transverse horizontal strips fitted to vertical slots in the adjacent sides of the mould. The moulds were keyed up and adjusted by the nuts on the inner ends of the bolts and to collapse them it was only necessary to strike successive vertical blows on the ends of the transverse pieces, which revolved on their axes like buttons and, becoming disengaged from the slots, allowed the side piece of the mould to move inwards, free of the concrete.

No moulds were required for the beams and girders as they were made by ramming the concrete in the spaces left between the floor moulds, which were arranged and supported as shown in the diagrams. The floor moulds were really cores between the beams and girders and were made with a horizontal top and four vertical sides with rounded and beveled upper corners. The side pieces were nailed to vertical cleats and had stiffening strips on the lower edges. The moulds were made in two equal parts with a hinged joint through the longitudinal center line of the upper surface. When in position the upper surfaces were in the same horizontal plane and the mould was locked open by transverse struts separating the lower edges.

The lateral distance between the moulds was fixed by loose horizontal boards planed on the edges to the exact width of the beams and supported on the flange-like projections of the strips which stiffened the lower edges of the moulds. The transverse wooden beams were carried by the ends of the moulds which rested on the projecting ends of the top cleats of the column moulds and by intermediate falsework posts made up of pairs of light vertical timbers latticed together. The falsework beams were in pairs, about 4½ feet apart, each made with a wide and a narrow plank spiked together flush on the lower edge. The upper edges of the narrow planks formed ledges on which cross pieces were set to carry the girder cores in the centers of the spaces between the ends of the overhanging floor moulds and independent of them. The spaces between the cores and the moulds were floored by boards which supported the soffits of the girders and could be blocked up to give the girders any required depth. Concrete was rammed solid over the tops of the columns, and at each two 4-inch holes were cored in it through which thin concrete was poured afterwards into the plaster moulds for the ornamental capitals.

The faces of the moulds for the projecting belt courses of the outer walls were made separate from the other sides and built up on triangular vertical transverse frames bolted to sills firmly clamped in position by screws engaging their outer ends, and the inner faces of brackets on cantilever beams projecting from the pier moulds. The face was quickly adjustable to the rest of the mould to which it was firmly locked. The plane surfaces were made with dressed boards and the curved surfaces with plaster Paris mouldings secured to the inner face of the mould. The faces of the piers were coursed to represent stone masonry by the use of wooden moulding strips secured to the insides of the moulds to leave joints, as shown in cross-section by the enlarged detail. Above the first story the wall piers and the walls between the window sills and the floors are dressed in panels to imitate cut stone. The panels were defined by 1x¼-inch strips nailed to the insides of the moulds, and after the concrete had set about 7 days the surface was dressed by workmen with pneumatic chisels, who could do about 500 square feet in 10 hours.

The removal of the floor and column moulds after the concrete has set is often difficult, slow and costly, in structural concrete work, and sometimes results in such injury to the moulds that they cannot be used again. To avoid this the moulds used in this work were made to collapse easily and to draw away from the concrete as already described, and an interesting special method was devised which was very successful for removing the floor moulds with great rapidity. A four-post wooden tower about 6 feet square and high enough to just clear the moulds of the ceiling above the floor on which it stood, was easily pushed by two men to place under the mould to be removed. It had a working platform about 6 feet below the column tops on which the men mounted and arranged the slack of a double rope tied to the ends of one upper cross piece parallel with the long side of the mould and close to it. The ends of the rope passed over the opposite rounded cross piece and through the tower to a sliding weight on the floor, which held them taut with moderate frictional resistance. The cross bars were knocked loose in the bottom of the mould and a few taps caused it to close enough on its center hinges to collapse, when, freeing itself from the concrete, it fell and was caught on the stretched horizontal ropes. Under its weight they slowly overhauled and sagged in the middle as they dragged the weight along on the concrete floor, and so gently and quickly lowered the mould to the tower platform whence it was quickly slid to the floor and carried off to be cleaned and greased ready for use again. The writer watched the removal of several floor moulds, which were carried off and the tower set ready for the next one, in one minute each, without any injury to the moulds.

Moulds enough were made for one complete story and they were usually left in position until the floor slabs were 7 days old. They were all numbered and marked to designate their position in each panel of the building and each mould occupied exactly the same relative position in every successive story. The falsework and bracing was similarly marked so that as the stories were essentially duplicates everything fitted and no time was lost in arranging or altering, as the materials were kept in order as taken down and set up again in reverse sequence without extra handling. The pier moulds were taken apart in sections and laid horizontally on the upper floors until ready to be used again in the next story. They were handled by special derricks mounted on castors and running on the highest completed floor. These derricks had light triangular towers with the fixed booms projecting from the top and rigged with a light tackle operated by a windlass on the tower frame. The boom had a short overhang and was continued to the sill to form a stiff-leg with its foot counterbalanced by concrete disks strung on a vertical spindle. The floor moulds were handled by two 3-ton stiff-leg derricks mounted on castors and having 18 and 22-foot booms. They were rigged with four-part tackles operated by hand and secured by winding the fall line on a cleat. Two men could easily move them all over the building, and they lifted each other from floor to floor as the work progressed. When in service the weight could be taken off the castors and slipping prevented by setting up on vertical screws through the ends of the sills, thus raising the derrick castors free of bearing.

The floor moulds weighed about 400 pounds each when thoroughly wet and were moved across the floor from end to end of the building by a special light truck. This had two wheels with a U-shaped axle, loop up, and a horizontal tongue in the middle. A clamp like a pair of ice tongs was suspended from the axle and, lifting the mould near the center, could be locked by a spring catch on one side so as to hold it firmly just clear of the floor. The moulds for the first and second floors were lowered by a telescopic tower on castors. It had a working platform on one side, about 3½ feet above the floor and a movable 4x6½-foot upper platform on spiral springs. The upper platform was guided between the main vertical posts of the tower and was counterbalanced by weighted levers attached to ropes led around sheaves so as to tend always to raise the platform. When it was released the mould dropped a few inches to the platform and the impact was taken up by the spiral springs and by the inertia of the counterweights which allowed the platform to descend easily to the floor, where the mould was rolled off, after which the platform automatically rose to the original position.

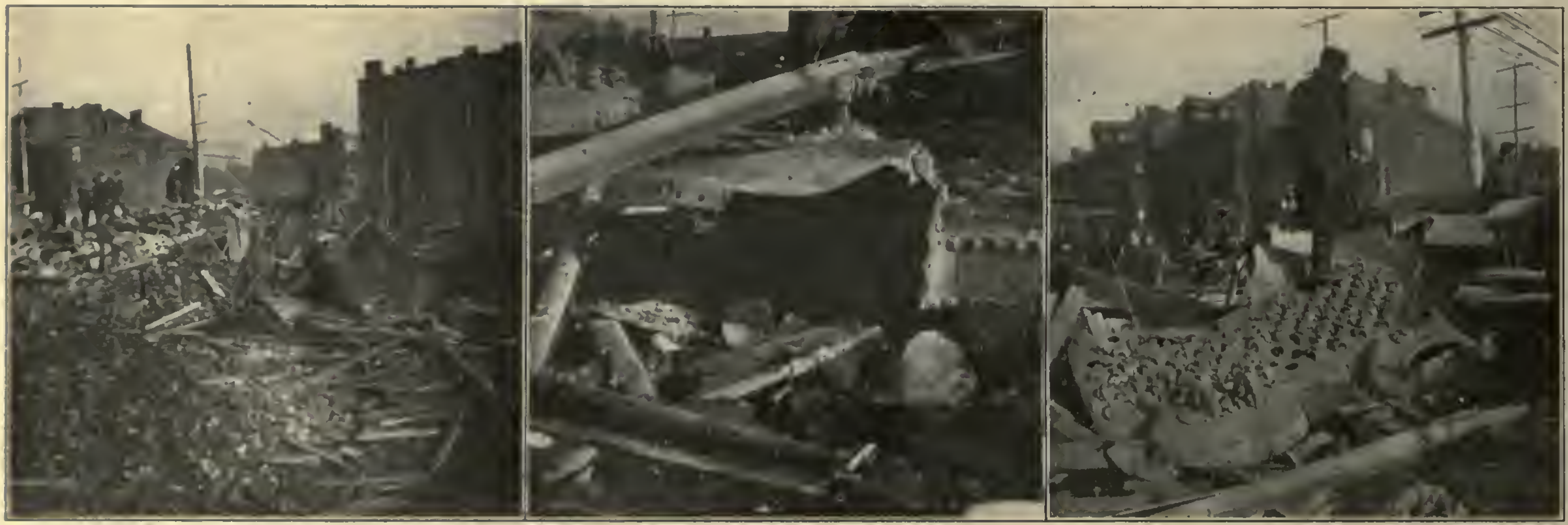
The regular force employed consisted of 5 men attending the mixer and hoisting apparatus, 4 men wheeling concrete, 10 men filling moulds, 8 men surfacing the floor with 1:2 cement and stone dust mortar, ¾-inch thick, 12 men (at night) setting and greasing moulds ready for the next day's work, captain and 8 men and derrick taking down falsework, 3 men taking down floor moulds, 4 carpenters making and repairing floor moulds, 5 carpenters assembling column moulds, 5 men erecting falsework, 3 men lining up belt course moulds, 5 men in shop making new moulds, doing repair work, etc., and 2 or 3 men twisting steel and doing miscellaneous work. Altogether about 85 men, including the night force, were employed for about three months and laid an average of about 100 cubic yards of concrete in ten hours. Considerable delay was occasioned by an unusual freshet which flooded the site and destroyed several hundred bags of cement and damaged the falsework so much that a large quantity had to be rebuilt, but in spite of this the work progressed rapidly and was substantially completed in about three months. Mr. E. L. Ransome, M. Am. Soc. C. E., New York, was the architect and engineer of the building, and the Ransome & Smith Company, New York, was the general contractor.

The Electric Wiring of the Tooting Bec asylum for aged imbeciles in London, England, is carried through brass conduits which are made to act as the return conductor as well as a protecting channel. One insulated conductor is run within each tube (or two where the three-wire system is employed) and the tubes are 5/16 to 7/16 inch in diameter. The conduits are, of course, grounded to prevent shocks.

A Peculiar Explosion of Water-Tube Boilers.

By John C. Higdon, M. E., Assoc. Am. Soc. M. E.

There occurred in St. Louis, on December 21, 1903, a most singular and destructive explosion of water-tube boilers. That a genuine explosion took place, is evidenced by the photographs taken by the writer on the morning after the explosion, which occurred about 5 P. M. The views show the enormous force exerted by the explosion, which spread apart the waterlegs and pulled out the ends of nearly all the tubes, the latter being thrown like tooth-picks all over the place. The first view shows the location of the boiler-room, swept completely clean. The fourth view shows several shells leaning against cars, where they were thrown and lodged fully 100 feet from their places, the water-legs being torn off at one or both ends of the shells. In one instance a water-leg weighing over a ton was thrown and lodged on top of a car standing in the car-sheds over 100 feet away, as shown in the fifth view. The second view shows the rear end of one shell with its water-leg attached. The small pipe is the blow-off pipe, not the feed-water pipe, the latter having been attached to the front of the shell. The third view exhibits the back ends of a pair of the shells, the force having been so enormous as to have sheared and torn out the rivets.



Wreck of the Boiler House and Boilers of the St. Louis Transit Company, St. Louis, Mo.

The exploded boilers had been subjected to over twelve years' continuous use in the plant of the St. Louis Transit Company, having been erected in 1891 by the Heine Safety Boiler Company. Seven boilers exploded, located at one end of a battery of twenty-three, all connected to a single steam-header. Seven men were killed, most of whom were colored firemen. Property to the amount of $50,000 was destroyed. There were, fortunately, very few persons employed at the plant, or the loss of life would have been much greater, and especially if the boilers had been located in the basement of one of our city "sky-scrapers."

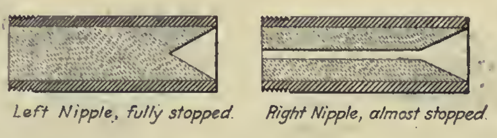
The coroners jury held as follows: "Either the boilers and apparatus connected therewith were not in good condition, or there was incompetency or negligence in running the plant." No inspection had been made by the St. Louis Boiler Inspector since February, 1903, almost a year ago, and so no blame could be laid at his door, as the law requires inspection but once a year. But it seems there had been a recent inspection by one of the casualty companies, and the Transit Company's chief engineer, who was on duty at the time the explosion occurred, testified, when asked what kind of an inspection had been made a short time before, that he and the inspector "walked up and down the boiler-room, and he looked at the water column which shows the level of water in the boilers." Needless to say, that if such action constituted an "inspection," there might as well not be any made in the future, because all real, live engineers know that the water-column connections frequently become stopped with mud and scale and render the glass-gauge and try-cocks unreliable, even though plenty of water be shown there. Undoubtedly there is much room for reform in boiler inspections, and as the feed-water pipes on the exploded boilers were found to be plugged with scale, we suggest that inspection, hereafter, particularly on water-tube boilers, include taking down the feed-pipes.

Herewith is a sketch of the two feed-water nipples of one of the boilers. One was found entirely plugged up with hard scale, so that not a drop of water could enter, and the other had but an ⅛-inch passage, utterly inadequate to supply so large a boiler, it being rated at 250 horse-power. There were no fusible plugs in the boilers. This would seem to have been a clear case of low water, in at least one of the boilers, as the feed-pipes were badly plugged with scale, and the engineer testified that he *depended entirely upon the glass water-gauge* to indicate the amount of water in the boiler. He also testified that just before the explosion, one of the boilers had been cleaned and supposedly filled with water, and fired up. The probability is that the tubes were only partially filled with water, owing to the plugged feed-pipes, and when fire was applied the steam accumulated to an enormous pressure, as the header-valve was also perhaps closed; and there is good evidence that a number of the safety-valves were so badly "stuck" with scale and corrosion that they could not possibly have opened at anything under 500 pounds to the square inch. There was also evidence that a new header had just been finished and connected to the boilers, so that it is very likely that the main steam valve was closed, cutting off the seven exploded boilers from the balance of the battery.

Even supposing that boiler to have contained only a barrel of water, the same would have generated sufficient energy to tear any boiler to pieces when subjected to over-pressure and low water. Many have wondered why the tubes alone did not burst, as usually occurs in explosions in water-tube boilers. In the present case, the tubes did not burst, but the water-legs were stripped off of the ends of the tubes, leaving the latter free. The evidence points to the probability that but a single boiler caused the explosion of all the others, it having been suddenly relieved of pressure by a broken steam-header, or perhaps by the giving way of a number of over-heated tubes during low water, with the safety-valve out of order and the header-valve closed, as this would be sufficient to break the header, and thereby release the steam contained in the remaining six boilers, which would have the effect of causing the superheated water contained in them, to at once flash into a great volume of steam, which no boiler could possibly withstand. It was stated by some of the witnesses that the boilers exploded one at a time, and that seven consecutive explosions were heard.

The sixth shows one of the tubes which had evidently been badly over-heated, which could only have been caused by low water.

The above described explosion should not at all detract from the popularity of water-tube boilers, as it has been clearly shown that the explosion occurred through no defect in construction. It would have required something like 1,000 pounds per square inch to have torn the shells of these boilers in the manner indicated. The writer, therefore, has no hesitancy in stating that, in his opinion, the Babcock & Wilcox, the Sterling or any other water-tube boiler would have gone to pieces under like circumstances.



Left Nipple, fully stopped. Right Nipple, almost stopped.

Since the above was written, the St. Louis Board of Engineers has made its report, as required by law, and they substantially affirm every statement, and even go further in their condemnation of the Street Railway Company's Superintendent of Motive-Power, Mr. Cook, who is not a licensed engineer, and yet is allowed under the present law, to give orders to many licensed men under him. The Board has revoked the license of the engineer who was on duty at the time of the explosion, on the ground of negligence or incompetency. Right here is seen a fatal defect in the present law, and no time should be lost in remedying it. No unlicensed man should be permitted to give orders to licensed engineers, even if the former be the employer.

The Board report is in part as follows: "A test of the safety-valves showed they required from 142 to 170 pounds to the square inch to force them open, when the law allowed them but 125 pounds. There has never been a boiler devised which cannot be exploded by an incompetent or careless engineer. A water-tube boiler in the hands of such an engineer is no safer than a fire-tube boiler."

Fragments of Boilers Thrown into Car Shed Adjoining Power House, and an Overheated Tube.

The Power Equipment for the Sackett & Wilhelms Lithographing & Printing Company.—II.

Current is generated at sufficiently above 230 volts to give that pressure at the power and lighting outlets. From the generators the leads and field wires are carried to the switchboard in separate pipe conduits under the floor. The dynamo leads are of stranded copper with rubber and braid covering and protected by a lead sheathing 3/32 inch thick. They are proportioned for a current-carrying capacity allowing a drop of not more than 1 volt between the generators and the dynamo switch lugs when running at full load. Two extra sets of conduit are in place to connect the future generators to the panels which will eventually be added to the switchboard. The current for power is distributed on a two-wire system and that for lighting on a three-wire system, a 7½-kilowatt balancing transformer being used to equalize the load in the two sides. A 115-volt pressure is also used for charging the storage batteries on the electric automobile delivery wagons, a separate 11-kilowatt balancer being used for that purpose.

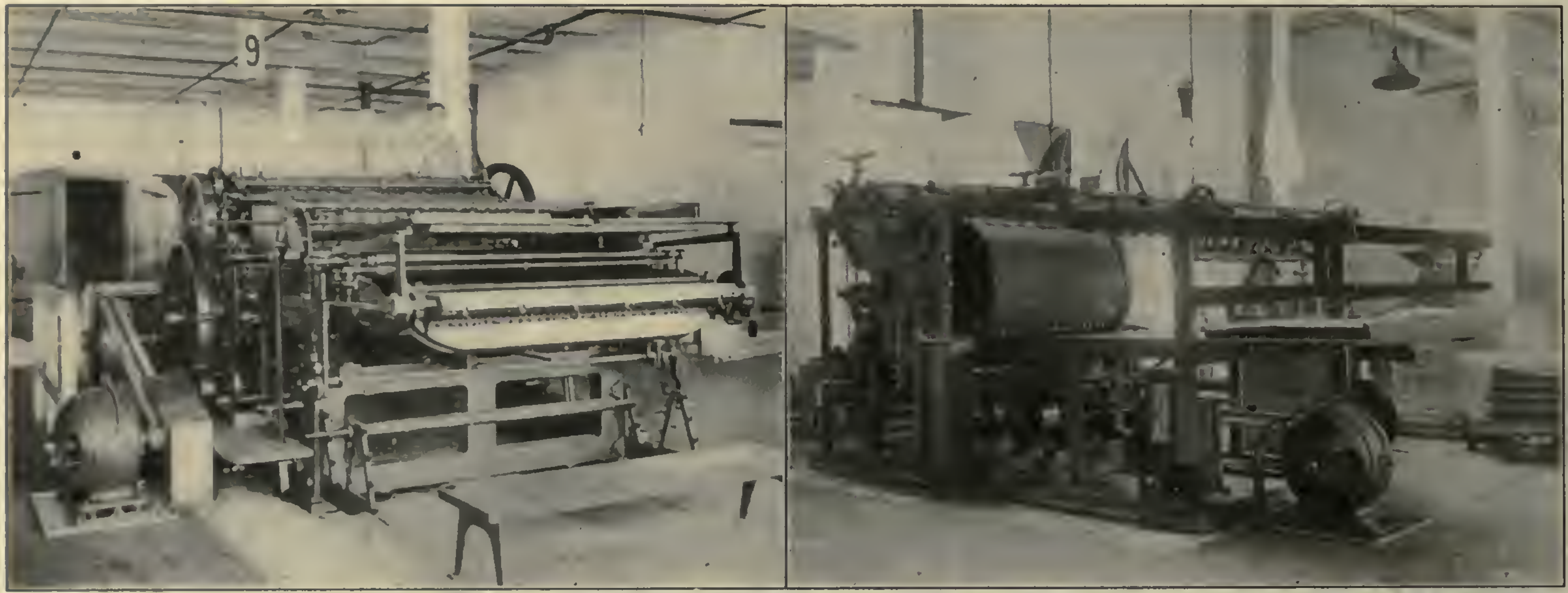
The provision for the charging of the automobiles is a unique and interesting one. It is so arranged that from one to four automobiles may be charged at one time, any or all of which may be either in the stable or the court-yard. This is made possible by the provision of four charging circuits each having two terminals, one in the barn and one in the court-yard, but as connection is made by a double-throw switch, only one is active at a time. The charging switchboard is located near the fire-proof vault in the basement of section B. It is of marbleized slate 1½ inches thick and has two panels each 30 inches wide by 72 inches high. The equipments on the two panels are similar and symmetrically arranged with respect to each other, the only difference between the two being that one has a voltmeter with a six-circuit switch and the other has an ammeter with a four-circuit switch. By means of meter switches the pressure and current in any of the four charging circuits may be measured, or the voltmeter may be placed across either leg of the three-wire system to test its balance. Two pole switches at the top of the panels control the two sides of the system, and the remainder of the equipment is in quadruplicate, one set serving each of the four charging circuits and including a 100-ampere fused double-throw switch, a single pole circuit-breaker arranged to trip at underload as well as overload to automatically open the circuit when charging at too high a rate, a Cutler-Hammer charging rheostat to regulate the amount of current as the charging proceeds, and a signal lamp to indicate to an attendant that there is an automobile being charged.

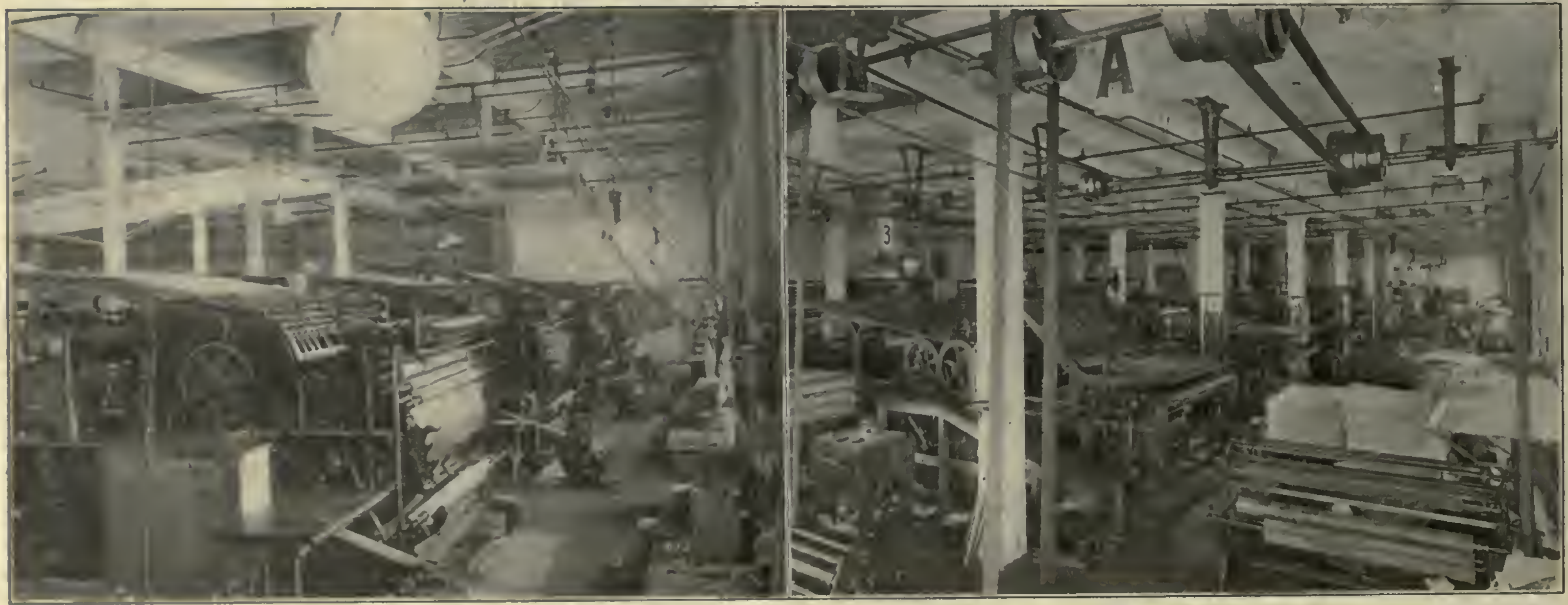
The main switchboard is of gray Knoxville marble 21 feet 4 inches long by 7 feet high. At present there are eight panels as follows: One for each of the 2-kilowatt generators, one for the 75-kilowatt and one for the 25-kilowatt generators; a panel for the two balancers; a distributing panel for the lighting system, and two power distributing panels. Separate bus bars are provided on the back of the generator panels for power and lighting, each consisting of a positive, negative and an equalizer bar. These may be connected by a "throw-over" switch or either set may be connected to any one or more of the generators. To allow for the latter a double-throw, three-pole dynamo and equalizer switch is installed on each generator panel, the rest of the equipment consisting of a circuit-breaker in each lead (both connected together so that one will trip the other), a field rheostat, a volt-meter, an ammeter, and a radial voltmeter switch to connect the meter with any machine at will. By means of this switch the attendant starting up a generator may compare its voltage with that of the other machines before throwing it in and may do so without moving away from the panel. The balancer panel has two ammeters, one in each side of the lighting system; two starting boxes, one for each balancer; a double-pole, single-throw switch and a single-pole neutral switch for each balancer, an equalizer switch for the two balancers, a three-pole bus-switch for the 11-kilowatt charging balancer, and a two-pole switch controlling the lighting distribution from the 7½-kilowatt balancer.

The lighting service panel contains thirty three-pole single-throw feeder switches arranged in six horizontal rows of five each. The general scheme assigns the vertical rows from left to right to the basement, first, second, third and fourth floors, and the horizontal rows from the bottom to the top, to sections B, C, D, E, F and G. Since sections E, F and G are but two stories high, the two right-hand switches on the three top rows are extras. Two of these are now used for the lights in section A, the boiler house, and the others are spare switches. The switches on the power panels are all double-pole single-throw, and have a similar arrangement to that on the lighting panel, but extended over two boards. The first has five switches for each of the sections B, C and D with the top row of five for extras, and the second four rows of four switches each for the sections E, F and G, with the right hand switches and the top row for spares. It was not found feasible to adhere to this scheme strictly, a few special switches being necessarily out of place; however, it assists the attendant in locating a switch quickly, and as all are labeled there is no chance for a mistake. The areas of contact of the switch clips and blades are proportioned for a current density not exceeding 80 amperes per square inch. All fuses are of the D. & W. enclosed pattern with tell-tales to indicate when they are burned out. Those for the dynamo and transformer panels are mounted on the rear of their respective panels. The fuses for the feeder switches are mounted on a special 1½-inch terminal board on the wall at the rear of the switch-board, following an arrangement corresponding with that of the switches.

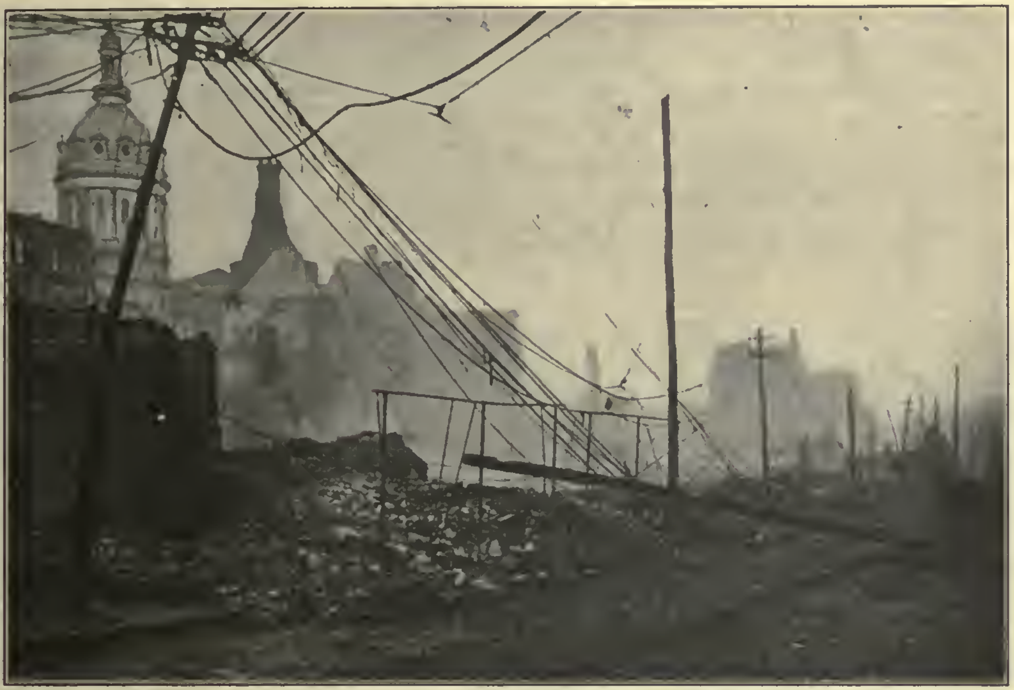
The feeders from the board are taken in conduits under the floor to the terminal panel, thence in conduits along the walls, ceilings and pillars to the various power and lighting outlets. The mass of conduits crowded together where they start from the terminal board are concealed by a light removable sheet-iron casing, to avoid an otherwise disfiguring background for the switch-board. Twenty-five of the conduits contain three-wire feeders leading from the switchboard to the switch distributing centers of the lighting system, where three-wire panel boards are installed. Each panel board has a separate feeder, both being identified by the same number and serving one section of one floor. The capacities of the feeders vary according to the number of lights they supply, the smallest having a capacity of 10 amperes, the largest 100, and the average 8 amperes.

There are twenty-one two-wire 240-volt feeders for power service, which are run from the


A Two-Revolution Press and an Underfeed Aluminum Press Driven by Semi-Enclosed Motors, in the Sackett & Wilhelms Establishment.


Four Aluminum Presses with Fly Delivery and Six Color Presses Driven by Electric Motors.

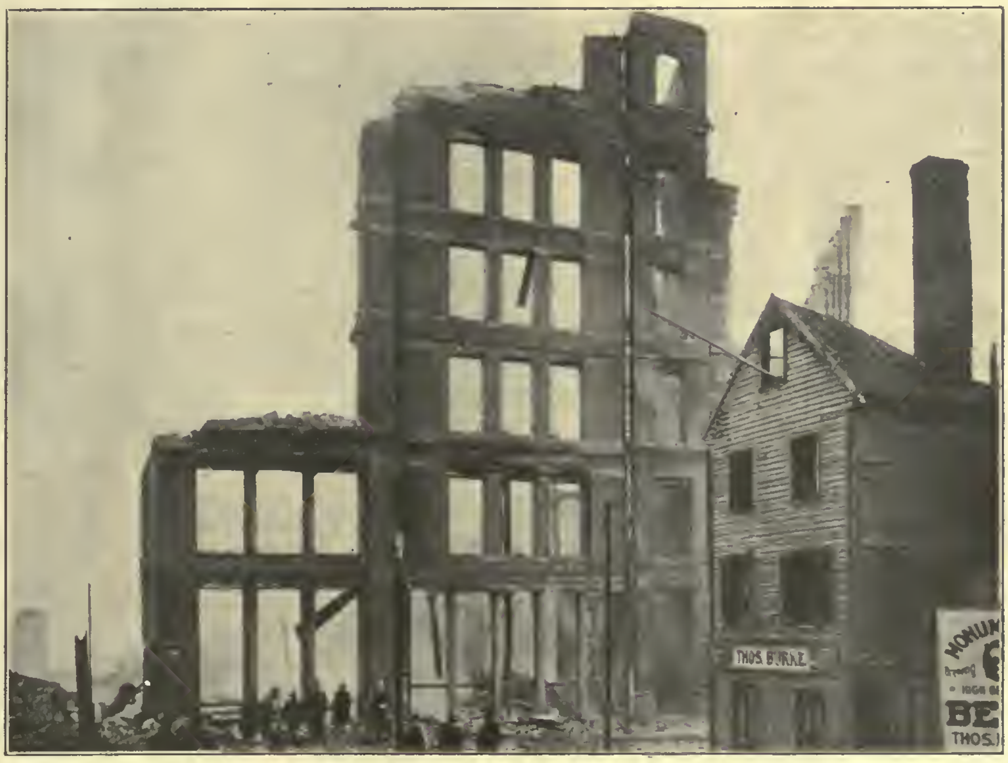
switchboard to the several points where the two-wire, power, panel boards are installed. Here again a single feeder serves a single section, and is numbered to correspond with the panel it leads to. The variation in the capacity of the feeders ranges from 100 to 320 amperes, the average being 190 amperes. The feeder conductors are stranded and have an extra heavy braided insulation for use in unlined conduits. They are proportioned to allow a drop in potential not to exceed 5 volts, when carrying full load current.


Baltimore Fire Ruins South of the City Hall.

The distributing boards are of marbleized slate, 1-inch thick or over, according to the size. These are mounted in hardwood boxes, slate lined, fitted with swinging doors which are protected on the inside with sheet-iron coverings, and provided with lock and key. Each branch conductor has a double-pole copper knife switch with an enclosed fuse in each leg. The feeders enter at the bottom of the board, the bus bars are vertical and the branch switches open and close horizontally.

The number of branch circuits leading from the lighting panels depends upon the amount of illumination demanded. Each one has a capacity of 25 amperes and supplies not more than ten 16-candle-power incandescent lights or two 5-ampere arc lights. The branch switches on the power panels are of either 50 or 100 amperes capacity, and are of a number to allow one for each motor at present installed, with several spares for future additions. Like the feeders all branch circuits are run in unlined conduits. Those carrying lighting circuits are run along the ceiling of the sections in which the outlets are located. Each of the conduits for the motor circuits is carried from the power panel down through the floor and along the ceiling below to a point near the motor where it is brought up through the floor and ends in a terminal box. The terminal boxes for plug receptacles and motor outlets are of hardwood, slate lined and provided with swinging doors hung on spring hinges. Lighting system terminal boxes are equipped with one 50-ampere double-pole, knife switch and one 25-ampere receptacle, and motor outlet boxes with one double-pole knife switch of a rating suited to the nominal full-load current capacity of the motor.

As previously stated, the total number of incandescent lights supplied is about 900, and arc lights, 150. There are also 66 motors, aggregating 350 horse-power. Of these, sixty are of Crocker-Wheeler make; five, of General Electric, and one, of Milwaukee. Thirty are of 7½ horse-power and the remainder range in size from 5 to ½ horse-power. These are variously employed in the driving of grinding machines and bench saws; bronzing, embossing and cutting machines and stitchers; type, job, litho and transfer presses; plate-graining machines, ink grinders, etc. The job presses are of Colt Armory and other makes. In type presses, R. Hoe & Company, The Huber Printing Press Company, Walter Scott & Company, and the Campbell Printing Press & Manufacturing Company are represented; and in litho presses, the Aluminum Press Company, R. Hoe & Company, and the Huber Company. The job and transfer presses and some of the machines are group-driven, but the type and litho presses and the greater part of the machinery are driven individually.



John E. Hurst & Company's Store In Which Baltimore Fire Originated.

Among the illustrations will be found a number of individual machines which show excellent applications of motor drive for their class of machinery. Connections are mostly by belt for the reason that slipping is often of advantage in saving both the machines and their motors from shock in ordinary running and more serious injury if anything goes wrong. In all cases the saving of floor space has been made of second consideration to the placing of the motors in easily accessible situations. Fair lengths between belt centers have been maintained, and large pulley diameters have been avoided by employing slow speed motors. This arrangement facilitates the handling of large quantities of work in a short time.

The structural details of the building are due to the architect, Mr. C. H. P. Gilbert, of New York City, and the consulting engineer, Mr. Walter S. Timmis, of Brooklyn, who also acted as engineer for the mechanical and electrical features and remains on the grounds as the firm's expert on printing press machinery. Mr. Arthur G. Stone, of Brooklyn, was the supervising builder, directing the construction work, and the following contractors, all of New York, installed the work indicated: Messrs. Hatzel & Buehler, the dynamo feeders and switchboard; Messrs. Weiderman & Conklin, the power and lighting circuits, and Messrs. Blackall & Baldwin, the motors.

Baltimore Fire Scenes.

The two pictures presented herewith will convey to the readers who have not seen the burned district in Baltimore and have not had opportunity of examining photographs, some idea of the devastation wrought by the flames, as well as showing how some inflammable objects have partially escaped destruction. The lower view shows the remains of the wholesale dry goods house of Messrs. John E. Hurst & Company, in which the fire originated and from which it spread eastward. The other photograph was taken looking northeasterly toward the City Hall, beyond which the fire did not spread in a northerly direction. The complete demolition of the brick buildings is clearly indicated, while the more or less complete preservation of many of the wood and tubular iron telegraph and trolley poles is worth noting. An example of the tangles of wires which encumbered some of the streets is given incidentally in this picture.

Col. William P. Anderson, President Can. Soc. C. E.

The new president of the Canadian Society of Civil Engineers has long been eminent in one of the most restricted specialties in engineering, that of lighthouse design and construction. Until the work of a lighthouse engineer has been investigated few people recognize its difficulties, although in a hazy sort of way it is understood to be a sort of lonesome calling, in which success is largely a matter of luck and the favor of the elements. But good engineers do not need luck for their work to be successful, for they foresee all the adverse conditions and provide for them. This sort of planning for lighthouse design is particularly difficult in many cases, on account of the nature of the site where construction must be carried on, its distance from a base of supplies, and the storms and seas which make the plant necessary for the work almost as difficult to design as the structure itself. Moreover, when the work must be done with a minimum of expense, as is the case with Canada, the problem becomes one of much complexity, even in the case of lights presenting no particular difficulties in construction.

Colonel Anderson was born near Quebec 53 years ago. His father was in the timber business and later in the Dominion service in connection with the crown timber lands. The son was educated at Bishop's College in Lenoxville, and then became a clerk in the Quebec legislative assembly and also in the office of a lumber house. The knowledge of business methods thus gained has proved of much value in later work as an administrative officer.

In 1872 he went to the Canadian Northwest as an apprentice to a land-surveyor, but the small future such a calling offers led him to abandon it for engineering. He accordingly took a preparatory course at Manitoba College, and then, in 1874, became a draftsman in the Department of Marine and Fisheries at Ottawa. He rose rapidly through the successive grades of assistant engineer and engineer, and finally became chief engineer about 24 years ago. In this position his duties have been manifold, embracing the construction of lighthouses, lightships, fog alarms, buoys and beacons; supervision of construction and repairs to government steamers and the construction and equipment of lifeboats; the administration of the vote for the removal of wrecks and obstructions in navigable waters; tidal and current surveys; hydrographic surveys, and the publication, examination and correction of hydrographic charts; construction of and repair to fish hatcheries and refrigerators; engineering points in connection with the construction and maintenance of fish passes; supervision of surveys of oyster beds; examinations for applications for foreshore, wharf and water lots as they affect the interests of navigation; preparation and publication of notices to mariners and hydrographic notes."

The manifold duties of this office are in strong contrast with the division of similar work among several bureaus in the United States. When the variety of the duties is coupled with very limited appropriations for carrying them out, it is evident that the utmost diligence as well as strict economy must be practiced by the department. Colonel Anderson accordingly made it a practice for many years in his lighthouse design to use inexpensive wooden structures, the lights themselves being of good quality. In this manner the essential features of the works were efficient while the remainder were in keeping with the resources of a country whose income was restricted. With the larger appropriations which have been possible of late, the structures have been made more durable, but the works built with the scanty sums available in the early days afford good examples of particularly great value of sound engineering advice when money is not readily obtained for public works.

While Colonel Anderson has been chief engineer of the Department, about 360 lighthouses and 50 mechanical fog signals have been constructed. Among the latter is a unique installation at Belle Isle, Labrador, where a small hydraulic power plant with a Pelton wheel has been built to furnish compressed air for a first-class siren. He is now having built at the Polson works in Toronto two steel lightships for the Gulf of St. Lawrence and the Bay of Fundy. These are steam propelled vessels with electric lights and compressed air sirens.

Col. William P. Anderson.

Among the lighthouses which deserve particular mention are two in the Traverse of St. Roch in the St. Lawrence River below Quebec. That at the upper end of the Traverse stands on a pier built in 42 feet of water in a current of about 7 knots. While this current made the construction difficult the design received particular care on account of the tremendous ice pressure which must be withstood in the spring. The lighthouse at the lower end of the Traverse, finished last year at a place where the river has a current of 9 knots, has a pier consisting of a steel shell filled with concrete and a superstructure mainly of concrete. Its equipment comprises a quick-flashing light and a first-class siren having oil motors to run it.

Another lighthouse built in Lake Erie is interesting from the fact that its brick tower is protected with sheet steel. Readers of The Engineering Record may recall an article some years ago on the deterioration of American brick lighthouse towers on the Great Lakes and the method of protecting them by means of a steel casing. The fog alarm at this lighthouse is run by a steam plant. Still another structure which deserves special mention is the light on Colchester reef in Lake Erie. This has a masonry pier built in a steel caisson and sunk in 13 feet of water, a rather unusual procedure in 1885 when the work was carried on. It should be added that until a few months ago he was also charged with the management of the lighthouses. He has been relieved of these duties, however, and is now able to devote all his attention to strictly engineering duties.

The hydrographic branch of Colonel Anderson's work is one in which he takes much interest, and some years ago he personally directed surveys of the Bay of Quinte. The supervision of all the Dominion hydrographic work and the prompt publication of the results is rendered possible by a thoroughly organized system, which alone enables one man to direct such an undertaking satisfactorily.

The Canadian Society of Civil Engineers has very properly elected Colonel Anderson as president, for he was one of its founders and served on the committee which drew up its constitution. He has already held office in the organization as a member of the Council for several terms and as vice-president. He is a member of the Institution of Civil Engineers and a member of the Geographic Board of Canada, being also one of its executive committee. This last office he considers particularly important, as much work has to be done to improve geographical nomenclature in the Dominion. Outside of annual reports Colonel Anderson has done very little writing on technical subjects, for reasons very well put in a recent letter from him, which reads: "My contributions to professional literature are conspicuous by their absence. When you consider that all the aids to navigation in the Dominion, covering a coast line greater than yours, have been in my sole charge, while in the United States there are some fourteen districts with an engineer in charge of each, you will understand the reason."

While official duties have thus prevented his contributing to technical literature they have not kept him from taking an active part in public affairs. He is now on the Ottawa Public School Board and chairman of one of its committees, and has long taken a deep interest in educational matters. He has been connected with the Canadian volunteers for many years. He gave up the command of the 43d Battalion of Rifles in 1891, but he is still carried on the active list, without duty, in recognition of his long and valuable service. He is an exceptionally good rifleman, and has been on a number of Canadian teams in international meetings.

The Condenser Plant for the power station near Elyria, of the Cleveland & Southwestern traction system, includes a Worthington surface condenser for each of two 1,000-kilowatt Westinghouse steam turbines. Each condenser is located underneath the turbine and contains 3,400 square feet of cooling surface, in 1-inch brass tubes. Each outfit is designed to condense 22,500 pounds of steam per hour under 27½ inches vacuum and 70 degrees F. circulating water.

Meteorite, an Aluminum Compound.

Persistent efforts have been made for years to alloy or otherwise treat aluminum so as to produce a metal which would possess the desirable qualities of aluminum and in which its defects would be corrected. Hitherto the success achieved has been only partial, but about two years ago European and American patents were taken out for an electro-chemical combination of phosphorus with aluminum invented by Mr. Walter Ruebel and named meteorite. This is not a mechanical mixture or alloy, but a chemical compound; hence it can be melted and re-melted without change, and the hardness and some other qualities can be varied within limits by varying the phosphorus content. Many claims are made for meteorite, which, if substantiated by the hard tests of commercial use, will make it a most desirable metal for scores of purposes. Its specific gravity is about the same as that of aluminum, 2.6 to 2.8; it fuses at about 600 degrees Fahrenheit, is dense and a good conductor of electric current. It is said to be tough, highly ductile and malleable, and to machine easily and at high speeds. It is dense, takes a high polish, and can be rolled cold and forged. Very small and very large castings have been successfully made. Nitric and organic acids and many solutions of salts have very little or no effect upon meteorite, and it is durable in sea water. It can be soldered and plated. Its hardness compares with that of iron. Although the metal has not yet been made in this country, it has already been put to many practical uses in Europe, and a number of interesting samples of wires, tubes, plates, castings and bushings were shown to a representative of this journal. The rights of manufacture for the United States and Canada have recently been secured by Mr. Ernest May, of 74 Beaver Street, New York, and any person interested can obtain further information by addressing him.

Letters to the Editor.

The Union Engineering Building.

Sir:—I was instructed to notify you that at an informal luncheon in San Francisco on January 28, the matter of a union engineering building was discussed by twelve members of the Am. Soc. C. E. residing in or near San Francisco and two others. The vote was unanimous in favor of co-operation. The following gentlemen were present: Arthur L. Adams, F. J. Amweg, H. De H. Connick, C. E. Grunsky, W. W. Harts, F. D. Howell, Jr., M. Manson, C. D. Marx, F. Riffle, C. H. Snyder, F. P. Stearns, J. H. Wallace, F. S. Washburn, C. B. Wing.

Very truly yours, Chas. D. Marx.
Stanford University, Cal., February 2.

Sir:—When the ballots for voting on the engineering building were received by members of the Am. Soc. C. E. in Washington, the local committee at once arranged for a meeting of the local members. This was held on Saturday evening, February 6, and was presided over by Brig.-Gen. Alexander Mackenzie, chief of engineers of the army. There were present thirty-three members, and letters were received from four others who were unable to attend. A collation was served and during the course of the evening the entire subject of the engineering building was debated with a view to aiding those present in coming to a conclusion as to the proper course to pursue in the casting of their individual votes.

As showing the tendency of feeling at the opening of this meeting, of the five letters received from those unable to attend, the sentiment of all was adverse to the proposition of the engineering building. Mr. Robert Peary, civil engineer in the navy and arctic explorer, wrote: "I am strongly opposed to the Am. Soc. C. E. becoming one of the constituent societies in the occupancy and control of the proposed union engineering building." Mr. W. M. Wallace wrote: "It is doubtful if segregation of allied societies or even allied industries always works to the good of the individuals, and situated as we are . . . we do not need the expressed aid of any outside influence to carry out the provisions of our constitution, . . . and the loss of individuality which would be the result of such a union would be most harmful to our society." Col. Thomas Symons, of the engineer corps; Mr. Kourt Berle, constructural engineer, and Admiral P. C. Asserson, civil engineer in the navy, wrote in similar strain.

At the opening of the debate, Mr. J. A. Quinton, a consulting engineer of the Reclamation Service, from Los Angeles, Cal., and Col. A. M. Miller, U. S. A., in charge of filtration plant, etc., in Washington, and Mr. A. P. Davis, supervising engineer of the Reclamation Service, from Kansas, made remarks in opposition to the project. Mr. Quinton, among other things, said: "Would a man in moderate circumstances, but yet able to support his family comfortably in a small home of his own, give it up to share a better and more commodious establishment offered him freely, to be shared in community with three other families?" Mr. Davis said that in his judgment the present house is adequate during 364 days in the year; only on one day, that of the annual meeting, would a larger and more commodious establishment be desirable.

In spite of the prevalent adverse feeling in the beginning, after the matter had been carefully discussed and information had been furnished on the other side, there was apparent a strong undercurrent of feeling favorable to the proposition. Several men, who had come with their minds fairly fixed on an adverse vote, left the meeting saying that as the proposition had been presented and in view of the facts submitted during the evening, they would vote favorably. Mr. Elwood Meade, director of the society, explained to the meeting the feeling expressed at the annual meeting in New York, and said that whereas he had, on attending that meeting been opposed, he now favored the engineering building. The most useful contribution in favor of the proposition was that submitted by Mr. William H. Wiley, of New Jersey. Mr. Wiley's point was specially taken with a view to showing the financial side of the proposition, and as he is a member of other proposed constituent societies and the treasurer of the American Society of Mechanical Engineers, he was able to give data which made it quite apparent that the possibility of any or all of these societies being unable to meet their share of the expenses and thus throwing the whole burden back on our society was very remote.

Mr. H. M. Wilson, of the Geological Survey, spoke in favor of the co-operation and union of all members of the profession of engineering regardless of their specialties as mechanical, civil, electrical or mining experts. He was in favor of casting his vote for the co-operation providing the Board of Directors of the society, in whom he had confidence, found that the finances and the interests of the society will be safe-guarded. The result will be that engineers visiting New York may be able to consult the libraries and discuss with individual specialists the many problems which they might have before them without the necessity, which they might neglect, of journeying over so great a city from the headquarters of one to those of the other of the now widely separated societies. Messrs. J. F. Hayford, and finally the chairman, Gen. Mackenzie, indicated preference for the union.

At the close of the meeting Gen. Mackenzie was elected permanent chairman of the local organization for the coming year and was directed to appoint a committee of three, who, in addition to himself, should formulate plans for a more permanent local sub-organization, and was directed to see that at least one other meeting of the local members should be held within the next twelve months.

Yours truly, H. M. Wilson.
Washington, D. C., February 8.

Sir:—The decision to be arrived at at an early date concerning the acceptance of Mr. Andrew Carnegie's generous offer to give a spacious building in New York City for the joint occupation; first, of the four main engineering societies, and second, of such other allied scientific organizations as may need and can be furnished with accommodation, marks a period of vital importance to the engineering profession in this country. That decision will unquestionably be far wider reaching in its effect than was supposed when the subject was first broached. It then and now, so far as the actual transaction on its face is concerned, meant and means only a joint ownership in and occupation of a conveniently arranged building, requiring no closer union of the different societies making up the holding corporation, than required as stockholders in a corporation. The arguments for and against such joint occupation of a building are simply those of details of ownership and management, which can surely be satisfactorily arranged on a suitable business basis.

The acceptance or declination of Mr. Carnegie's proposition by any one of the individual societies to be named in the deed of gift, is to a great extent also purely a business consideration; simply whether the additional convenience to be secured in occupying the proposed building and securing such a large addition to its capital is or is not worth some slight sacrifice of identity. But there is a much more important question raised; that is, is not the time fast approaching when it will be desirable to abandon much of the narrow conservatism of the past, and, taking joint occupation of the proposed building as the start, look to the ultimate amalgamation of the different societies and the organization of one great American Engineering Institution. Such a society may well have sections composed of those members particularly interested in special lines of engineering work, and branch headquarters in many places, but one central executive government.

Though to-day it is more the custom for "civil engineers" to be called into consultation on the broadest questions of corporate management and great constructive works, while engineers having more specialized training are not called in until questions of detail are to be considered, it is not at all improbable that in years to come the training of all engineers may be such as to primarily fit them for the breadth of duties, and secondarily for the special fields. Opposition to such union is largely on the score that some men are admitted to membership in some of the societies who are practically not engineers in the broad sense of the term. Unquestionably this is true, but admission to the great Institution can be set at a high standard, so that new members will be men of proper attainments, and in course of years those of low grade now on the rolls of individual organizations would either become worthy, by reason of continued experience, or drop out because out of keeping with their surroundings, or in the course of time, will surely drop out by death.

The medical profession many years ago was face to face with a proposed wide differentiation of practice, with the probable establishment of many different organizations, but fortunately wise heads controlled, and there is to-day but one medical profession, though with probably a much wider line of specialists than there is ever likely to be among engineers. There are probably some who believe that there is room in this country for a number of strong, separate engineering societies. About forty years ago there were many people who thought there was room in this country for many different governments. The whole trend of progress during the last half century has been towards centralization and consolidation; and when honestly carried out, the general wisdom of such a course has been proven.

According to the amended present scheme, it would seem that the decision of the American Society of Civil Engineers (unless Mr. Carnegie should again modify his proposal), will determine the fate of the joint engineering building. Therefore, there is a moral obligation on the part of that society, if the joint building promises to be specially beneficial to the other societies, of aiding them to secure such benefit, if it would not result in seriously handicapping its own work. There would seem to be only one possible handicap in such a course, and that is the slight loss of prestige, perhaps, in not being able to point to its own separate building on a fine wide street in a central neighborhood, and to again come in contact with some men not properly fitted for membership in such a society.

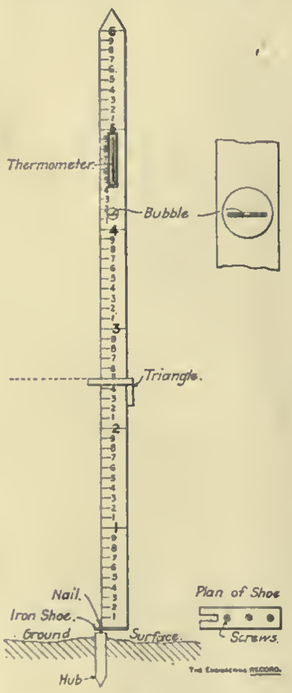
I hope personally that the American Society of Civil Engineers will waive petty matters and some of its conservatism, and will decide to join in the present plan, provided the details can be arranged on an equitable sound business basis; and that the building be located where it shall be deemed most desirable, even if on another site than the one at present selected, and further, that the American Society of Civil Engineers shall lead the way in the organization of one great American Institution of Engineers.

Yours truly, Louis L. Tribus.
Member American Society Civil Engineers.
New Brighton, N. Y., February 9.

Experiments in Tape Line Measurements.

Sir:—I note an article in your issue of November 28, 1903, entitled Engineering Experiments, calling attention to the neglect or failure of engineers to give to technical journals the results of experiments in various lines of engineering work. It occurs to me that in many instancea this seeming negligence is the result of a feeling on the part of the engineer that the subject is of minor importance, or that his method or appliance has no really new features; or, if by chance there should be some novel or original ideas, that there are many other superior modes and appliances. This idea, however, should not deter engineers from giving the results of personal experiments and acquiring additional knowledge on the subject by discussion. Taking this view of the subject, I will venture to describe some experiments and results from actual work in Tape Line Measurements.

Several years ago the writer had occasion to make a resurvey of a city where errors in the original survey aggregate in some instances 11½ feet in a distance of 5,160 feet. A surveyor's chain was used in the original survey, which evidently exceeded 100 feet in length, as the errors in all cases were found to be in excess of the true measurement. In the resurvey all excess was pro-rated between lots, the original or recorded width of streets being maintained. A Keuffel & Esser steel tape was used of Stevens excelsior pattern, tested to U. S. standard of length. At the 100 foot mark on the tape a compensating scale for temperature was etched, also the pounds tension to be applied when the tape was lying on the ground or suspended. When supported, that is lying on level ground, a tension of 7 pounds was required, and when suspended its entire length 22 pounds tension was required, A Keuffel & Esser spring balance being used to determine tension. The instrument used on sloping ground in lieu of plumb bobs, the use of which proved so satisfactory in the work referred to and in similar work at present in progress, and which the writer desires particularly to describe, was constructed as follows: A rod of hard wood 6 feet in length, 2½ inches in width and 1¼ inches in thickness, had the feet and tenths inscribed on its face, and the edge was carefully dressed to a true line. On the bottom an iron shoe was placed extending ¼ inch beyond edge of rod, and a slot was cut in the projection of the shoe of sufficient size to admit one of the three-penny finish nails which were used in the wooden plugs set at 100-foot stations and at all breaks of tape on slopes. A bubble was placed in the side of the rod about 2 feet from the top to insure the vertical position, and directly above the bubble the side of the rod was slightly recessed and a thermometer placed to record temperature. By placing a wooden triangle, which was attached to the rod by a rubber band on the side of the rod and sighting over the top of the triangle, the difference in ground elevation was quickly ascertained and the end of tape raised to the proper point, thus insuring the horizontal position of the tape. The advantages of the rod over the plumb bob on sloping or undulating ground, where it is necessary to establish points every 400 feet, is in accuracy and speed, which proved most satisfactory. Base lines one mile in length were measured and checked by remeasuring in the opposite direction, each station being lined by transit and temperature, tension and slope being carefully considered. Remeasurements of base lines from 1,500 feet to one mile in length, in opposite direction, checked almost exactly. The accompanying cut shows the rod used, which is of home-made construction throughout. Hoping this article may not prove wholly devoid of interest, I am



Respectfully yours, C. W. Swearingen.
Havre, Montana, January 31.

Hospitable Relations between Diverse Engineering Societies.

Sir:—So much has been said about the worthy gentlemen who formerly managed the Am. Soc. C. E., that it may be interesting to inquire how they got along with other engineering organizations. The following is an extract from the report of the Board of Direction, November 4, 1876, which spoke of the Centennial Exposition:

"In this connection, the Board refers with particular gratification to the most useful, harmonious and agreeable co-operation of our Centennial Commission, with that of the similar commission of the American Institute of Mining Engineers, whose rooms in the city of Philadelphia, with their large collections of maps and periodicals, have been open to all engineers, and in whose weekly *conversationes* our members have been invited to take as conspicuous a part as their own. The joint action of these two commissions has been of greater service to foreign guests and to the members of the respective societies than their independent action could have been, and it has during the meetings, receptions and excursions of the two societies in June last and on numerous occasions throughout the period of the exhibition, promoted a very large acquaintance and a most kindly feeling among their respective members. It is reasonable and gratifying to believe that the value of this co-operation will not terminate with the Centennial year, but that its results, while in no way interfering with the independence of either society, will continue to be a permanent benefit to both and to the profession at large." (See *Proceedings* Am. Soc. C. E., vol. 2, pp. 4, 19, 69, 147, 149-50.)

A joint meeting on Technical Education was held June, 1876, at Philadelphia. In February, 1877, also a meeting of the American Institute of Mining Engineers was held at the rooms of the Am. Soc. of C. E., in New York, and a joint discussion took place there in the evening. (See *Proceedings* Am. Soc. C. E., vol. 3, pp. 8, 18 and 26.) A dozen years later the Am. Soc. C. E. returned the visit. "February 20, 1889:—By invitation of the American Institute of Mining Engineers, the society attended the meeting of that Institute at Hardman Hall, at which occurred a discussion on Iron and Steel." (*Proceedings* Am. Soc. C. E., vol. 15, p. 38.) The Board of Direction in its next annual report said:—"On February 20, a joint meeting of the society and the American Institute of Mining Engineers was held, at which occurred a discussion on Iron and Steel." (*Proceedings* Am. Soc. C. E., vol. 16, p. 44.) At this time there was also an exchange of courtesies with the American Institute of Electrical Engineers. At the annual meeting of the Am. Soc. C. E., January 15, 1890, the Secretary of the Am. Soc. C. E., said: "The American Institute of Electrical Engineers has for some time been meeting in our rooms. We have been very happy to aid that Institute by offering them the courtesies of our house." The Secretary of the American Institute of Electrical Engineers addressed the meeting, presenting a set of massive wrought-iron grate fixtures, and said among other things: "Your society and your officers have afforded us every facility, have given us words of encouragement from that day to the present time, and, from surface indications, it appears that the same cordial feeling will continue to exist hereafter. . . .

"It gives me pleasure to present to you these fixtures, with the hope that the warmth that permeates through them may represent the feeling that has grown up between us as fellow engineers." (See *Proceedings* Am. Soc. C. E., vol. 16, pp. 14-15.)

Yours respectfully, Fred. Brooks.
Boston, February 6, 1904.

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The Fire Risk in Lofty Buildings.

Elsewhere in this issue are two accounts of the fire at Baltimore, one by the manager of the Baltimore Bridge Company and the other a statement of the observations made by a representative of this journal, supplemented by information from builders, engineers and city officials of Baltimore, whose courtesy in giving assistance under such trying circumstances is highly appreciated by The Engineering Record. The full story of the conflagration cannot be told as yet, for the facts must be collected from many witnesses and from a thorough inspection of the ruins. Technically, however, there are certain self-evident facts, which might just as well be openly acknowledged as partly concealed under specious statements of the percentage of damage done to the various buildings. While a few of the well-built structures of low height can be made serviceable again very quickly, the high office buildings are wrecked from the point of view of the tenants. While the condition of these lofty structures is an indisputable proof that they are more secure against fire than the ordinary commercial building and that their construction represents the highest type of fire-resisting design, the mere fact that thousands of tenants of such buildings have been burned out renders the lesson of the conflagration one that cannot be escaped. The condition of the steelwork and floors in these buildings is deservedly receiving the appreciative comment of architect, owner and builder; it is an excellent proof of the efficacy of the best systems of construction. The tenant's view of the subject seems to be neglected, although it is the tenant who makes such buildings profitable. From his point of view, the destruction was complete, and this highly important fact should be recognized. None of the lofty Baltimore office buildings can be occupied for many weeks, and the tenants are forced to find other quarters in addition to losing their books and furniture. Their material loss is trivial, but the interruption in their business is of the greatest importance.

While the partial demolition of these buildings in Baltimore has proved that such structures are not indestructible, the great lesson they have taught is one which the chief of the fire department of any large city could have taught long ago had any one been willing to listen to him. The high building contains great quantities of combustible materials, and while the arrangement and construction of floors and partitions in a structure of the best type will prevent the spread of an interior fire, there is nothing to speak of to check a serious external fire. The insurance companies are generally able to persuade owners to put iron-shutters on the windows overlooking back courts, but the street fronts are without such indispensable protection against a severe external fire. It has needed the Baltimore fire to prove this indisputably. The flimsy department-store building of the ordinary type is nothing but a fire-trap; all specialists in fire protection have known this for a long time. The experience in Baltimore has shown that the same is true of the well-built office structure provided it is attacked by external flames strong enough to beat in the glazing at many places practically simultaneously. The wood flooring of most such buildings has not been fire-proofed, and the furniture is very inflammable. If a few floors are once in flames, particularly when a strong wind is blowing, the fire will speedily pass from the windows of one floor to those of another, and the fire-protection will inevitably fail to protect the tenants' belongings. The building becomes a kiln and none of its contents can resist the high temperatures.

The danger point of such buildings is the unprotected glazing of the street fronts. These lines are written in a building which has two-thirds of its front occupied by windows. Across the street is a similar structure. Although one of the most important streets of a great city separate the two buildings, the average office boy would have little trouble in throwing two oranges out of every three from a window on one side of this thoroughfare to the corresponding window on the other side. That intervening space is assumed to be a sufficient protection against the passage of flames across the street. Fire chiefs have laughed at this assumption, and now everybody knows it is ridiculous.

The truth is that architects must make the street fronts of these buildings safe against exterior fires. They must put fire-resisting shutters on these windows, for the narrow streets between the buildings may readily become great flues, aiding rather than checking the leap of the flames from building to building and floor to floor. Our streets are too narrow for these high structures, but street widths cannot be doubled and trebled and lofty structures must be erected to meet the demands of business. The Engineering Record feels confident that when the fire-protection of the street fronts and roofs receives the same skilful treatment as the interior and court walls and the floors, the solution of the problem will be finally reached. Good steel shutters on every window supplemented by a perforated pipe just under the cornice of each front and supplied with water by the fire pumps in the building, should render it as resistant to external as internal fires. The lofty building has come to stay, for it is necessary; it is a remarkable piece of design even in its present condition, but it is not perfect because the protection of every part of it from external flames has not been carried out. That is the great engineering lesson of the Baltimore fire.

Cement Plant Promotion.

It is commonly understood that in the past considerable money has been made in the manufacture and sale of American Portland cement, but the present condition of the business certainly does not warrant any large investment for new works at this time, except under special conditions which can only be realized by people in the industry. Nevertheless, the former promoter of wildcat mines and dry oil wells is abroad in the land with cement propositions, and the glibness which has brought trouble to many homes is being exercised to draw the dollars of thrifty people into the most extraordinary undertakings. The Engineering Record has frequently stated within a year that there are plenty of cement mills in existence to-day to satisfy the current needs for this material, and that while many of these mills need extensive repairs and much new machinery, there are but a few places where a new mill has any chance of succeeding until the demand for cement is much greater than at present. The raw materials for this product are not particularly difficult to find, but the manufacture of the cement and its sale are problems requiring technical knowledge, experience and a thorough acquaintance with freight rates. The mere introduction of a new brand of cement on the market at the present time would involve a very large expenditure.

One of the most interesting of the new propositions which has come to this journal's attention has been brought out in a succession of documents. In the first communication it is announced that the promoters have "a proposition that is sure to be a winner," for they have "a most excellent quality of Portland cement in almost inexhaustible quantities." As a natural deposit of excellent Portland cement, presumably supplied by nature in sacks and barrels, is a little out of the ordinary, attention was at once turned to the prospectus accompanying the letter. This was not quite so surprising. Its author evidently felt that it would hardly do to claim possession of a bed of cement, so the statement was restricted to an assertion of ownership of a tract on which a large number of acres had been stripped and found to show "an excellent quality of Portland cement stone, which averages from 75 to 95 per cent. pure Portland cement." As a further advantage of this remarkable deposit, fuel and water are to be had close at hand, and the site is near railroads, street car lines and other public improvements. For some reason this scheme was soon consolidated with a smelting plant proposition. It seems the smelter produces a large amount of waste heat which has annoyed the economical owners to such an extent that they have determined to make Portland cement with it. In their two furnaces they "produce hot combustible gases equaling about 200 horse-power" which will be "passed under pressure into a larger calcining furnace which they already have in their plant, calcining without additional fuel or expense rock for about 1,000 barrels of Portland cement per day. The smelting furnaces are also water-jacketed, and the water from these jackets at about the boiling point, with very slight additional heat, supplies in two boilers steam for their engines of 300 horse-power." The details of the manufacturing process are so simple that old hands in the industry will be disgusted to think they never hit upon them. The gases from the smelting furnaces are to be passed in a flaming condition into the calcining furnace where the thousand barrels of cement clinker a day are to be produced. Thence they will go to cooling and settling chambers where all heavy values will settle, and finally pass through filter bags which will catch the remaining values such as white lead and white zinc. The utilization of by-products thus brought about is as interesting as the schemes that were to make the Consolidated Lake Superior Company famous for its technical achievements.

It might be mentioned that in the evolution of this project, the deposit of pure Portland cement again changed its character. In the latest form of the proposition the land is said to have a bed "from which numerous assays average 95 to 97 per cent. carbonate of lime." On another property of the company the remaining ingredient of cement is found, "the very best quality of fire clay," although it is to be regretted that the assay of this material is not also given. Taken all in all, it is not surprising that the promoters "have no hesitation in recommending an investment in the stock of this company as a first-class speculation and one that is sure to bring splendid profits in the near future." There is a trifling ambiguity, however, in the mention of who will reap the splendid profits.

The Pavements of Chicago.

One of the most energetic and useful organizations of a local character in this country is the Commercial Club of Chicago. Although the membership is limited to sixty, it includes the names of most of the leading professional and business men of the city, who have formed this club for the purpose of discussing the great civic problems which face the people of such a new and large community. The Chicago business man has become famous for ability and shrewdness largely through his habit of gathering about him experts able to give advice of value in every field in which he has interests. The same plan has been followed by this club in its investigations of the various subjects it has considered. Its discussions are based on the evidence given by men of experience rather than the ideas evolved from the casual observations of the members. An example of this is afforded by its method of taking up the subject of street pavements, a topic which certainly merits the careful attention of every taxpayer in Chicago.

When the subject was brought up last summer, it was decided to have a complete report on the conditions of the streets of the city from a disinterested engineer. Mr. John W. Alvord, M. Am. Soc. C. E., was accordingly retained for the purpose. He visited a large number of cities in the prosecution of his investigation, and personally examined the character of their traffic and its effect on the pavements. All this information was then used as a basis of comparison with the conditions in Chicago, as shown by a careful census of travel on its leading streets and an examination of the character of the pavements. It has rarely happened that such a comprehensive study of paving conditions has been undertaken under equally favorable conditions, and the results are correspondingly valuable. This is particularly so because Mr. Alvord has presented them in a manner free from technicalities yet without any sacrifice of accuracy. Unlike many documents of an engineering nature, his report does not require an engineering education to understand it, and in many respects it is the most satisfactory explanation of the purposes, cost and character of pavements that has been prepared for general readers. It is also a piece of work characteristic of the broad-minded manner in which this club is striving to serve the best interests of the great city where its members live.

It is to be hoped that the club will see its way clear to publishing the report in pamphlet form for distribution among those taxpayers who desire information concerning the manner in which public works should be conducted. It sometimes appears as though such unofficial missionary work had no direct result, but an analysis of facts rarely fails to reveal the importance of these efforts. The valuable work of the tenement house commission of New York would not now be possible but for the time and money spent years ago by private citizens in calling into existence a general interest in the conditions of life in the crowded parts of the city. In the same way the public baths of New York owe their present prosperous state to private incentive. The visible results of to-day are due to the almost forgotten pioneer labors of public spirited men. In the same way, the distribution of such a report as that prepared by Mr. Alvord will awaken an interest in good pavements through the knowledge it will afford, and it will not be until this knowledge is possessed by the leading people of Chicago that the paving problem will be materially improved.

The reason for this is not far to seek. Although the money spent in street pavements in this country is probably second in importance and amount only to that expended for railways, there are few works in which the returns are so unsatisfactory. While the railway manager can tell to several decimal places the cost of moving freight and passengers over his lines, very few public officials can make even a fairly good guess at the cost of handling the vastly greater traffic on city streets. The taxpayer is allowed too much latitude in deciding upon the character of pavement to be laid in front of his property, at least in the present state of his information on the subject. He believes that there is very little technical knowledge needed for paving work and that the principles involved are so elementary that anyone can evolve them from his inner consciousness. As a result the engineering profession is not allowed to decide the broader problems of such construction in the manner they should be settled, and the waste of money which results is prodigious. Probably the main cause of the waste is the selection of an unsuitable type of pavement in the first place, which will call for large expenditures for repairs and in a short period for entire reconstruction. Street pavements are not durable works at the best, and at their worst they are evanescent adornments of a neighborhood, pleasing for a few days and eyesores for the remainder of their existence. All this is explained so clearly in Mr. Alvord's report that the people of Chicago, who have been struggling for years with the paving problem, will find the information of direct value if the club will only make it generally available.

Report of the Alloys Research Committee of the Institution of Mechanical Engineers.

The sixth report of the Alloys Research Committee of the Institution of Mechanical Engineers, London, deals mainly with the effects of annealing steel containing 0.13 to 1.3 per cent. of carbon and manganese, generally less than 0.20 per cent. Tests were made on the bars, first, as received; second, after annealing for half an hour at temperatures of 620, 720, 800, 900 and 1,100 degrees centigrade; third, after soaking for twelve hours at the temperatures just given; fourth, quenched at 720, 800, 900 and 1,200 degrees centigrade in water, and fifth, quenched in oil (a) at 720 degrees, (b) at 720, 870 and 1,000 degrees and reheated to 350 degrees, (c) at 800 and 900 degrees and reheated to 600 degrees. The methods of annealing and of recording the temperatures are first dealt with; then the preparation of the photomicrographs is considered, whilst the effects of annealing at the various temperatures are discussed under distinct headings.

The series of steels consisted of eight members, containing 0.13, 0.18, 0.254, 0.468, 0.722, 0.871, 0.947 and 1.306 per cent. of carbon, by chemical analysis. The steels as received from the rolls show a rise in the breaking strain from thirty tons per square inch at 0.13 per cent. carbon to fifty-eight tons at 0.871 per cent. carbon, with a slight falling off in the case of the two steels containing more carbon. The reduction of area falls from 34.7 per cent. at 0.13 per cent. carbon to 3.4 per cent. at 0.722 per cent. carbon, followed by a uniform rise to 8.5 per cent. at 1.306 per cent. carbon. The elongation in two inches shows a minimum at 0.871 per cent. carbon. The contraction of area and the elongation are extremely low for all the bars, due to the presence of some sorbite which must have resulted from rapid cooling near the critical point Ar_1. On annealing at 620 degrees centigrade for one-half hour but little change is discovered in the breaking strain, a maximum being found at 0.871 per cent. carbon as before; but the reduction of area shows a marked change. The curve indicates a fall from 62.85 per cent. at 0.18 per cent. carbon to 9 per cent. at 0.947 per cent. carbon. In other words the increase in reduction of area varies inversely with the carbon content, the change having occurred mainly in the ferrite. Hence we may judge that the rolled bars had been worked after some of the ferrite had separated out and slip-planes had been formed in them. The elongation shows a similar change. Annealing at 720 degrees centigrade for one-half hour produces a lowering of the breaking strain with a great increase in the elongation and reduction of area, the curve for the latter showing a fall from 73.26 per cent. at 0.13 per cent. carbon to 40.4 per cent. at 0.871 per cent. carbon, whilst the elongation in two inches shows a fall from 44.5 per cent. at 0.13 per cent. carbon to 20 per cent. at 0.871 per cent. carbon. The above changes are due to the production of coarser pearlite on account of the annealing above Ac_1 and slow cooling past Ar_1. The coherence of the cleavage planes of the ferrite has been more complete than in annealing at 620 degrees, and so there is a greater elongation and reduction of area.

Annealing at 800 degrees centigrade for a half hour produces little change in the breaking strain up to 0.468 per cent. carbon from that after annealing at 720 degrees, but the bars containing 0.722 and 0.871 per cent. carbon are much stronger. The breaking strain reaches a maximum at 0.871 per cent. carbon, whilst up to this point the elongation and reduction of area are lower than in the bars annealed at 720 degrees. But with increase in carbon they both increase. Annealing at 900 degrees for half an hour shows that the breaking strain, the elongation and the reduction of area are practically the same as in annealing at 800 degrees, up to 0.871 per cent. carbon. Beyond this point there is a decided increase in the breaking strain, but a lowering of the elongation and reduction of area, due to the partial decomposition of cementite setting free amorphous carbon and producing a saturated steel. Annealing at 1,100 degrees centigrade for a half hour produces but slight falling off in the breaking strain when compared with those bars annealed at 900 degrees. The elongation is about the same, whilst the reduction of area shows a falling off. The photo-micrographs show that the three high-carbon steels have been overheated and that more or less cementite has been decomposed to iron and amorphous carbon.

Since great stress has been laid on the time which structural steel should be allowed to soak, the series was soaked at different temperatures for twelve hours to note the changes in mechanical properties brought about by this treatment. Soaking for twelve hours at 620 degrees centigrade produces a considerable lowering in the breaking strain when compared with the original bars, and also a lowering when contrasted with those bars annealed for half an hour. The curve shows an increase from 26.8 tons per square inch at 0.18 per cent. carbon to 45.25 tons at 0.871 per cent. carbon, and a slight increase to 46.96 tons at 1.306 per cent. carbon. The elastic limit is in all cases less in the soaked than in the annealed bars and the elongation and reduction of area are also less. Soaking at 720 degrees gives the same breaking stresses as annealing for half an hour up to 0.722 per cent. carbon, but above this there is a falling off amounting to over seventeen tons in the case of the steel containing 1.306 per cent. carbon, showing that prolonged heating only a few degrees above Ac_1 causes a marked decrease in strength. The reduction of area is much less than that after a half hour's heating, and also less than that of the bars soaked at 620 degrees, except in the two high-carbon steels, containing 1.306 per cent. carbon, giving 18 per cent. increase. The elongation is very similar.

Soaking at 900 degrees for twelve hours gives but slightly less breaking strain than annealing for a half hour. The reduction and elongation are about the same, excepting the bars that contain 0.947 and 1.306 per cent. carbon. The latter shows a marked increase. Soaking at 1,200 degrees for twelve hours, when compared with that at 900 degrees, shows a slightly less maximum load up to 0.722 per cent. carbon, but above this percentage of carbon, there is a great falling off, the bar containing 0.947 per cent. carbon having a breaking strain of only twenty-four tons. Again the reduction of area is slightly less up to 0.722 per cent. carbon, but shows a great increase above this point, the 0.947 per cent. carbon bar giving a reduction of over 40 per cent. as compared with the 900 degree soaked bar with 11 per cent. The elongation is also less up to 0.722 per cent. carbon, but very much greater above this point, due to the decomposition of the cementite in high-carbon steels.

The report next deals with hardening, and describes various methods used. The results obtained by quenching in water, by quenching in oil, by quenching in oil and then annealing are given. A number of stress-strain curves were taken autographically, and these are described, and the "yield points" discussed. Finally a number of photo-micrographs of thermally and mechanically treated steel are described. The report is illustrated by thirty-nine plates, half of which are photo-micrographs which are so arranged that the effects of each kind of treatment on the series can be seen on one page, there being eight photographs to a page. The amount of work covered is very great and can only be appreciated by those who know the percentage of experiments in research which give negative results. The whole is a splendid contribution to the technical knowledge of steel and the effects of heat treatment.

Notes and Comments.

The Lack of Perfect Symmetry in many of the famous cathedrals and temples of Europe has been a subject of many investigations by Mr. William H. Goodyear, of Brooklyn, N. Y. Ruskin pointed out the aesthetic meaning of this asymmetry and a few others have noticed it, but no careful study was made until Mr. Goodyear undertook the work. Some years ago he pointed out the presence of curvature in the horizontal lines of famous buildings, and more recently he has established the divergence of columns and the presence of vertical curvature. The most important result of the measurements seems to be a proof that from the time of the Greeks, and possibly the Egyptians, until the Renaissance gradually drove out Gothic architecture, the master builders of the greatest skill were accustomed to modify the straight lines of their structures by various devices to improve their appearance to the observer. It is the failure to do this which has produced in modern building a sense of something lacking, according to Mr. Goodyear.

Municipal Electric Lighting has been investigated for the City of Minneapolis by Mr. F. W. Cappelen and his results are not encouraging to those who would have that city embark on such an enterprise. He has made an analysis of the cost of building and running a lighting plant, in which allowances are made for interest on the investment, the depreciation of plant, the loss of taxes paid by a private company engaged in similar service, insurance and the like. Assuming that there is the same standard of efficiency in management as marks similar plants under private control, it appears from Mr. Cappelen's figures that the service from a municipal station will cost just six per cent. less than it does from a private plant. This result is in pretty fair accord with what may be considered the facts of the case in most large cities. Of course the six per cent. difference can be readily made to vanish if the management is allowed to deteriorate, which it too often does when political influence as well as ability is needed to gain a position on the force.

Water Purification at Vicksburg is the subject of some interesting reports to the Vicksburg Water Works Co., by Mr. R. E. Milligan and Dr. R. W. Jones. The water is pumped from the Mississippi into a 100x15x8-foot basin from which it passes into a 120x100x10-foot basin and then into another 50x100x12 feet. These are provided with baffles and in them about 35 per cent. of the suspended matter is removed. From the third basin it passes to the fourth through a galvanized iron flume in which it receives first a dose of sulphate of iron and then one of lime, about 1.12 grains of the former and 0.36 grains of the latter to the gallon. The fourth and fifth basins, the latter 45x100x14 feet in size, serve as coagulating basins from which the water passes to a series of New York Continental Jewell filters. According to the reports, the filtered water has no trace of iron sulphate and the number of bacteria is about 98.7 per cent. less than in the river water. Mr. Milligan reported that the number of bacteria in the filtered water was so small as to classify it as very pure, while it contained less iron than the raw water and turbidity was entirely removed.

A Ridiculous Sewage Disposal Resolution has recently been passed by the State Board of Health of Minnesota. It prohibits the discharge of sewage from any city, village or other municipality into any well, pond, lake stream or river unless it is "first passed through a septic tank or filter bed or both tank and filter bed," after the close of the current year. Any violation of this resolution is to be punished by a fine of not less than $50 or more than $100 for each day the sewage is permitted to enter a water-course in an untreated condition. The resolution is so completely at variance with sanitary science and engineering principles as to seem like the work of some practical joker, bent on making the Board a laughing stock in the eyes of all people informed on the subject. Not only is it oftentimes wholly unnecessary to purify sewage in any way before turning it into a body of water, particularly a large river, but when it requires purification it may not be desirable to employ the septic tank for the purpose. Intermittent filtration has advantages that the Board has apparently never heard about; in fact, the Massachusetts State Board of Health, the organization which all others acknowledge to be the model body of the sort in the country, has always shown a strong belief in the efficacy of intermittent filtration, even for conditions where some engineers would not hesitate to adopt the septic tank. The resolution of the Minnesota Board is so manifestly unjust and impracticable that it cannot be upheld in the courts.

The Housatonic Rivea Development described in this and the preceding issue is presented under the authorship of Mr. Walter Scott Morton, the chief engineer of the work, through whom it has been possible to give a comprehensive account of construction methods as well as a discussion of design. There are, however, a number of points not referred to at length by him. The main dam has a decided bow upstream but any arch action which may be attributed to concrete structures of this formation was ignored and instead the strength figured as though the dam were straight, thereby increasing the factor of safety against overturning. For the cross-section of the dam the design was based on the theories laid down by Mr. Edward Wegmann, with the apex of the formation triangle 8 feet above the crest of the dam and not 10 feet, as shown in the cross-section cut on page 188, last week. The weir dam, shown also on that page, is of unusual construction, having an upstream face of rubble masonry backed by concrete and a rock-fill down-stream part with an ogee face protected by a concrete envelope. According to Mr. Morton its cost was less than one-half that of a concrete or masonry dam. As regards the canal, the sectional area, 375 square feet for the rock cuts and 450 square feet for the earth sections, was computed for an elevation 2 feet below the crest of the dam, allowing the pond to be lowered 2 feet without reducing the area below the established figures. The flared openings at points of canal entrance and discharge are 1.4 times as wide as the standard canal width, the distance from the opening to the standard canal section is seven-tenths of the canal width, while the sides are arcs of circles with a radius 1 1/3 times the canal width.

Description and History of the Water Works and the American System of Filtration at Trieste, Austria.

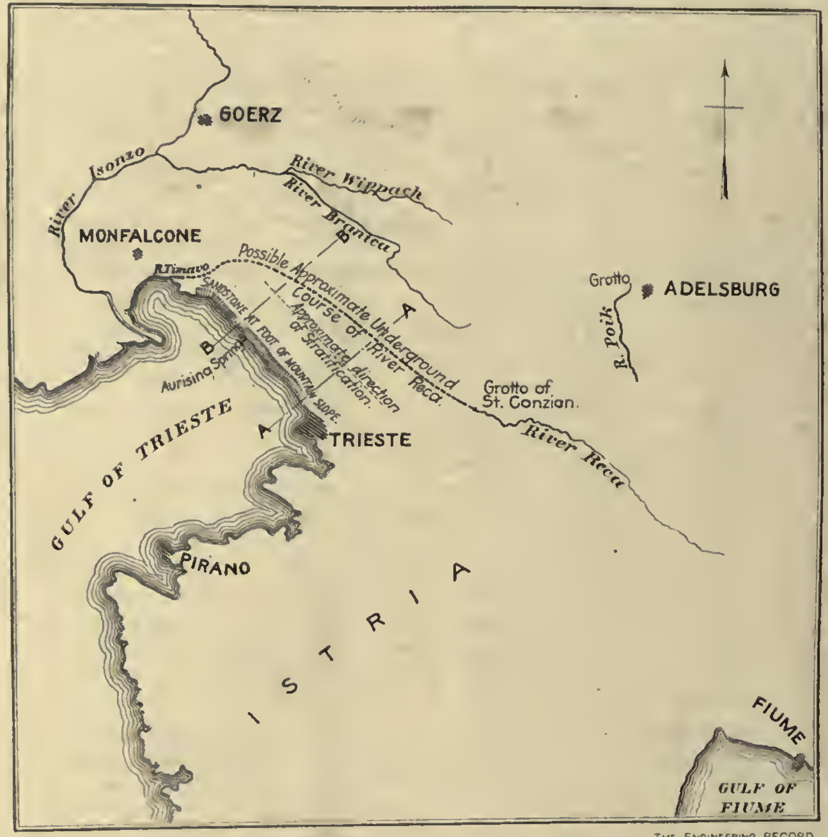
By E. A. Gieseler, C. E.

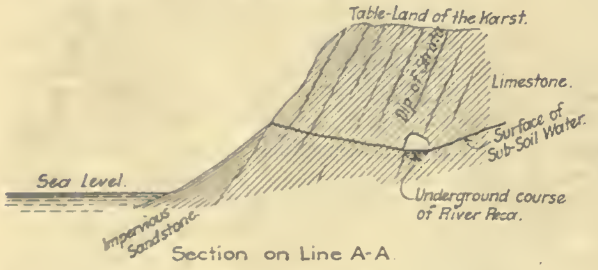
Geographical and Geological.—The middle of the three terraces forming the Karst mountains, the Triestine Karst, extends from the valley of the River Isonzo in the northwest to the Gulf of Fiume in the southwest, including an area of probably 600 or 700 square miles, with an average annual rainfall of about 48 inches. The formation consists principally of limestone, and underground grottos, caves and water-runs are frequent. Through fissures and seams and through the great funnel-shaped holes (dolines) peculiar to the Karst, the precipitation falling on the table-land above passes into the interior and gathers into smaller and larger water courses, which constantly continue the work of erosion and destruction of the yielding material, and of further honeycombing the mountains. The only river existing on the table-land of the Triestine Karst, the Reca, makes its appearance at the foot of Mount Lissac and, after a course of 21 miles, vanishes in the depths of the wonderful cave of St. Canzian. It is by some supposed to continue thence on an unexplored underground course until it reappears not far from Monfalcone under the name of Timavo and, after a short run, empties into the sea. At a number of points on this supposed underground course, which is marked in a broken line on the accompanying map, the rush of great masses of subterranean water can indeed be heard, but all attempts to demonstrate by experiment the connection between the Reca and classical Timavo have so far failed.

From the City of Trieste the seashore runs in a northwesterly direction for about 12 miles, and is formed by the rocky slope of the table-land of the Karst, which drops down to the sea from a height varying between 600 and 800 feet. The direction of the stratification here is from southeast to northwest and the dip is towards the southwest at a varying angle, sometimes approaching the vertical. At the foot of the slope, the limestone is separated from the sea by a formation of impervious sandstone, which prevents the fresh water moving in the hollows of the Karst from passing out into the sea. These conditions are illustrated by the accompanying ideal section on the line AA near the city. The surface of the subsoil water slopes from the impassable sandstone barrier at the shore down to the supposed underground bed of the Reca, and the flow is, of course, in the same direction.

At one point, about 7½ miles from the city, the sandstone formation for a short distance sinks below the sea level and below the supposed underground course of the Reca. The conditions existing here are illustrated by an ideal section on the line BB. From the higher bed of the Reca, the surface of the subsoil water slopes towards the sea, its motion being, of course, in the same direction, and as the confining sandstone barrier at the shore does not exist at this point, the subsoil flow passes out through the fissures and seams of the limestone and forms the Aurisina springs.

Such is probably the course of events if the above mentioned supposition of an underground route of the Reca in a single undivided bed is the correct one. But in view of the absence of any proof of this, the possibility exists that her waters, after having entered at St. Canzian the honeycombed interior of the mountain, divide themselves into a number of minor branches, and if this is the case, then one of these branches probably is the origin of the Aurisina springs. In these springs, we see the unique spectacle of fresh water in great quantities flowing from the foot of a rocky slope, where it dips into the sea, many of the springs being actually submarine. On account of the natural filtration it undergoes, the water is of an excellent quality during the greater part of the year, and becomes turbid only during prolonged periods of heavy rain.





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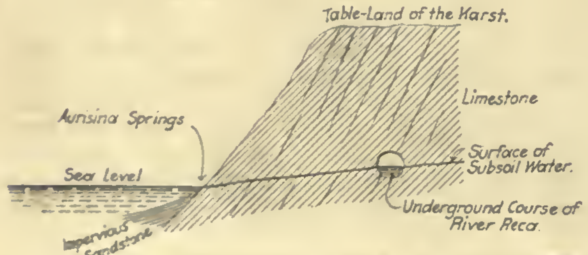

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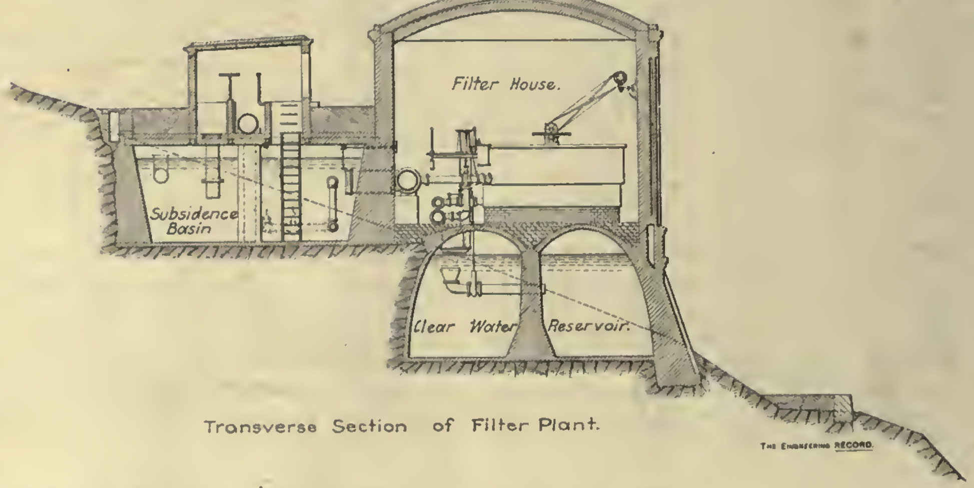


Transverse Section of Filter Plant.

Map of Region around Trieste, Austria, and Sections of Water-Bearing Cliff and of Filter Plant.

Historical.—In 1851 the Austrian Government commenced the construction of the Karst Railroad, then the only missing link in the railroad connection between Trieste and Vienna. This road, on leaving Trieste, ascends to the height of the Karst table-land, along the above described seashore slope of the mountains, and therefore passes (at a considerable altitude) the site of the Aurisina springs below. It was natural that these springs should be considered in connection with the water supply required for the railroad, and as natural that, the water question once having been raised, the needs of the growing city in this respect were also discussed. The outcome of the deliberations was the organization at Trieste of a private company under the name of Aurisina, and for the purpose of utilizing the Aurisina springs to supply water to the railroad and to the city. Excellent water, in sufficient quantity for the anticipated demand, was easily obtained by sinking a shaft into the rock at the shore, a pumping plant was erected over the spring, and a reservoir of 8,000 U. S. gallons capacity was constructed 450 feet above it, on the hillside, close to the railroad. Into this reservoir the spring water was pumped, and thence it was conducted to the city by gravity through a 12-inch main laid between the tracks in the road-bed.

In 1858 the entire railroad from Trieste to

Vienna was sold by the Government to the Southern Railroad Company, which latter also purchased from the Aurisina Company the pumping plant, the high level reservoir and the 12-inch main leading down to the city, thus leaving the water company in possession only of its system of pipes in Trieste. The railroad company at the same time agreed to sell to the Aurisina, at a stipulated price, all water over and above their own needs, for distribution in the city. In this way the needs of the latter became a secondary consideration, dependent on the convenience of the railroad company, whose increasing consumption soon caused the occurrence of instances when the city had to go without water for days. This wretched state of affairs lasted for twenty-three years, until at last, in 1881, relief was procured by constructing a collecting basin for some of the springs running to waste into the sea, and thus securing a steady daily capacity of about 1,500,000 U. S. gallons. Very soon after this, in 1884, the city supply was further secured against accident by the construction of a distributing reservoir of 900,000 U. S. gallons capacity, at an altitude of 250 feet above the sea, which was a few years later enlarged to twice its original size.

Trieste Water Supply: Lower Slope of Karst Mountain at Aurisina Spring; Foot of Cliff, before Construction of Works, in Storm.

The constant growth of the city necessitating further improvement, it was finally determined to enclose the entire stretch of shore (about 900 feet) where the impervious sandstone sinks deep enough to allow the fresh water to spring from the rock. It was estimated that in this way a minimum daily supply of about 5,000,000 U. S. gallons could be secured, which was considered sufficient for a long time to come. It was further resolved to increase the entire plant correspondingly, by the erection of a new pumping station, the laying of a new 20-inch main to the city, and the construction of a reservoir of 800,000 U. S. gallons capacity at an elevation of 400 feet, so as to supply the higher portions of the city's suburbs.

These various works were commenced about 1899, and some of the accompanying illustrations give an excellent idea of the progress of a very interesting part of them, viz.: the construction of the collecting basin for the springs. Roughly described, this basin simply consists of a wall about 900 feet long, built in the sea at a very short distance from the shore and parallel to it. At the two ends, short flank walls were built to the shore, so that a long rectangular basin was formed, which was arched over to prevent the waves from beating in. The interior space is thus sealed water-tight against the sea and affords access only to the fresh water springing from the mountain side, which is conducted from it to the pump wells in the engine house.

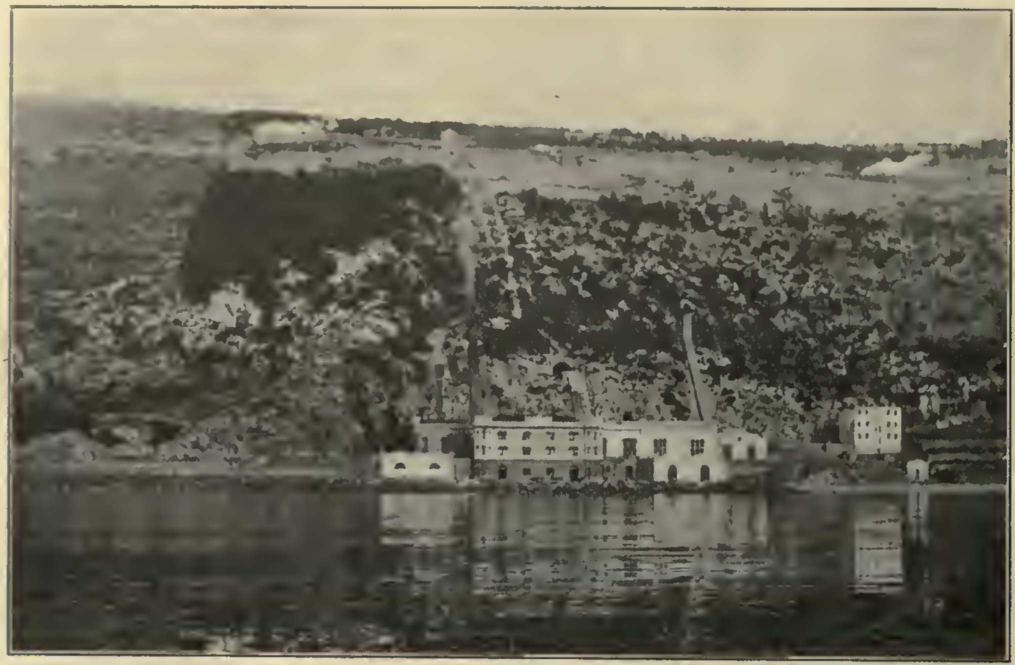
While these works were in course of construction, plans were worked out for a new filter plant to take the place of the existing old and obsolete sponge filters. These plans, which contemplated the introduction of a slow sand filter system, were about to be carried out, when the writer, as the representative of the Jewell Export Filter Company, approached the city authorities and the water company with a view of inducing them to adopt the American rapid system of filtration in the place of the contemplated slow sand system. He finally succeeded in convincing the authorities of the desirability of the American system, and in negotiating with them a contract for the construction of a new filter plant of that type. The leading features of this filter plant were embodied in the writer's preliminary sketches. The final plans for the filter plant were drawn under the direction of Mr. Edmund B. Weston, M. Am. Soc. C. E., M. Inst. C. E., consulting engineer, of Providence, R. I.

Description of the Filter Plant.—The filter plant is located about 7 miles from Trieste on the previously described seaward mountain slope, where the required space had to be obtained by blasting. It is at an altitude of about 460 feet above the sea and principally consists of the following parts: Three settling basins of an aggregate capacity of 475,000 U. S. gallons; the filter house containing six low-type steel gravity filters of the Jewell design, each having a filter-bed 17 feet in diameter; the clear water reservoir under the filter house, of 370,000 U. S. gallons capacity; the motor and pump room, and the gravity coagulant apparatus (sulphate of alumina). The rate of flow through each filter is kept constant by a Weston automatic effluent controller.

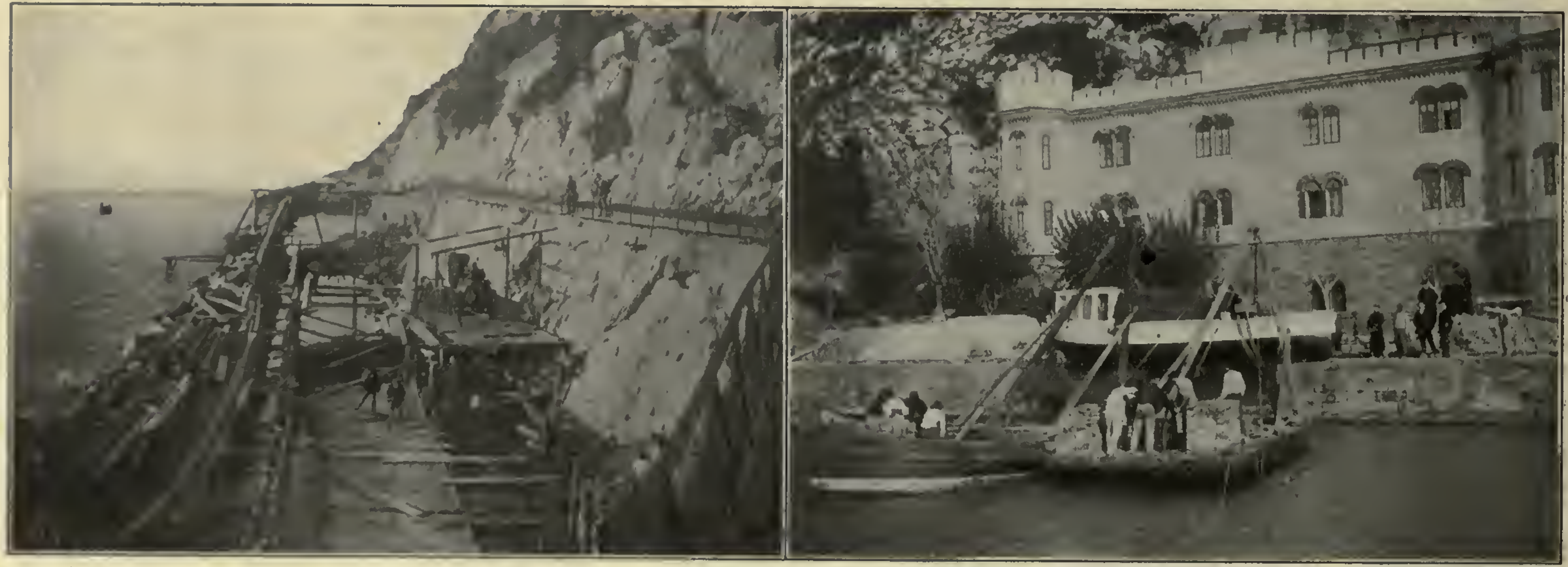
The raw water is pumped up from the pumping station into the settling basins, the coagulant being applied by gravity immediately before these basins are reached. From the settling basins the raw water enters the 30-inch supply pipe in the adjoining filter house, and thence the filters themselves. After having passed through these, it is discharged into the clear water reservoir underneath, from which it flows by gravity through a 20-inch main to the two distributing reservoirs previously described.

The capacity of the plant is about 4,000,000 U. S. gallons per 24 hours, at a rate of filtration of about 127,000,000 U. S. gallons per acre per 24 hours. The filter tanks are of the Jewell low gravity type and are made of steel; each filter-bed contains about 40 tons of sand, the effective size of which is about 0.50 mm., and which was imported from the United States. A 10-inch centrifugal pump delivering about 2,000 U. S. gallons per minute is used for washing; this pump and the agitator used for stirring the filter-bed during the process of washing are driven by two Otto benzine motors of 30 horse-power each. A third motor and a second pump have been installed as a reserve in case of accident. A small Otto motor of 6 horse-power serves for the electric plant by means of which the various structures are illuminated. The height of water in the settling tanks and in the clear water reservoir is registered by floats acting on electric connections. The sulphate of alumina coagulant is stirred by an air compressor.

The pumping plant which lifts the water collected in the previously described collecting basin up to the filter plant, is shown in the accompanying illustrations. There are now four horizontal double acting pumps, each capable of lifting about 2,400,000 U. S. gallons per day to the required height of about 475 feet. The accompanying general view indicates the relative positions of the pumping station and collecting basin, at the foot of the cliff and the filter house and the railroad above.



Trieste Water Supply: General View of Works.



Trieste Water Supply: Construction of Collecting Basin at Foot of Cliff; Part of the Aurisina Pumping Station.

Trieste Water Supply: Wall and Top of Finished Collecting Basin between Foot of Cliff and Sea.

Widening the Gauge of the National Railroad of Mexico.

By J. L. Bothwell.

The standardizing of a narrow-gauge road is always full of certain features of more or less interest to engineers and the public at large, and while the work recently completed by the National Railroad Company of Mexico did not require any particular features in construction, still it possesses some points that ought to be of interest. As is well known, this road has been operated as a narrow-gauge road from Laredo to the City of Mexico, and has been doing an enormous business, notwithstanding its gauge; but it was decided to change the gauge so as to allow a better exchange of cars at the border, and also to put it on a par with its main competitor. After many surveys and discussions, and after other features had been adopted, work was ordered begun, materials purchased and everything done to facilitate the work, no attempt being made, however, towards breaking a record for rapid work.

Trieste Water Supply: Filter House, Subsidence Basin and Clear Water Reservoir.

The line practically followed the old line to San Miguel Canyon, where a change from the original line was made. In following the old narrow-guage line, there were cuts and embankments to be widened, bridges to be replaced or strenghtened, culverts to be enlarged, new culverts to be put in, and a general overhauling of the whole way. When the San Miguel Canyon was reached, it was decided to straighten the line as much as possible, and at one point, El Codo, or the Elbow, it was decided to pierce the mountain with a tunnel nearly 1,300 feet in length, making it the longest railroad tunnel in Mexico. It was through this canyon that the line was considerably shortened and several curves eliminated.

From Gonzales, a station on the old line, a new line was surveyed to the east for a shorter and better line, all the work on which was entirely new and contained quite a number of interesting features. It was on this last named line that the principal reduction of curves and grades took place, and when it is said that on the old line the maximum grade was 4 per cent. while on the new line it is 1.50 per cent., the gain will be appreciated. The new line runs parallel to the Mexican Central Railroad through the Hercules Canyon. A new tunnel was drilled through the mountain here, which is an excellent piece of work, notwithstanding the difficult work required to complete it. The line here runs through a magnificent agricultural country and the advent of a new line was hailed with delight by the ranchmen in the vicinity.

Following on down the line, we come to the "Big Fill," a fill built on a curve and containing 400,000 cubic yards of earth, which is one of the large fills of the continent. The Chone Barranca is crossed on a modern steel bridge of 220-foot span, 177 feet above the bottom of the barranca. The view from this bridge is grand. To the east of the bridge stands a high wall of rock forming a dividing point of two streams of water. These walls are nearly 160 feet high and are of a pink sandstone of various shades. Leaving the Hercules Canyon and coming on down the line, we soon meet the Central Railroad again, which runs parallel until both roads go through the Barrientos Hill with a double tunnel. This tunnel is about 720 feet long and of sufficient height and width for two tracks. The walls and the arch to a height of 3 feet above the spring line are of mass concrete, while above this height the arch is of concrete blocks laid in cement mortar. Work was prosecuted day and night on this tunnel, and the work was completed five days before the expiration of the contract time. This tunnel is a fine piece of work and reflects great credit upon its designer and builder.

As was expected, new round-houses, turntables, stations, ware-houses, coal-chutes and several interlocking plants where the road crosses foreign roads, were required. The project was carried out successfully and with little interference with the traffic. The whole work, requiring the boring of three tunnels and the building of several new bridges and culverts was executed with military precision. Connecting yards were laid with three-rail tracks, switches etc., and the main line was laid with seventy-pound rails the entire distance. This standardizing of the National Railroad, together with the shortening of its distance, has done a great service for the traveling public, and it is already beginning to make its advantage felt. This new line was completed and put into operation almost before the public were aware of it.

The standardizing of this road required the purchasing of new rolling stock, and in a great many instances the newer rolling stock of the narrow-gauge system was converted to standard-gauge system and is doing good service. The entire work is now being gradually brought up to the standard requirements, and when it will have been completed this road will have no superior in the Republic as to road-bed, rolling stock and general efficiency.

Trieste Water Supply: Interior of Filter House.

A Special Telephone System has been installed between the Lansing and Detroit plants of the Olds Motor Works, as the ordinary telephone service proved inadequate. The new line renders communication between the plants, about a hundred miles apart, as easy as between the buildings of each local plant. Special telegraph lines between distant plants are not uncommon, but such a long-distance telephone line for one company deserves mention.

The Baltimore Fire.

Shortly before 11 o'clock in the morning of February 7, a fire started in the heart of Baltimore, which raged about thirty hours and consumed a large portion of the banking, wholesale and warehouse district of the city, involving a direct loss of property estimated at over $100,000,000. The burned district was comparatively level ground. It comprised two portions, one about a quarter of a mile wide from north to south and three-quarters of a mile long from east to west, embracing the banking and office buildings, the other portion a triangle of about 40 acres south of this, which extended to the water front and included the wharf and warehouse districts. The bank district was built in solid blocks averaging about 300x350 feet, separated by narrow and moderately wide streets at right angles to each other.

Very few of the buildings were more than five or six stories high and nearly all had brick walls. Probably 80 per cent. had wooden floors and roofs and perhaps 75 buildings had steel floor-beams and girders, some of which were supported on steel or cast-iron columns, and others on brick walls and partitions. Most of the exterior walls supported the outer ends of the floor-beams and all of them were self-sustaining. Very few of these buildings made any pretension to fireproof protection for the steel work. In only a very small percentage of the buildings were there iron shutters to protect some of the windows, but they were rarely provided for the street windows. In most cases they were made of very thin sheet metal, which proved inadequate to withstand the flames.

There were scarcely a dozen tall buildings of skeleton steel construction with fireproofed frames in the district. One of them was sixteen stories high and several were twelve stories or less. In many cases the framework, walls and floors of these buildings have endured the fire without very serious injury, so that many of them can be repaired or need be only partly torn down. The other buildings, with a very few remarkable exceptions, were entirely destroyed by the fire. From the testimony of witnesses and from the effects observed, it seems that the intense heat of the fire in most cases broke the windows of buildings in advance of the flames and ignited all the woodwork and combustible contents, or else the buildings were set on fire through their roofs and by the large blazing embers which were carried to great distances by the high wind. If the roofs and windows of even the non-fireproof buildings had been properly protected it is believed that the fire would not have attained unusual proportions. These, however, are the very points where protection was lacking. A few buildings were saved by their thick iron shutters and one, which is elsewhere mentioned, was doubtless saved by water curtains over the windows. In all it is estimated that about seventy blocks, including 1,500 buildings, were burned.

A high wind was prevailing during the fire and an intense heat was soon developed which produced a remarkably complete destruction of all combustible portions of the buildings and their contents, so that surprisingly little charred debris is seen in the ruins, which consist principally of heaps of bricks, broken masonry and cast-iron fronts and columns and twisted steel shapes. The fire was driven by the wind for eight or ten hours in a northeasterly direction to the northern limits of the burned district, where the last buildings attacked were the tall steel-cage Equitable and Calvert buildings. Their contents were entirely consumed, but they suffered comparatively little serious structural injury and interposed a considerable barrier to the spread of the flames. Just beyond stood the massive masonry walls of the new court-house, the post-office and the city hall, the last two being separated from them by wide streets. This circumstance enabled the firemen to make a determined stand at this point. The massive public buildings resisted the fire and escaped with practically no other injury than some surface damage to the front of the court-house.

About the time that the fire reached this point the direction of the wind changed from southwest to northwest. This together with the conditions above described, prevented the further spread of the fire to the north, but swept it unimpeded to the water's edge, on the southeastern boundary of the bank district, and through the wharf district as far as the little stream called Jones Falls, where a stubborn fight was made with a large number of engines. The fire was kept out of the lumber-yard district except in one spot.

The fire early gained such headway that the efforts to check it in the bank district were almost wholly unsuccessful. In many instances the horses' harnesses and the firemen's clothing caught fire and drove them away before they could get the engines in operation, and in one case the engine had to be abandoned entirely. Along the north side of the burned district efforts were made to stop the conflagration by destroying unburned buildings by dynamite. Holes were drilled in the foundation walls and several cartridges were fired in them by electricity. In some cases this resulted in the entire destruction of the buildings, and in others it only partially demolished them. Most of these buildings were close to the fire when dynamited and at best their destruction cleared only narrow spaces, across which the flames swept without any apparent hindrance. It was generally considered that the dynamite as employed produced no good effect and its use was soon discontinued.

A large number of fire engines from Washington, Philadelphia, New York, Wilmington and other places assisted the Baltimore engines. The police force was reinforced from other cities and a considerable number of regular soldiers were detailed for service during the fire and to patrol the district afterward. Temporary offices for many of the companies burned out were established in the vicinity of the destroyed buildings and business was resumed to some extent as soon as the fire was extinguished.

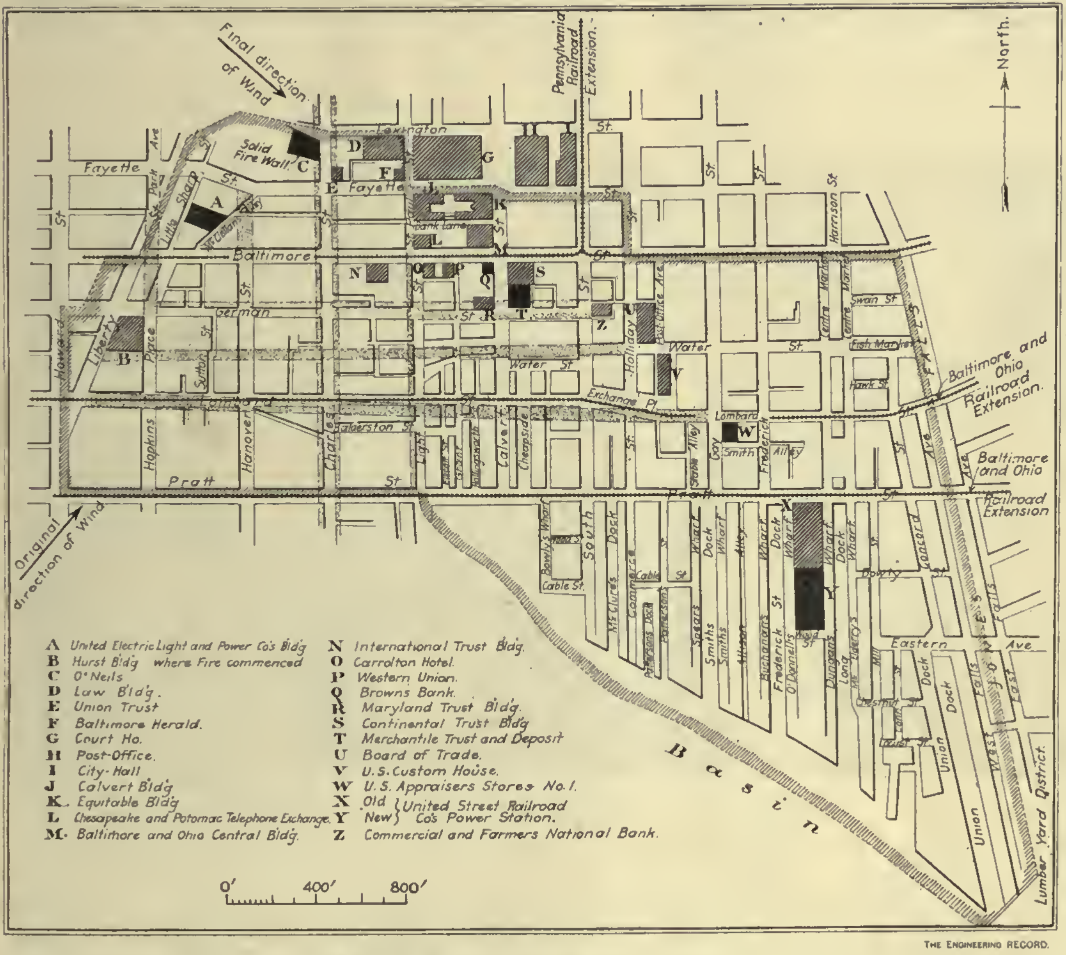
Water Supply.—For about twenty hours all the Baltimore fire engines, which together used some 12,000 gallons of water per minute, and an equal number of foreign engines, of larger average capacity, played streams of water having an aggregate estimated at about 30,000 gallons per minute. During this time Mr. A. M. Quick, president of the water board and water engineer, visited every engine and found it abundantly supplied with water at a good pressure. The Baltimore water system is divided into high service, middle service and low-service districts. The middle service district, in which the fire originated, is supplied from elevated reservoirs. About two hours after the fire commenced, the Mount Royal pump, with a capacity of 17,500,000 gallons a day, was connected to the mains of the system and supplemented the reservoir service. When the fire reached the low-level district, the by-pass between it and the middle district was opened and the pressure was maintained at 80 pounds maximum. Of the water not furnished from the pumping station, the supply was drawn at first from the Druid Lake reservoir of 430,000,000 gallons capacity. The level of the reservoir did not begin to fall until Monday, when it dropped 0.4 foot, equivalent to 6,000,000 gallons. A larger amount of water was drawn from the low-service, from the 265,000,000-gallon Clifton reservoir and the 500,000,000-gallon Montebello reservoir, about 20,000,000 and 34,000,000 gallons respectively, as indicated by their gauge readings. It was considered fortunate that within a year about thirty of the old single-nozzle hydrants had been replaced by improved two-nozzle hydrants, which were found to give abundant flow during the fire. Within two years all mains less than 6 inches in diameter had been removed from the burned district, and all the larger mains were cross-connected so as to provide excellent distribution and complete circulation in this part of the city. Other very decided improvements in the water service had been effected since 1896, as indicated by the following items of increased installation, namely: Mains from 10 to 48 inches in diameter, increased from 100 to 162 miles; storage capacity of mains, from 9,380,000 to 14,544,000 gallons; reservoir capacity, increased by 271,000,000 gallons; fire hydrants, from 1,757 to 2,350; area in which pressure was less than 40 pounds decreased from 53.4 per cent. to 13.8 per cent.; minimum pressure 20. It is estimated that the water department will sustain a loss of about $70,000 this year in its collections from the burned district. This is the only loss or injury sustained by this department.

Ruins and Debris.—The water front and the other boundaries of the burned district are closely patrolled by a large number of soldiers under the command of Adjutant-General Clifford L. Riggs, and very few passes are issued to enter the district except for the contractors and officials at work on the ruins and debris. The soldiers are divided into three relays, each being on duty for eight hours at a time; part of them have quarters in the armories and part of them have cooks who provide their meals at open camp-fires. Most of the few buildings which partly escaped destruction are closed and strongly guarded by private watchmen and police. Orders have been issued that no safes shall be opened in the burned district, but owners are permitted to remove them beyond the limits. Stringent rules were necessary to guard the millions of dollars worth of valuables in the ruins and to prevent loss of life from falling ruins and from explosions. Many buildings were in a very unstable condition, and bricks, stones and even safes were constantly falling. It was impossible in many cases to tell whether a building could be entered with safety.

Wrecking parties were immediately organized to systematically raze unstable walls and pull down iron-work and other portions of the buildings. These parties included ninety U. S. engineer troops equipped with ten days' rations and having a ton of gun cotton and other explosives. The dynamiters were in charge of Mr. R. E. Lafferty, and were equipped with a steel magazine on wheels, which contained 450 pounds of dynamite in half-pound cartridges. This was thawed when necessary in pails of water heated at a bonfire, and the cartridges were inserted under the foundations, tamped with clay and discharged by an electric battery.

Immediately after the fire an examination was made by Mr. Edward B. Preston, building inspector, who marked all dangerous walls and buildings and was followed by the wreckers, who overthrew them. In some cases lines were shot over walls which were too dangerous to be approached, and several steam hoisting engines were used to pull down the heavy masonry by the means of steel cables. The second, third and fourth story vaults of the Consolidated Gas Company were built into a steel shaft, which alone remained standing above the ruins of the building; false-work was built around the shaft to give access to the vaults so that their contents could be removed, which was done in safety.

The aggregate length of the streets in the burned district is about 20 miles, and fully two-thirds of their area was filled with bricks and other debris, frequently reaching a depth of 10 feet. It was not at first attempted to remove this material, but large forces of men were employed to clear it out of the streets and throw it back on to the sites of the buildings. By this method about 7 miles of the principal streets were cleared by the evening of February 13. Preparations were then being made to extend the tracks of the Pennsylvania and of the Baltimore & Ohio railroads through the burned districts in three main east and west lines, as shown on the accompanying map. From these main lines spurs will be run as needed in the north and south streets. Alongside them inclined platforms will be built. The debris will be excavated with pick and shovel and removed by one-horse dump carts of 45 cubic feet capacity. These will be driven on to the elevated platforms and thence deposited on platform and gondola cars. The debris will be used for reclaiming land and filling along the water front, or will be dumped on barges and carried out to deep water.


Final direction of Wind
Original direction of Wind
North
Solid Fire Wall
Pennsylvania Railroad Extension.
Baltimore and Ohio Railroad Extension.
Baltimore and Ohio Railroad Extension
Lumber Yard District
Basin
A United Electric Light and Power Co's Bldg
B Hurst Bldg where Fire commenced
C O'Neils
D Law Bldg.
E Union Trust
F Baltimore Herald.
G Court Ho.
H Post-Office.
I City-Hall
J Calvert Bldg
K Equitable Bldg
L Chesapeake and Potomac Telephone Exchange.
M Baltimore and Ohio Central Bldg.
N International Trust Bldg.
O Carrolton Hotel.
P Western Union.
Q Browns Bank.
R Maryland Trust Bldg.
S Continental Trust Bldg
T Merchantile Trust and Deposit
U Board of Trade.
V U.S. Custom House.
W U.S. Appraisers Stores No. 1.
X Old } United Street Railroad
Y New } Co's Power Station.
Z Commercial and Farmers National Bank.
0' 400' 800'
THE ENGINEERING RECORD.

Map of the Burned District in Baltimore.

The work is entirely done by white laborers who are paid $1.50 a day by the city, or by trained gangs of trackmen furnished by the railroad companies, who are paid for their services by the city. The city has 150 carts and expects to secure 300 or 400 more and employ a total force of about 3,000 men, who will be worked in three successive eight-hour shifts.

Electric Service and Gas Mains.—The results of this fire demonstrate in an impressive manner the advantage of having the electric wires underground. In the business section of Baltimore it was required by law that all electric poles should be abolished and the wires laid in the subways, recently constructed in the burned district. Considerable opposition to this requirement had been manifested by some parties, and some of the branch wires were still carried on poles; but in the burned district all the railway feeders, street-lighting mains and telegraph and telephone lines were in the subways. Both the subways and the wires they contained were entirely unharmed and have not been out of service at all. The fire-alarm system had its mains carried through the subways and continued in operation throughout the fiercest of the fire. The street lights were also in operation until their poles were destroyed. The distribution branches of the electric-light system were carried on poles and were completely destroyed. The wires of the Maryland Telephone Company were burned off at the buildings, but the ends of the mains were sealed up as soon as possible at the conduits and the circuit remains unbroken. The Chesapeake & Potomac Telephone Company used a block system on the walls of buildings, which was, of course, burned out. The offices of the Western Union and the Postal Telegraph companies in the burned district had separate mains leading to and from each outlet. These two mains were by-passed outside the offices so as to cut out the latter, and new connections were made between the main thus carried past the old office and those outside the burned district, so that operations were resumed before the fire was under control.

Power for the different street car lines had originally been furnished from several stations scattered over the city. Most of these had been shut down so that all current was furnished from the old and new power-houses of the United Railways & Electric Company. This plant included a total installation of 24,000 horse-power, but machinery of about 12,000 horse-power was disabled by the burning of the old part of the station. The remaining supply was interrupted by the destruction of the exciter for the generators in the new power-house, where none of the machinery was in any degree injured, the exciter itself being outside of this building. A 250-horse-power Westinghouse engine and dynamo was hastily removed from one of the sub-stations and installed in the power-house by Mr. Wallace Stebbins, and enough power was then furnished from the uninjured plant to operate most of the electric cars in the city with the aid of some additional power from such of the old stations as could be again put into service.

Some difficulty and danger were experienced from the gas mains, which were broken at nearly every burned building and thus leaked great quantities of gas. This collected in numerous places and caused a number of explosions, none of which, however, was serious. The supply was shut off as rapidly as possible, and as a further precaution all of the pipes and manholes in the burned district were filled with water.

Proposed Improvements.—The officials and citizens have not been slow to realize that the reconstruction of so large a part of the city affords splendid opportunity for making radical improvements that could not otherwise have been secured. The mayor has appointed a committee of citizens to take preliminary action of an advisory nature concerning the reconstruction work. The functions of this committee will be:

1. To collect and supply authoritative information concerning the financial condition and resources of Baltimore, so as to allay needless anxiety at home and abroad.

2. To suggest such public measures as will enable the municipal authorities to take advantage of present conditions in the improvement of the burned district.

3. To give advice to property owners concerning the reconstruction of their destroyed property.

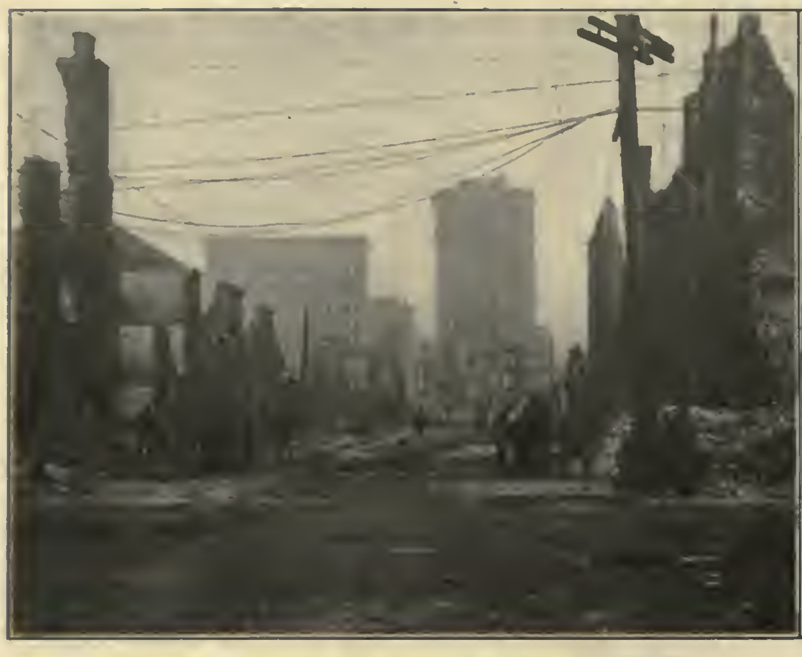
4. To offer to the municipal authorities such suggestions as business men and experts may formulate regarding the best methods of handling the many questions which must arise in dealing with the burned district.

5. To suggest such legislation as may be required with a view to present or future needs.

6. To suggest the best means of dealing with the problems of reduced taxable basis and increased municipal expenditure with which the city is now confronted.

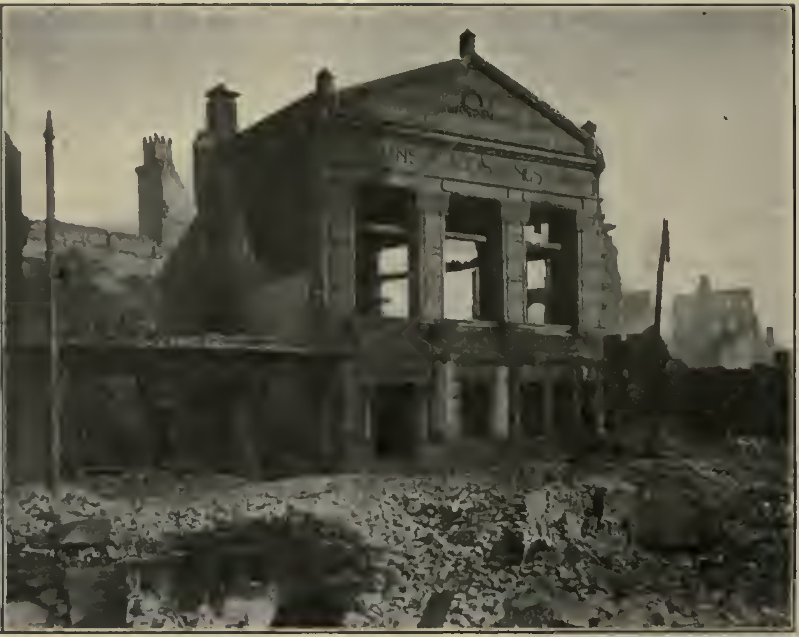
At this writing no improvements have been decided upon in regard to the betterment of the streets, although it has been considered desirable to straighten and widen a number of the principal thoroughfares in the burnt district and extend others there as indicated by the dotted lines and shaded places on the map. These improvements will interfere with the subways and the water and gas mains, but not materially with any important sewer construction. They may be accompanied by changes in street grades, especially at the bridges over Jones Falls. Legislative action will be required to accomplish these improvements. The standing commission for opening streets already exercises the right of assessing both benefits and damages, and as these often prove about equal they may in this case operate to prevent very large additional expense.

Building Laws.—The existing building laws are considered inadequate and unsatisfactory and will probably be radically modified before the new construction is permitted. At present all permits for new buildings are withheld until decisions are reached concerning the changes in streets and modifications of the laws. The latter refer chiefly to dimensions, strength, materials, etc., and have but very few specific references to fireproofing, the principal requirements being that buildings over 100 feet high shall be fireproofed throughout; that stores and warehouses more than two stories high must have fireproof shutters on all openings not on a street; that all outside walls shall be built of stone, brick, iron or other non-combustible ma-



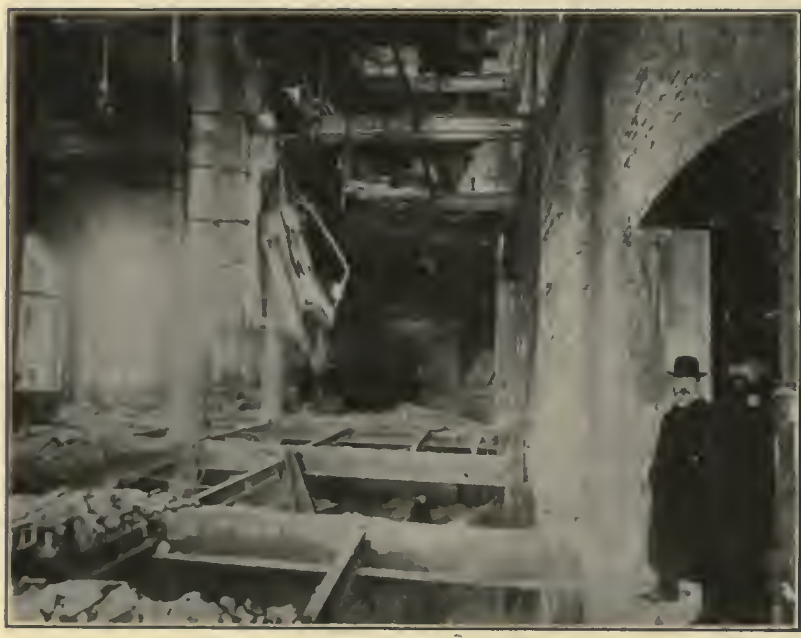
Calvert Street, Looking North, Showing Ruined Buildings.

In background, Maryland Trust at left: Continental Trust at right, with cast-iron frame of four-story building in front of it.



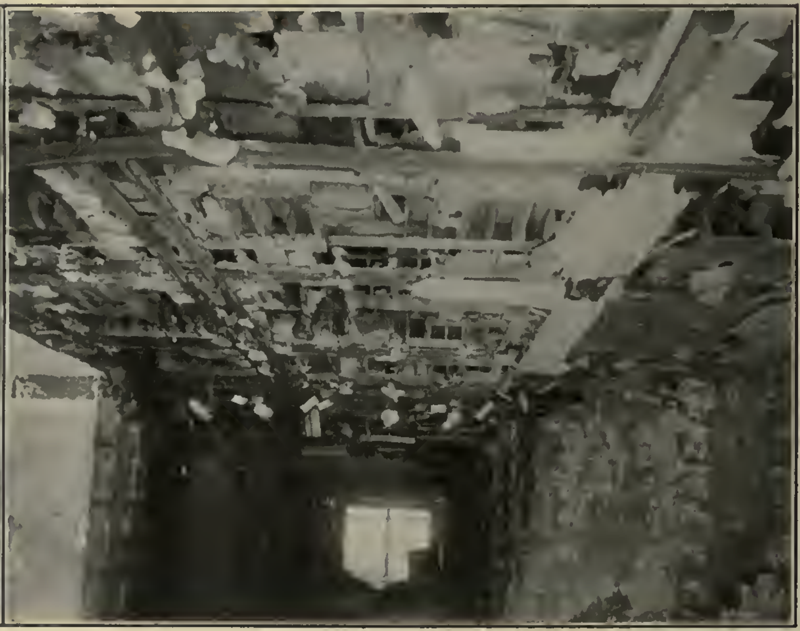
Hopkins Place Savings Bank.

Marble front resisted fire well. All the adjacent buildings were completely destroyed, as clearly shown in the picture.



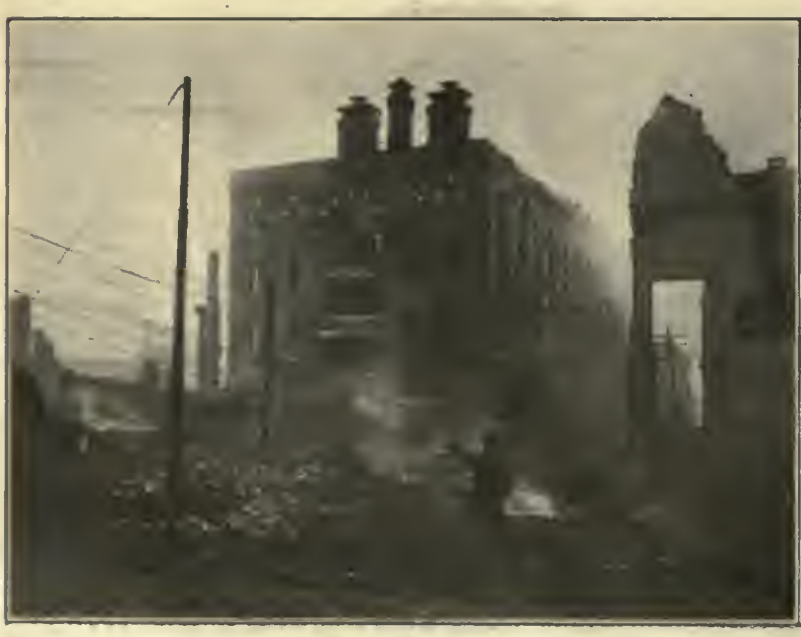
Main Hall in Second Story of Equitable Building.

Showing expanded metal ceiling furring, uninjured cast-iron columns and piles of fallen safes in basement.



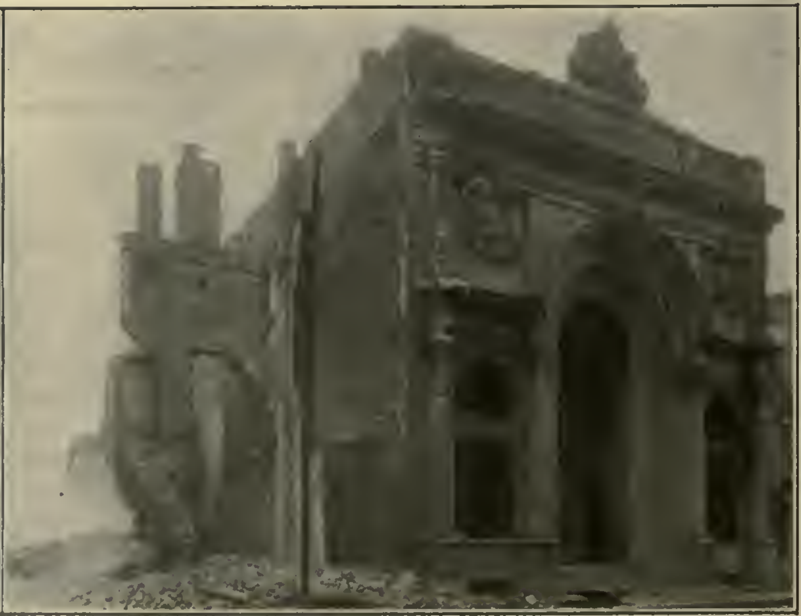
Corridor in Continental Trust Building.

Showing floor arch tiles, beams and girders still in place. Few if any tile ceilings were damaged more.



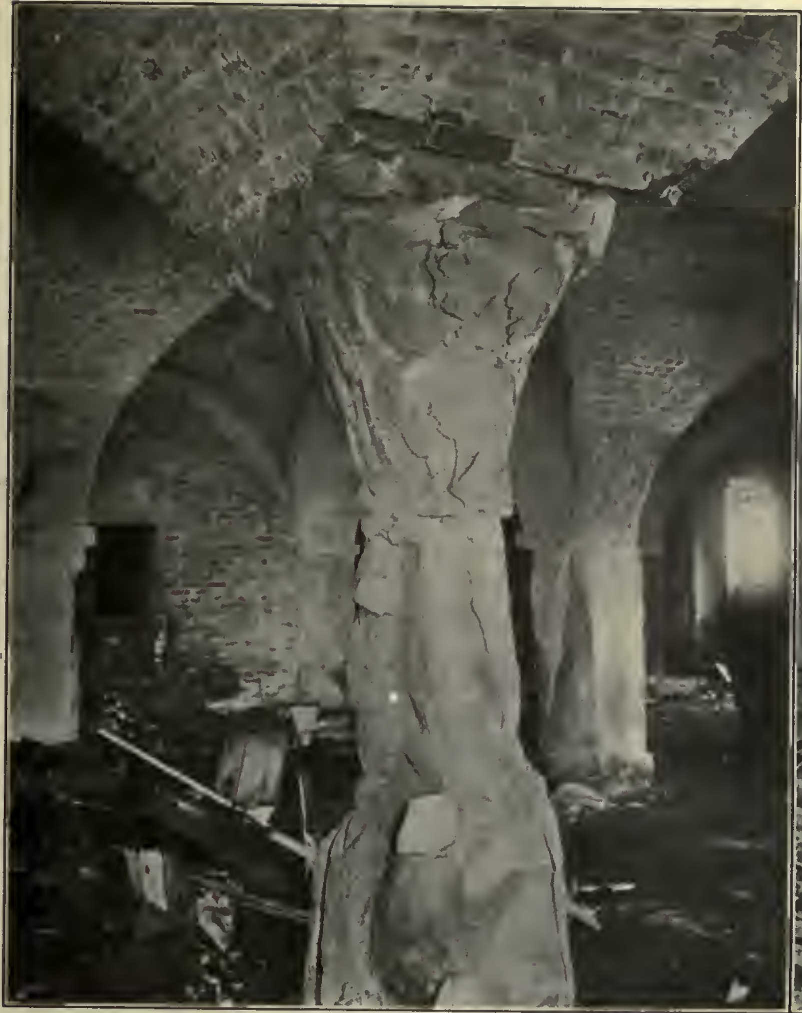
The Chamber of Commerce.

Wooden roof burned; steel framing of floors in good condition.

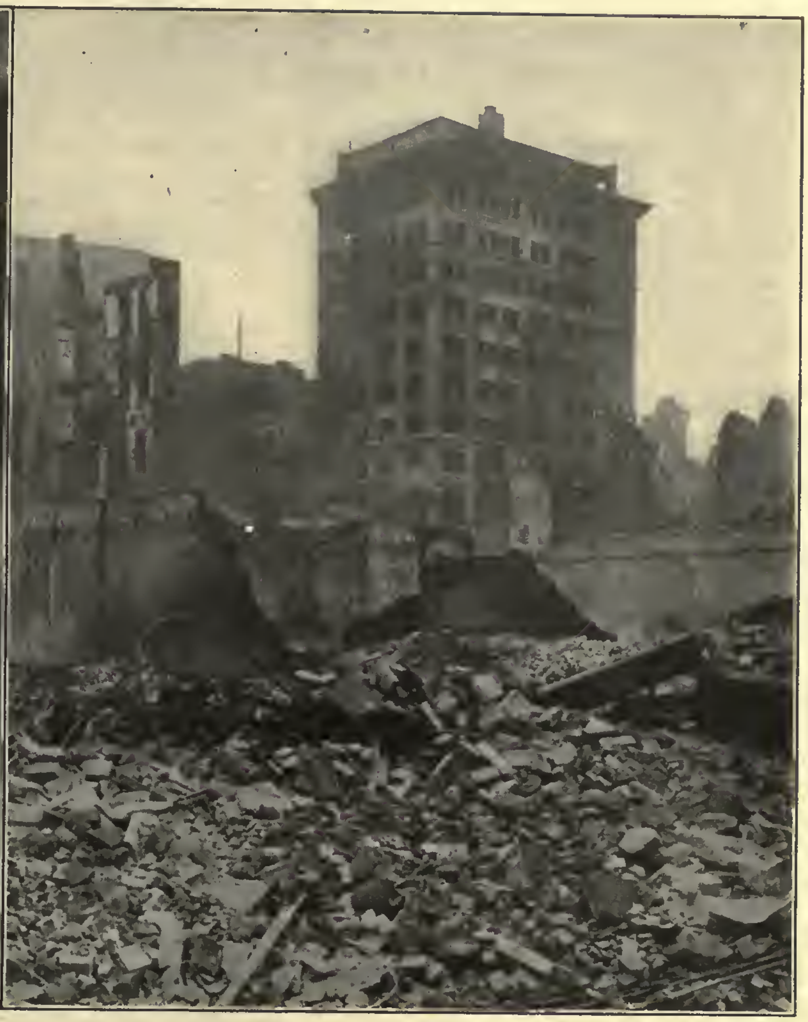


The National Bank of Commerce.

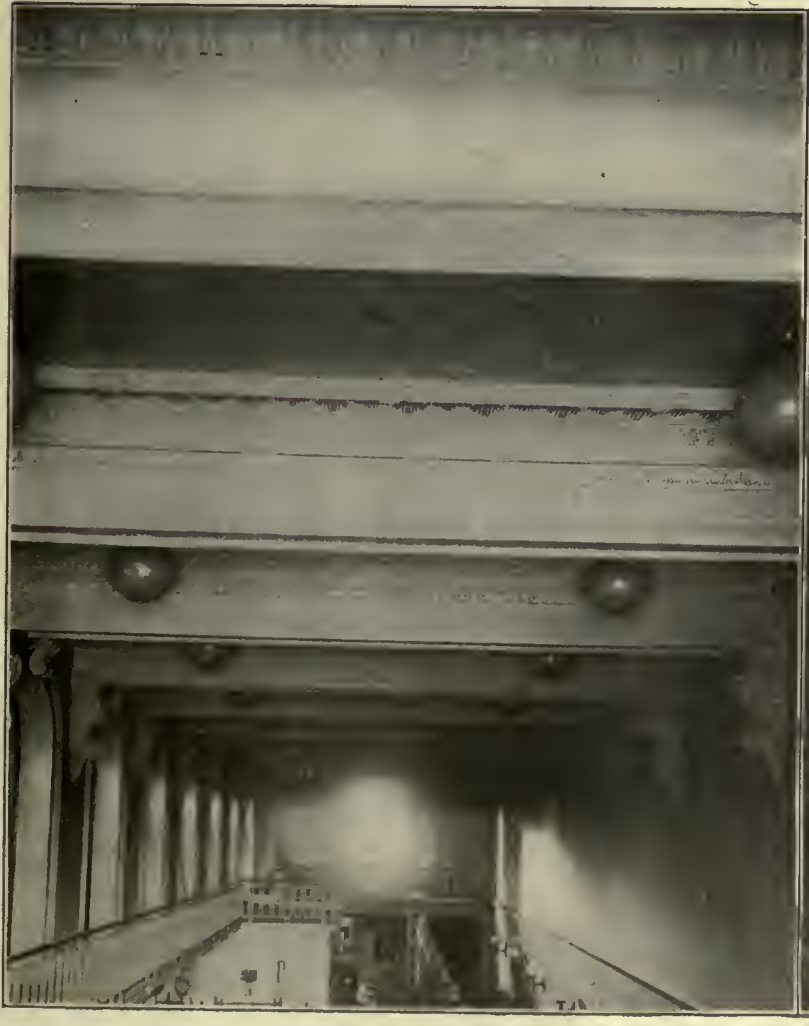
Concrete roof and floors uninjured, although a brick wall fell on roof.



Granite Columns Formerly Two Feet Square, in Third Story of U. S. Appraisers' Warehouse.

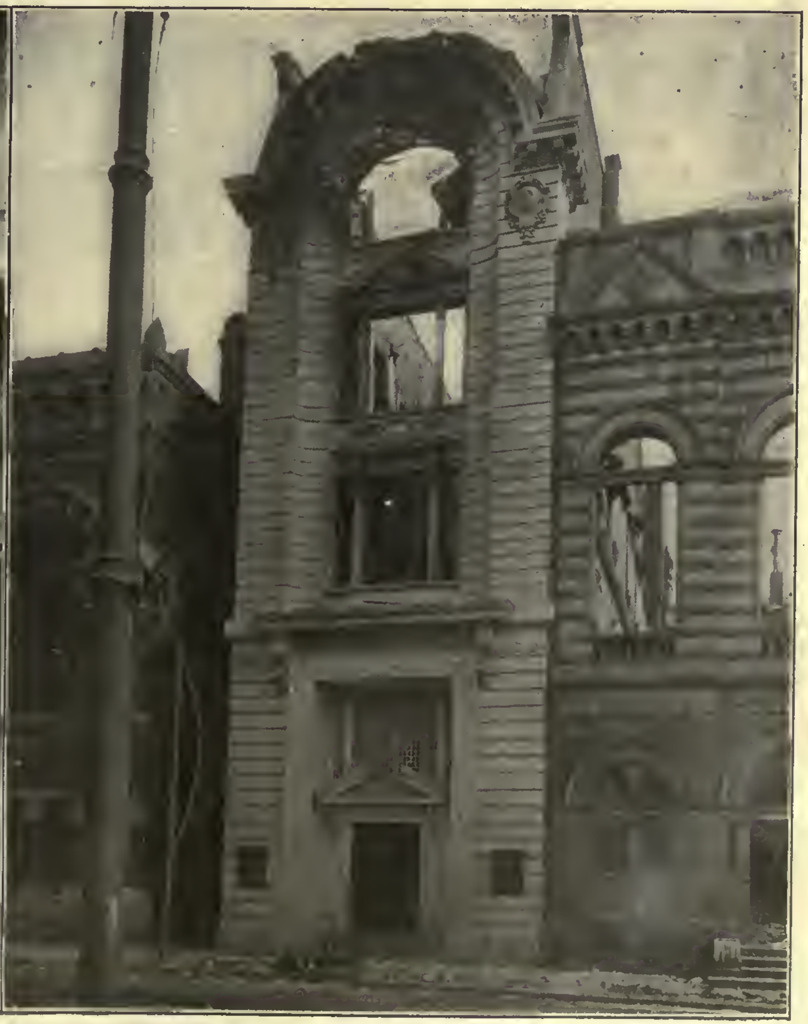


Union Trust Building, Stone Work Injured, Fireproofing and Floors in Good Condition.



The Commercial and Farmers' National Bank.

Street floor banking room preserved from injury by concrete floor above.



Four-Story Commercial and Farmers' National Bank.

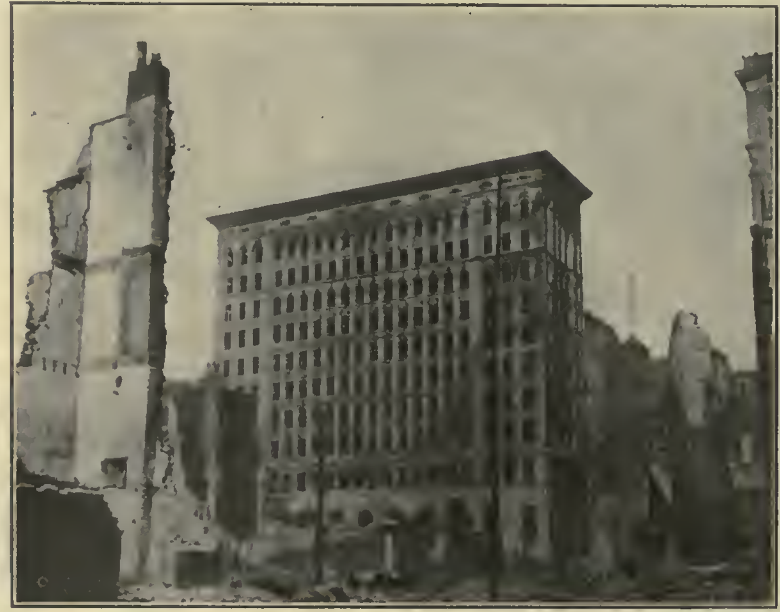
Wooden roof and two upper floors were completely destroyed.

terial and that the roof sheathing shall not extend across the front, rear, side, end or division walls. The building inspector has for four years endeavored to secure the revision of these laws and now hopes to have them modified so as to eliminate all wooden frames and sash in steel buildings; to limit the heights of all buildings to eight 15-foot stories; to require all plans to be filed and approved, and to require some form of efficient window protection like rolling steel shades or wire glass. Electrical distributing lines should not be run, in his opinion, from house to house through the cellars. Provision will probably also be made for satisfactory fireproof construction and the equipment of buildings with fire apparatus. At present the department maintains eleven inspectors, but this number is considered entirely inadequate and will probably be increased. The requirements for dimensions of walls should be modified and provision made for curtain walls. It is proposed to establish in this department extensive municipal experimental physical and chemical laboratories for the investigation of materials by the department and by builders and contractors.

Condition of Buildings.—The sixteen-story Continental Trust Company's building was finished in 1903 at a cost of about $1,000,000, D. H. Burnham & Company being the architects and Charles McCall the contractor. It is much the tallest building in the burned district and has a steel framework carrying the walls at every story. The floors are flat hollow tile arches and the partitions are built of 4-inch hollow tiles. The columns are fireproofed with flat tiles. The outer walls are of brick with special face brick not bonded to them but secured by metal anchors. The cast-iron mullions of the light court windows have T-shape cross-sections and are bolted at the top and bottom to the wall girders and spandrel beams. The building was subjected to fierce driving flames which broke the windows, deposited large quantities of live coals in the tenth story, burned its contents and wrecked all the rooms. All woodwork, window sashes, etc., were completely consumed even to the nailing strips bedded in the concrete floors, which were also observed to be wholly burned in several other buildings of similar construction. Some steel and brick vaults became so hot that although themselves intact their contents were destroyed. The safe deposit vaults in the basement and their contents were uninjured; their time locks were rewound by the automatic attachment and duly opened after the fire was over. The floors, main walls, and most of the partitions and column fireproofing endured well. The fierce flames appeared to have been driven through the corridors more violently than elsewhere and there the plaster was mostly destroyed, much of the under surface of the floor tiles was broken off and the marble wainscot was shattered. The light ornamental work around the elevator fronts was destroyed and the cast-iron stairs and their marble treads were completely wrecked. The tiles protecting the lower flanges of the floor-beams were secured with steel straps as well as by keying into the arch tiles and were well kept in place. The stone and terra cotta mullions and lintels were much broken and the cast-iron mullions in the light court buckled and bowed badly. The spandrel beams there were apparently exposed to the flame when the window heads were burned and many of them buckled out, carrying the curtain walls which tipped out several inches. The framework of the court walls is in bad condition and will probably have to be rebuilt. Much of the face brick on the outer walls came off in large patches.

The interior fireproofing was efficient, the floors are sound and did not even break under any of the safes and the main structural work appears to be in good condition. The owners of the building publish the following letter from Mr. D. H. Burnham: "I have minutely examined the steel structure of your building on the corner of Baltimore and Calvert streets, from the basement to the roof, and find the same intact and as good as the day it was put up. This applies to the supporting columns, the girders and joists. A few of the apron beams between the soffits of the windows of one story and the sills of windows above in the court must come out, as they are warped. These, however, have nothing to do with the main structure, as they only carry said aprons, and they can be taken out story by story without reference to any other part. The structural part of the floors of the building are unaffected, and need no renewals. I advise you to at once proceed to repair this building."

The eleven-story Equitable building was built in 1891 from the plans of Messrs. Carson and Sperry, associate architects, by Norcross Brothers, of Worcester, Mass. It had brick walls, cast-iron columns and 9-inch floor-beams of 8 feet maximum span which were designed to support Guastavino arches, but afterwards the floor was built of 6-inch hollow tile segmental arches, carrying wooden platforms and not filled in over the haunches. The columns were fireproofed with terra cotta tiles and the partitions were made with 3-inch hollow blocks of limesteal about 2 feet square. There is a light court about 20 feet wide and 60 feet long on the west side of the building and at the inner end of it there is a large cast-iron projecting bay in every story containing the cast-iron stairs with slate treads.


The Maryland Trust Company's Building.

The flames, intensified by the burning of an adjacent wooden building, were driven into the court and entered the building through the unprotected windows. The wooden sash and floors and all combustible trim and contents were consumed, but the cast-iron framing of the bay and the stairs and all but the largest slabs of their treads were uninjured. The elevator fronts were not badly damaged, but the partitions were most of them destroyed, and the floor arches were broken through in many places and many of the beams were bent and injured.

The offices were originally 15x20 feet, but many of them had been divided by wooden partitions in the middle and there were a large number of safes in the building which, it is said, were required to be seated on wooden platforms a few inches high. Many of those safes broke through the floors, probably the more easily on account of the impact when they settled down from these supports and through the spaces over the haunches of the arches. The falling safes carried away sections of all the floors below them to the basement where dozens of them were found piled up in heaps. Probably most of the holes through the floor arches were made in this way.

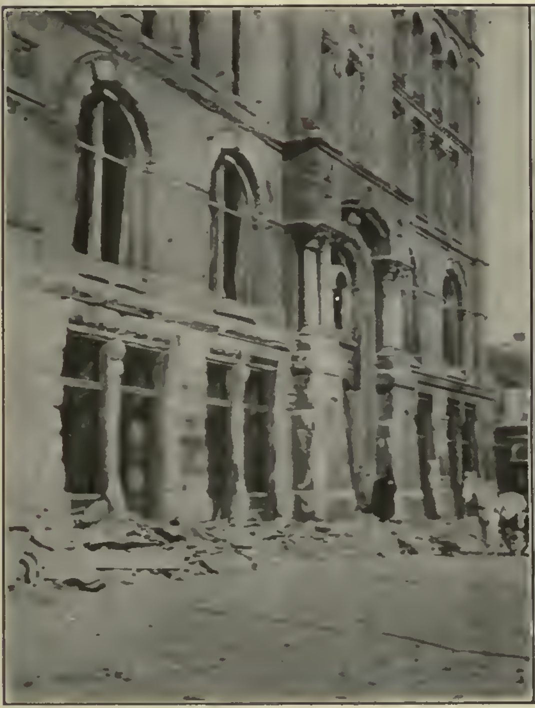
A few of the columns in the upper stories are damaged, but most of the main framework is in good condition and can readily be repaired. The outside walls, although subjected to great heat that blistered and in some cases spawled off the surfaces of the bricks, are in very good condition and are plumb and straight, including the cornice. The walls of a 20x50-foot interior light shaft were faced with glazed brick which was badly cracked and chipped, and about 8 per cent. fell off, exposing the red brick behind. The furniture and carpet in one office room escaped injury and the safe deposit vaults and contents were uninjured and its time lock was not stopped. Mr. Orlando Norcross examined the building, estimated the damage, and stated that it could probably be repaired with a renewal of a very few beams and columns and by refinishing the interior, without rebuilding the walls or a large part of the floor arches, probably cleaning the faces of the walls with a sand blast.

The twelve-story Calvert building was built in 1901 at a cost of about $1,000,000 from the plans of Mr. J. E. Sperry, by the George A. Fuller Company, Messrs. Purdy & Henderson being the structural engineers. It is about 92x135 feet with a 32x60-foot light court on the east side. The riveted steel columns have closed rectangular sections and have riveted connections to 15-inch floor-beams of 24 feet span about 7 feet apart. The brick and terra cotta walls are carried on 15-inch channels bracketed out from the faces of the columns at every story. The floors are of flat hollow tile arches and the columns are fireproofed with hollow tiles. The cast-iron mullions and the angle iron lintels over the windows were free to expand and have not bulged or buckled.

From the roof of a neighboring high building the flames were seen to enter simultaneously through many windows of one side and almost immediately burst out of the windows on the opposite side of the building. The woodwork and combustible contents of the building were consumed and some of the fireproofing was detached, but very little damage was done to the structural steel, the floors, the walls or most of the partitions; the structure as a whole enduring remarkably well. One of the columns was exposed and softened near the middle allowing all four sides to buckle outwards several inches and shortening it so much that it produced a settlement of several inches in the roof and upper floors. Another column was slightly injured and the pipes carried under the column fireproofing were exposed in places. The cast-iron stairway against the outer wall and its slate treads were uninjured and the ornamental work on the structural steel framework of the elevator shaft was not much injured, although the heat was great enough to melt the glass bulbs on the gauges. The marble wainscot in the corridors and stairways was badly broken and the thin large flat tiles in the corridor floors were very much warped and buckled.

Although the fire was worst in the upper stories the steel lath and plaster ceiling which was suspended from the roof was intact and the roof itself was entirely uninjured except for the settlement above the injured column. The wall girders were protected by brickwork between their lower flanges and the tops of the window lintels and were uninjured when the window frames burned out. The double pitched 9x42-foot skylight over the elevator well was glazed with wire glass. It was supported on short wooden columns and when these burned out the whole skylight dropped about 2 feet to the top of the brick wall, but remained practically uninjured. The outer walls were uninjured but the large blocks of terra cotta in the upper stories of the walls of the 30x60-foot light court on the east side of the building were badly cracked and broken.

The six-story Baltimore & Ohio Building had outer walls faced with granite on the lower story and of brick above. These were exposed to intense heat and the granite was destroyed in many places by chipping and spawling, which wasted away the outer surface to a depth of 6 inches in some cases. The stone peeled off in thin sheets and flakes, sometimes as much as 2 feet long, 6 inches wide and only ¼ inch thick. The brick withstood the fire much better, although damaged in places.


Granite Facing of Baltimore and Ohio Building.

Continental and Mercantile Trust Buildings.

The power house of the United Railways & Electric Company occupied most of the space between two slips on the water front and consisted of three brick buildings with steel and slate roofs. The section nearest the shore was the old power house in which was installed the old 12,000 horse-power direct-current plant. The second or middle section contained the boiler plant and the third or river section was a new building, in which is installed four 2,000-kilowatt, 13,200-volt, three-phase, flywheel-type alternating-current generators. The buildings were surrounded by fire on three sides, part of it from large piles of lumber only a short distance away. The flames entered the windows of the old power plant and burned the sashes, trim and the wooden ceiling under the light pin-constructed roof trusses of 70 or 80-foot span, which collapsed and fell with the slate roof, pulling down a portion of one side wall. Some injury was, of course, sustained by the machinery, but at the time of this writing it was not apparent whether it had been seriously damaged.

The building for the alternating-current plant was made thoroughly fireproof with brick walls, steel and slate roof, copper-covered window sashes, doors and trim, and wire glass. It resisted the flames and preserved the contents of the building from all injury, so that the service sustained an interruption of only about 28 hours. The boiler plant described in The Engineering Record of November 2, 1901, and February 1, 1902, was uninjured and the exterior walls were damaged only by the spawling of the stone work.

One of the most interesting buildings in the burned district is the United States Appraisers Stores No. 1, which was built by day labor in 1835. It is a four-story structure about 60 feet wide and 90 feet long, with brick walls 3 feet thick at the bottom, and 20 inches thick at the top. They are pierced with small windows having heavy wrought-iron sash and small panes of thick glass protected by wrought-iron shutters ⅜-inch thick with ⅜-inch frames. The shutters are on the outsides of the windows in the lower story and inside in the upper stories. All floors and roofs are of solid brick semi-circular groined arches of about 12-foot span. They are 18 inches thick at the crown and filled up level with solid masonry over the haunches. They are supported on columns 2 feet square, which, in the lower stories, are made of granite slabs and in the upper story of brickwork. In the middle of the building there is a circular stone stairway and two wells, one of which was used for a steam elevator and the other was closed by hatchways at the different floors. Over the wells and stairway there is a copper monitor roof with unprotected glass clere-story sides.

The adjacent buildings contained a great deal of liquor, the fierce flames from which burst through the monitor windows and descended through the hatchways to the third story without igniting the very combustible goods stored in the fourth story. A quantity of high wines and proof whiskey in the third story was set on fire and about $20,000 damage done to them without burning more liquor stored in other portions of the same room. The heat caused the granite columns to crack and spawl, as shown in the engraving. Six of them were very much reduced in section, and two more which are not visible in the illustration were entirely destroyed, so as to collapse altogether and afford no support to the floor above. In these cases the masonry developed sufficient strength to carry the double spans of the unsupported arches without cracking or any indication of injury, except a settlement which caused one of the brick piers in the fourth story to crack entirely across in a horizontal plane leaving a space through which daylight could be seen between the upper and lower parts. This was absolutely all of the structural damage done to the building, and it will be repaired at a cost of about $2,000, including the repairs to the monitor. The latter was made of copper nearly ¼ inch thick, which was not much damaged and only needs straightening and re-glazing. The elevator machinery was injured and the small annex to the building was burned, causing $2,000 or $3,000 additional damage. Mr. W. S. Blair, superintendent of the building, intended to remain in it throughout the fire, but was driven away at 4 o'clock in the morning by the increasing density of the smoke. The building and its contents were entirely uninjured except as above described, and it is remarkable that the window glass which was exposed to intense heat outside of the upper iron shutters was not broken.

The Mercantile Trust Building is two stories high with thick walls and a steep slate roof. It stood next to the Continental Trust Building, and was evidently protected by it as it was one of the very few buildings saved in the burned district and was reported to be structurally uninjured. The wire glass skylight was broken by debris from the Continental Trust Building and admitted sparks which burned some of the interior, but the damage was so slight that the building was ready for occupancy again in a few days. Another curious example was that of a three-story frame building adjacent to the Hurst Building, where the fire originated, which escaped although the fire extended some distance beyond it against the wind.

The Farmers & Merchants National Bank was a six-story structure with brick and stone walls and riveted steel floor-girders supporting wooden beams, floors and roofs. The interior and contents were entirely consumed, leaving the girders in position badly warped and twisted and most of the walls standing.

The six-story Herald Building, of which Mr. J. E. Sperry was the architect and Mr. John Hills the builder, had brick and terra cotta walls, hollow tile flat arches and limeateal hollow block partitions. The contents of the building and the interior trim were burned, but the walls are in good condition and the floors sustained the safes and were not much injured.

The Bell Telephone Building and the Merchants' National Bank had hollow tile floor arches and fireproofing which are in excellent condition.

The Mechanics Bank, Messrs. Baldwin & Pennington, architects, and Mr. John Waters, contractor, had steel beams and rowlock brick floor arches reported as entirely uninjured by the fire, which is said to have injured the exposed steel work but little.

The unfinished United States Custom House has heavy granite walls which were built up to about the middle of the second story. These were injured only by the flames from small quantities of combustible material near them and by the burning of the wooden protections for the finished angles, which, in many cases, caused them to spawl and break seriously. The steel work was somewhat injured in one place by the burning of an adjacent contractor's tool shed.

The twelve-story Maryland Trust Company's Building cost about $500,000 and was completed in 1900. Messrs. Baldwin & Pennington were the architects, Purdy & Henderson the consulting engineers, and the George A. Fuller Company the contractor. It has a steel framework and brick and terra cotta walls, with hollow tile flat floor arches and 3-inch tile partitions. The walls on the three street sides are self-supporting but do not carry floor loads. The fourth exterior wall is supported by its columns. The outer walls were apparently uninjured except by the cracking and spawling of the stone work. The partitions and the under sides of the floor arches were damaged and the granolithic floor surface was heaved and cracked in the corridors. The upper story was used for the storage of great quantities of books and papers which produced a layer of ashes 3 feet deep. One of the columns here became exposed and was so much softened that it bent double on itself into a complete S-shape. It did not fall, but, of course allowed the roof above it to settle a considerable distance. The building is reported not to have received serious structural damage and to be in condition to be easily repaired and refinished inside.

The eleven-story Union Trust building cost about $500,000 and was built in 1898. Messrs. Winslow & Wetherall were the architects, Purdy & Henderson the consulting engineers, and the George A. Fuller Construction Company the contractor. It had steel Z-bar columns and 12-inch floor-beams 5½ feet apart supporting hollow tile flat floor arches covered with concrete. The partitions were built of hollow tiles and the side walls of brick. The woodwork and contents were consumed and the stonework in the fronts was badly spawled and checked so as to need considerable replacing. Otherwise the walls and the floors are in excellent condition. The steel framework is intact throughout and most of the fireproofing is in good condition. The cast-iron and marble stairs in the center well, which were exposed on three sides, are practically uninjured and it is reported that the building can easily be repaired.

The National Bank of Commerce, Messrs. Baldwin & Pennington, architects, and J. J. Walsh & Sons, contractors, is three stories high with the main banking room extending through the whole height of the building. The roof and main floor and the floors of the two galleries on each side of the banking room are of Roebling construction cinder concrete. Flames entered through the windows and destroyed most of the interior trim and contents of the building and developed heat sufficient to melt silver, brass and other metals, but did not cause any perceptible damage to the roof or floors, which appeared to be intact and in many places have the plaster still adhering to them. The walls of an adjacent building fell on the roof and covered it deeply with heavy debris without causing any apparent damage other than a slight deflection.

The Commercial & Farmers National Bank, Messrs. Wyatt & Nolting, architects, and John Cowan, contractor, was four stories high with the roof and two upper floors of wooden construction with wire lath and plaster partitions. The ground and first floors were of Roebling construction cinder-concrete arches. The three upper stories were burned and all the debris, including a safe in the fourth story, fell on to the first story floor without breaking through it or cracking it. The first story was occupied by a banking room which, with its contents, was entirely uninjured. The windows of the bank opened on a narrow alley with a high blank wall on the opposite side.

The Roebling Construction Company reports that its system of cinder-concrete arches was also used for the floors of the one-story Hambleton Bank and the one-story National Union Bank and endured the fire and heavy impact from falling walls without sustaining any injury in one case and but little in the other case.

In the block bounded by Grant, Mercer and Sherman streets, an old-fashioned, four-story building had a cast-iron front and floors of reinforced concrete. The floor concrete was extended to enclose the girders, and to it was attached a plaster ceiling. The roof and contents of the building were entirely consumed, but the floor and the fireproofed I-beams and columns were intact. Part of the brick side walls had fallen out and the cast-iron front had tipped slightly forward so as to be separated from the side walls about 6 inches at the top, this being due to lack of anchorage to the main part of the building, the front itself being apparently uninjured.

In another case in Baltimore Street the riveted steel fronts of some buildings became detached from the buildings and revolved outwards into the street, obstructing the street but still remaining fastened together. In these cases there was no evidence of anchorage between the front and side walls, and the falling was thus evidently due to a fault of construction rather than to the severity of the fire or to the crippling of the steel work itself.

THE ROYAL VICTORIA HOSPITAL at Belfast which accommodates 300 patients and a large staff, cost, as stated at a recent meeting of the Royal Institute of British Architects, about $1,500 per patient's bed, including all engineering requirements and a steam laundry. Some 703,000 cubic feet are ventilated on the plenum system with velocities in the main duct of 7 and 10.85 feet per second, corresponding to 7 and 10 changes per hour respectively. There are two 110-inch propeller fans, which may be used together, and these are mounted on the same shaft, which is provided with clutch couplings and may be driven from either one or both of two 9 x 16-inch steam engines. One unit is planned sufficient to change the air throughout the hospital seven times an hour, with an expenditure of 1.07 indicated horse-power per 1,000,000 cubic feet of air per hour.

An Account of the Baltimore Fire, with Some General Deductions.

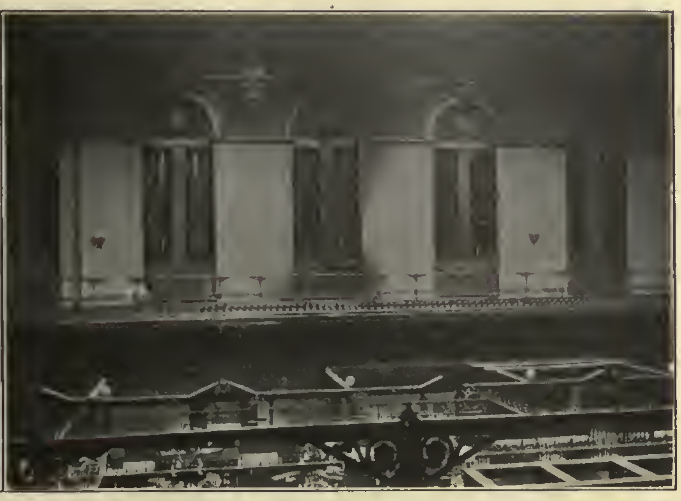
By H. D. Bush, Manager Baltimore Bridge Co.

It will take many weeks to learn the lessons of the Baltimore fire, and much writing of many men to present them. Many leading engineers and builders are now in Baltimore trying to learn these lessons. The cause of the fire is still in doubt. A large wholesale dry-goods establishment began burning a little after 10 a. m. Sunday, February 7. It does not yet seem clear whether the building was fitted with automatic sprinklers. Some little time after the fire started there was a terrific explosion, felt and heard all over the city, for miles from the burning building. Probably an official investigation will be needed to determine whether the explosion came from gasolene, but it is well known that gasolene engines were used for light and power purposes in other buildings in the heart of the city. This explosion scattered the fire into adjoining buildings. It is freely stated that such dynamiting of buildings as was done was done too late. In some instances burning buildings were dynamited and windows in adjoining buildings broken by the explosions, so that the fire was driven through the openings.

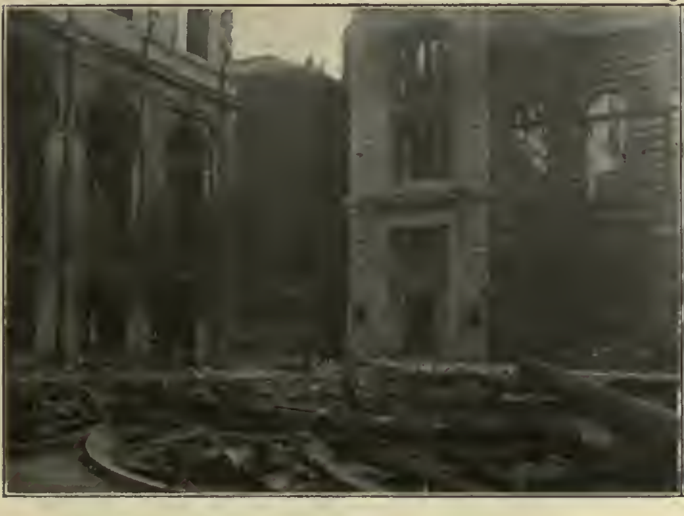
Pratt Street Power House, United Railways & Electric Company.
Old portion in foreground, new portion in background.

Various wild statements have appeared in the daily press about this fire. One of these was about the rapidity with which the fire spread. As a matter of fact, the Baltimore fire went a less distance in twenty-four than the Ottawa fire in four hours. The Baltimore fire was always orderly, jumping but once beyond its bounds—from the Continental Trust building to the Maryland Institute—and behaved exactly as should have been expected. But for the preceding twenty-four hours of soaking rain the results would have been far different. The map on page 213 shows the burned district; two arrows indicate the two directions of the wind, during Sunday, until about 9 p. m., from the southwest, after that from the northwest. As the fire increased in volume the air became full of sparks and flying embers. Even sheets of roofing tin were carried several blocks in advance of the fire before they fell. The writer saw one ember a foot long fall on the sloping surface of a mansard roof, just under a wooden window sill on a small building in Calvert street. This was watched by a helpless crowd of people while it burned for several minutes. It went out without doing harm. If the fire had occurred after a dry spell many small fires would have been started in advance of the main fire, approximately along the line of Gay street. Then when the wind turned there might easily have been a fire half a mile or more wide, to sweep down across Canton, or southeastern Baltimore, and add the horror of thousands of homeless and destitute people. This good luck of Baltimore should not be lost sight of in other large cities where the conditions that prevailed here still exist. The Baltimore fire started and progressed through the most substantial portion of the city. There were no wooden buildings here, and the fire did not reach the vicinity of the lumber yards until after there was enough fire apparatus here to hold it in check. The creek called Jones' Falls not only proved a barrier to the spreading of the fire towards the east, but was a useful reservoir from which the fire engines could draw unlimited water.

Buildings Opposite O'Neill's Store.



Interior of Safe Deposit & Trust Company's Building.



Safe Deposit & Trust Company's Building, in Center.
Adjacent buildings were destroyed as indicated. Ruins of cast-iron fronts in foreground.

Court House and Law Building.
Shows chipping of granite at top of Court House.

The buildings attacked may be divided into three classes. Class I.—Old-fashioned buildings of moderate height, with brick, stone or cast-iron outer walls, interiorly constructed in accordance with the rules of "combustible architecture," and filled with inflammable contents. Buildings of this class were all destroyed. Class II.—Modern office buildings, heretofore miscalled "fire-proof." None of these was destroyed, but not one of them preserved its contents. In some of them even the fire-proof vaults next to partition walls were burned out. Class III.—Buildings that remained proof against the fire. There are only three in this class, as follows, in the order in which they were attacked: O'Neill's dry-goods store, the Court House and the bank building of the Safe Deposit and Trust Company. Of these the Court House need not be considered; it is of massive masonry construction, but its small windows were unprotected, except by the superhuman efforts of the firemen, who kept a number of streams of water playing from these windows against the Law Building, Class I., opposite. The effect of the fire on the stone work near the top of the Court House is shown in one of the views. The windows of this building are an excellent example of how to leave a supposedly fire-proof preserver of records so as to invite destruction from without.

Returning to consider briefly the buildings in Class II., it is unnecessary to contradict the statement in a daily paper that they burned like papier mache. The wooden trim of the windows burned, the glass fell out or in, and the fire found the equivalent of a cord or two of kindling wood in each room in furniture, floors, doors and closets. These all burned in quick, hot, clean fires, in some cases not even discoloring the ceilings. Many thin partitions of tile or expanded metal and plaster were destroyed, but main floors were little injured. The problem in these buildings is fire-proof windows, and the solution seems to be metal frames and sash, wire-glass and inside steel shutters.

In Class I. the only safeguard seems to be fire-proof shutters on all sides, street side as well as rear, and all the larger buildings should be provided with automatic sprinklers. Both these provisions should be compulsory for the general good.

The writer wishes to speak particularly of Class III. On the rising grade of Charles street, at the southwest corner of Lexington, directly in the path of the fire some hours before the wind turned, stood, and still stands, O'Neill's dry-goods store. This building is at the apex of the fire, everything having been burned up to it. It will be seen that a blank fire wall offered the greatest resistance; nevertheless, the windows in the rear, or west side, caught the force of the fire diagonally. There are ruined buildings almost under these windows. Two small burned buildings opposite on the east or Charles street side are shown in one of the illustrations, and also the Union Trust building, Class II., which was entirely burned out. The tin roof of the O'Neill building was burned through in places, and fire in the front cornice started the sprinklers under the roof, doing some slight damage to the stock. The wood staves of the big tank on the southwest side are badly charred, and yet this building did not burn. If it had burned, the Fidelity building, Class II., opposite it in Lexington street, would have burned, and the fire would have started on its way up Charles street, after which, when the wind turned, the Court House and back of it the Post Office, would have been attacked on two sides, and both would probably have been gutted. Baltimore therefore owes much to O'Neill's building. Why did a dry-goods store, with apparently shutterless windows, protect this portion of the city? Because each window had a water curtain. Across the top of each window, outside of the building, is a pipe with a flat nozzle in the center, the thin stream from which spreads out and completely covers the window with a film of running water, the pressure being supplied from the tank on the roof. The apparatus, including the sprinklers inside, was installed only three weeks before the fire. The water was turned into these pipes about 5.30 p. m. and kept on as long as necessary.

The Safe Deposit and Trust building, 100 feet square and about 60 feet high, stood in the path of the hottest fire. It is true there were narrow streets front and back of it, and an alley 8 feet wide each side. Nevertheless, other smaller and less exposed buildings were gutted by the fire. The officials of the Safe Deposit and Trust Company went into their building Monday morning and found one desk burned. The decorators had been working on the gallery and it is believed some spilled paint there caught fire from the intense heat and dropping to the president's desk below, set fire to it. This building was preserved by the inner steel shutters, made of about ¼-inch plate, stiffened with a narrow frame of the same thickness. The slight warping of these shutters in two windows is clearly shown in the photograph. The gold paint in the inside of the shutters was blackened and blistered, and the walls slightly discolored near the windows, but otherwise the building was as good as ever inside, and ready for immediate use. This building had a large wire-glass skylight, fortunately not broken by falling walls and uninjured by heat. The building of the International Trust Company suffers by comparison. The latter building apparently had no windows, but the fire ate through the wooden front doors. The wire-glass skylight is about half broken in by falling walls. The half not so broken is not injured by fire.

The condition at the close of the fire of the old and new portions of the Pratt Street power-house of the United Railways & Electric Company is clearly indicated. The old portion had iron roof trusses with wooden purlins and sheathing. The new portion has wire-glass windows and fireproof roof.

[According to information subsequently obtained by a member of the editorial staff of this journal, it would seem fair to include in Class III. the U. S. Appraisers' Storehouse No. 1, the new portion of the power-house of the United Railways & Electric Company, the Mercantile Trust Company's building and the Alexander Brown & Sons' bank.]

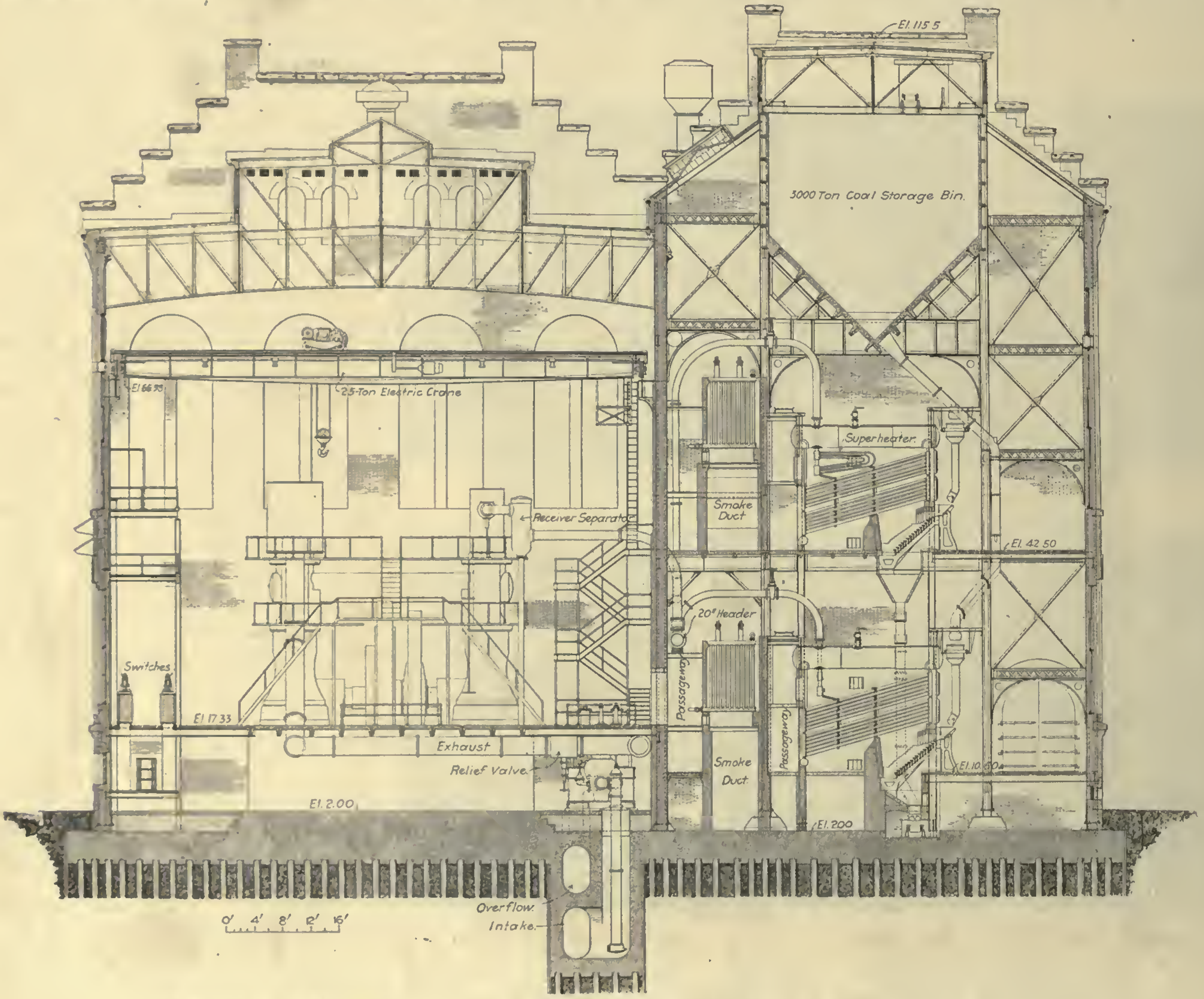
Railway Tunnel Ventilation.

A series of interesting articles has been running in "The Engineer" of London on the ventilation of some European tunnels. In view of the divided opinions held with respect to the air moving effect of trains themselves, the following notes disclose some actual results:

The first tunnel considered at length was the double track St. Gothard, which, starting at Göschenen, Switzerland, rises for 4.4 miles at an average rate of 1 in 170 and then descends for the remainder of the distance, 4.9 miles, to the Italian entrance at Airolo on a gradual incline of 1 in 750. The prevailing direction of the natural air current is towards Airolo, that is, from the north to the south, and a ventilating plant on the Saccardo system was located at the low or Göschenen end. This method of ventilation, it will be remembered, consists ordinarily of forcing air into the tunnel through a conical ring arranged concentrically with the tunnel, so that its action resembles that of the annular blast pipe in a locomotive. The tunnel is roughly 24.6 feet wide and 15.6 feet high. With a natural air current of 6.56 feet per second, from south to north, the use of the fans created a reverse current of 4.9 feet per second. When the natural current was 6.5 feet per second from north to south, it was increased to 9.2 feet by the fans. There are two of these of the Ser type, 16 feet 7 inches in diameter of wheel and 16 inches in width of blade, which were run in the above instance at 65 revolutions per minute. The air velocity was increased to 13.1 feet at 100 revolutions. When it was desired to head back a natural air current of 6.5 feet per second from the south to north, it required 1,427 horse-power to reverse the current to 13.1 feet per second, whereas to aid a current in the prevailing direction at 6.5 feet to bring it to 13.1 feet velocity required but 699 horse-power. The traffic through the tunnel is now so great that the velocities of 10 to 13 feet per second are necessary to render the air respirable for workmen in the tunnel.

The effect of train movement was referred to in connection with a description of the ventilating equipment of the Signorino tunnel. The plant was planned to drive in or draw from the tunnel at a rate sufficient to annul the effect produced by the movement of trains in the opposite direction. Before a freight train enters the tunnel the ventilator is started and a gauge shows that the air current induced by the train is at first nullified and then gradually the current begins to follow the train, rising slowly to 3¼ feet velocity, and then to 5 feet, at which figure it remains constant until at length, after about 9 minutes, the train passes out of the tunnel. The descending current now unopposed attains the full descending speed of 11.5 feet. The fan is then run eight or nine minutes for the air to travel the length of the tunnel and is then shut down awaiting the next train.

The Signorino tunnel is 3,520 feet long and 248.3 square feet in cross-section. The length of the aspirating chamber of the ventilating system was ascertained by experiments at the Pracchia tunnel with a cone especially fitted for blowing toward the exterior of the tunnel, and as a result it is 20 feet long in the Signorino plant. The fan in this case is a small one, being driven by a 23 horse-power engine. The plant, like the others of the system for the Pracchia and the Piteccio tunnels, is fully equipped with recording and indicating apparatus and instruments. The direction and velocity of the air current, for example, is obtained on a drum driven by clock work registering by means of electric current controlled by the spindle of a tunnel anemometer. The moment of entry and exit of trains is ascertained electrically by connection with rail triggers fixed at the tunnel entrances. Manometers having two orifices, one turned toward, and the other away from, the direction of the current are also employed to indicate both direction and velocity. Registering barometers are placed near the tunnel extremities and registering thermometers and hygrometers at given points within the tunnel. These are all fitted with two drums, one of which serves for recording conditions over long periods, revolving once in 24 hours, while the other gives more detailed indications, revolving once in one or two hours. Air pressures in the fan passages, engine indicator cards and many other observations are regularly made and reported to the head offices.



Cross-Section of the Manchester Street Power Station of the Rhode Island Suburban Railway Company, Providence.

Manchester Street Power Station of the Rhode Island Company, Providence. I.

A 10,500-kilowatt power station, especially instructive from the standpoint of power-plant design, has practically reached completion in Providence, R. I. It is the property of the Rhode Island Suburban Railway Company, of Providence, and is known as the Manchester Street station, being located on the Providence River, at the foot of that street. It furnishes direct current for local consumption and alternating current for distant points, but the chief interest lies in the arrangement and details of the machinery and apparatus and in the attention paid to the architectural and constructional features of the building, resulting in a fireproof structure having a majestic exterior and a lofty, well-lighted and appropriately-finished interior. The plant is operated condensing with an independent jet condenser for each unit, and the fresh feed water constantly required is warmed by auxiliary feed heaters and by economizers. The boiler plant is arranged on two decks and is equipped with mechanical stokers and extensive coal and ash-handling plant, and is served by natural draft. Among the details of special interest are the condensing-water system, including the intake chamber, several patterns of pipe supports, an oiling system and the feed piping system. Throughout the plant measuring and indicating intruments have been furnished to secure full records of the plant performance.

Manchester Street Power Station for the Providence Street Railways.

Building.—The building has a steel-frame structure with red brick enclosing walls, trimmed with heavy granite capstones, water-table, window sills and the like. The steel columns and walls are carried by concrete footings on the top of piles. These are spaced all over the site, and concrete spread over them, forming the floor of the engine and boiler-room basements. The other floors, the sides and bottom of the coal pocket and also the roofs are all of expanded-metal construction in Portland-cement concrete; the windows are glazed with wired glass; the window casings are sheathed with copper, and all doors are likewise enclosed in sheet metal, in the interest of fireproof construction, the outside doors in copper and the inside in tinned sheet iron, painted. The metal-concrete roofs are covered with tar and gravel roofing rolled into hot pitch on the concrete. The end walls are carried up in parapets, as shown in the accompanying reproduction from a photograph. In the interior, the floors are finished in granolithic blocked off in large squares, as usual, and the walls have been coated with a white enamel paint, except the lower eight or nine feet, which are of a dark green. Besides the large amount of window area in the side walls, the verticals of the clere story over the engine room and the top of the monitor are glazed. There are five large ventilator hoods in the ridge of the monitor and ventilating registers in the end walls, exhausting to flues within the walls. The boiler room is unusually light and is noteworthy for the longitudinal platforms and passageways, giving access to apparatus. The engine room is spanned by a 25-ton Niles electric-traveling crane.

The general proportions of the building are given in the accompanying engravings. The engine and boiler rooms are separated by a partition wall built with air spaces, and at one end of the engine room is an extension containing an office, oil room, stock room and lavatories on the basement and main floor levels. The building stands 55 feet back of the bulkhead line and between it and the wharf is a combined coal tower and ash pocket. The ground space occupied by the main building is about 29,580 square feet, or 2.8 square feet per kilowatt of the rated output of the main generating units. In the engine room there are 1.5 square feet of floor space per kilowatt and in the boiler room ⅔ square feet of ground area per boiler horse-power. On the basis of the cubic contents above the foundations, there are roughly 260 cubic feet per kilowatt.

Coal Handling.—Coal is ordinarily brought to the station by water, and is transferred to the station coal bunker by means of a continuous Hunt bucket chain conveying system. A bucket of ½ ton capacity, hoisted by a 25 horse-power electric motor, lifts the coal from the barge into a timber pocket in the coal hoist tower, and thence the coal passes through a coal cracker, to a weighing hopper and into a hopper delivering into the conveyor buckets. One man in the tower controls the hoist, which handles under ordinary circumstances ½ ton per minute. The conveyor is electrically driven from a 15 horse-power motor above the coal pocket and is utilized also to carry ashes. In the usual way it travels longitudinally over the coal pocket, down the far end of the boiler room, underneath ash hoppers in the basement and back to the hoist tower. Its passage from tower to main building is through a covered truss bridge and from building to tower through a short tunnel. Through a covered opening in the roof of the latter, it can receive coal delivered by wagons. The conveyor chain has eight changes of direction and is about 630 feet in total length containing about 270 buckets. The tower is 16x32 feet in plan and is supported 18 feet above ground by steel columns and rises 66½ feet above grade, to the bottom of the conveyor bridge. It also houses the ash bin which is built of expanded metal and concrete with vertical sides and delivery spout to wagons hauled underneath it.

The coal storage bin is a single bunker 156 feet long, with vertical sides 30 feet apart, and a V-shaped bottom with the slopes at an angle of 45 degrees. It has a capacity of 3,000 tons, or 15 days' supply at maximum load. Extending longitudinally through the boiler room are two rows of columns which, with the wall columns, constitute the main members of the boiler-room structure and by means of these interior columns and plate girders carried by them the coal-bin structure is supported. The bin itself is formed of concrete reinforced with expanded metal, and the surfaces are plastered smooth. From the bottom of the bin a chute 256 square inches in inside area is taken for each boiler and the run of these is shown in the drawings. The chutes are cast-iron, in sections bolted together, and at various points are provided with sight holes by which a slicing rod can be inserted in case the coal should for any reason get wedged or blocked. Each chute ends in a gate valve from which coal can be delivered at will into a measuring chute. This is a traveling spout, hung by small wheels on double tracking extending across the boiler fronts. One is furnished for every battery or pair of boilers, so that coal for both boilers can be supplied from either chute, and the spout commands the entire width of the feed hopper of the mechanical stoker. The weight of the coal that the chute will hold affords a measure of the coal consumption of each boiler, and the traveling carriage allows it to be hauled out of way when tubes have to be drawn from the setting. Arrangements are under consideration, however, looking to its replacement by a traveling weighing hopper, in case it seems desirable to secure a more positive record of coal consumption. The stokers are of the Roney type and dump into ash hoppers which are fitted with gates for discharging on the coal conveyor at night or at such times as coal is not being handled. The ash hoppers are lined with concrete and those for the upper deck of boilers are of boiler-plate.

Boilers and Economizers.—The boiler plant comprises sixteen 515-horse-power Babcock & Wilcox water-tube boilers, arranged in four batteries on each deck, two boilers per battery. At present three pairs of boilers have not yet been installed in the second story. Each boiler has 5,159 square feet of heating surface, with 252 tubes 4 inches in diameter and 18 feet long, arranged 21 sections wide and 12 tubes high. Each boiler has also three 36-inch steam and water drums, and in addition the boilers of the second deck are provided with superheating surface which is to be given a trial, before the boilers below are equipped. The boiler settings are faced with white glazed brick.

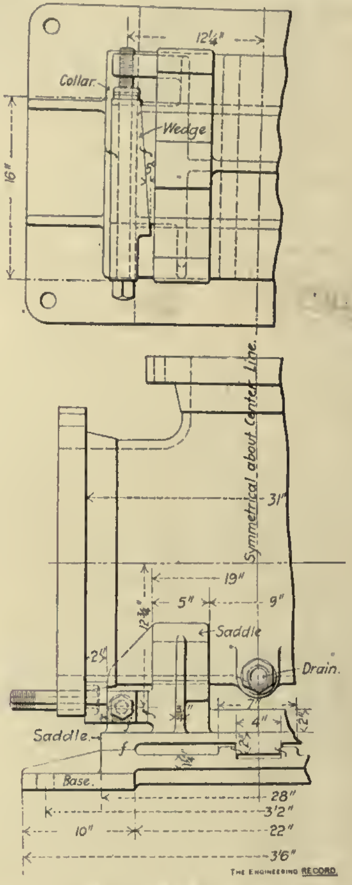
The products of combustion are carried off by natural draft, but economizers are employed, as already stated. These are of the Green pattern and are arranged in an interesting manner, according to the so-called unit system, one for each battery of boilers. Each group comprises 280 tubes and presents 3,360 square feet of heating surface. The economizer cleaners are driven by electric motors. As shown in the drawings, the gases from the boilers flow into a passage between the economizer setting and the corresponding battery and the passage opens at one end so as to cause the gases to pass through the economizer or at the other to by-pass the economizer. The main flow passage is located underneath the economizer, increasing in depth toward the stack where the horizontal breeching is 8x15 feet in size, of 3/16-inch steel plate reinforced with angle bars. The walls and bottom of the smoke passage underneath the economizer settings are of brick, while the top is of terra cotta book tiles 8 inches thick plastered top and bottom with Portland cement mortar. The chimney is of the Custodis radial perforated brick construction 312 feet 7½ inches high above the foundation and 16 feet in inside diameter at the top. There are, of course, dampers in the passages to and around the economizers; and there is a main damper in the breeching near the stack in both decks, these under the control of Locke damper regulators.

Steam Piping.—The high-pressure steam piping from the two decks of boilers is all brought to one steam header, which is noteworthy from the fact that though nearly 160 feet long, it is provided with but two valves, as will be explained. The steam pipe from each boiler is 10 inches in diameter and the two pipes from the boilers vertically in line are united in a special connection before joining into the header. The usual long radius bends are employed in the pipes to and from the header, as shown, and the gate valves, which are of the Chapman pattern with bronze valves, seats and stems, are placed in them in the boiler room. The valves in the boiler leads are accessible from an iron slat walk located over the smoke duct, in the case of both tiers of boilers, and the valves in the supply pipes to the engines are close to the header.

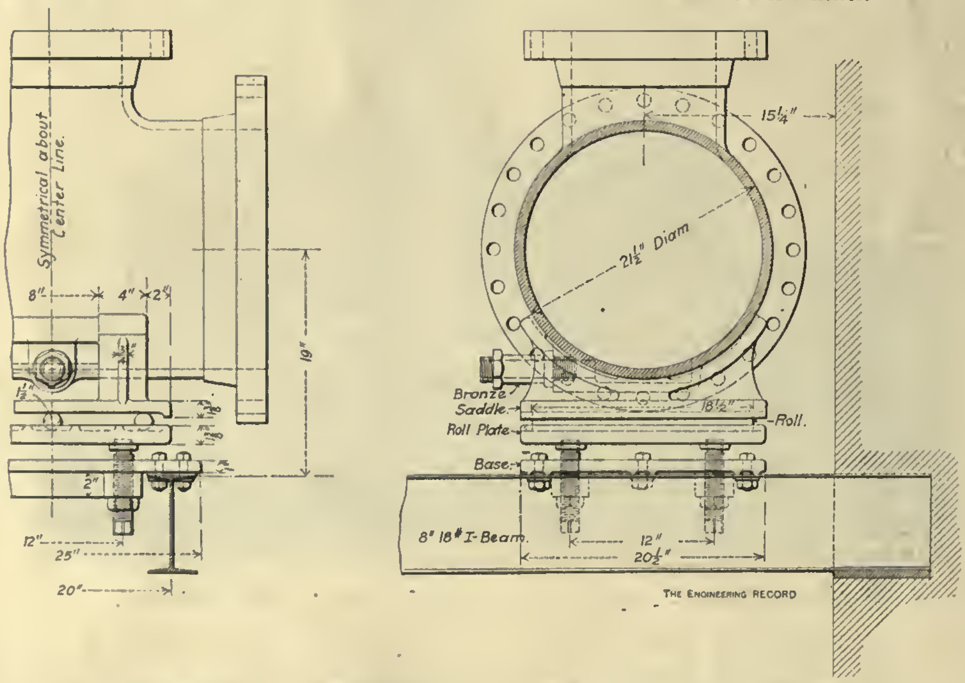
Wherever possible, provided there is no chance of receiving oil, the condensation in the high-pressure lines is returned to the boilers by means of the Holly gravity return system. In that connection an alarm whistle set against the partition wall in the engine room, is connected to blow should the system fail to act, allowing water to accumulate. On each side of the whistle is a brass hand-wheel; if the alarm is given, one is turned to cut out the regular connections and the other turned on to blow off the water and thus to prevent its reaching the engine cylinders in any way. The live-steam piping is lap-welded Bessemer steel pipe, ⅜ inch thick, with flanges welded on, and having rebated joints with corrugated copper gaskets. The fittings are open-hearth steel castings.

Expansion in the steam header is allowed for by the long, curved lateral pipes, as usual, and the header is anchored at a center point, so that the amount of movement at the ends is reduced to a minimum. Besides the anchor the pipe rests on three roller bearing saddles to accommodate the movement, and the bases of supports and anchor are bolted to short cross I-beams indicated in the drawings. Detail sketches are also given of these supports, which are placed under the tees for the engine supply connections. In the case of the expansion bearings the tee sets in a saddle and this in turn on three 1½-inch steel rollers between the saddle and the roll-plate, which roll-plate is brought into position for the proper alignment of the pipe by means of four screws in the base attached to the I-beams. In the case of the anchor the saddle bears directly on the base, with finished mating surfaces, and the saddle has a lateral tongue with finished sliding surfaces fitted into a groove in the base to allow for lateral but not for longitudinal movements of the pipe. To lock the tee to the anchor a wedge piece at each end is fitted between the saddle and a block held against the flange of the tee, and, as shown, each wedge contains a screw by which it is tightened. The tees, it may be noted, are provided with drain taps which are brought sidewise from the bottom through an opening which had to be left in the saddles for that purpose.

The steam pipes to the main units enter the room through the partition wall, as shown, and immediately within the engine room, each is tapped for the supply of the corresponding condenser air pump, and in the case of the horizontal units also for a live-steam pipe by which high-pressure steam can be delivered to the receiver when necessary and in one instance also for the steam-driven exciter. With regard to the subdivision of the high-pressure steam header, it will be seen that by the location of the two valves provided in it, the center section of the header can supply one direct-current and one alternating-current machine, if either end has to be cut out, and similarly in the event of an accident to the center section or to the boilers connected thereto, an alternating unit can be run from one end of the header and the direct-current supply can be maintained from the other, pending repairs. The header is located close to the partition wall and to facilitate handling connections whenever the necessity may arise, there is an opening 2x4 feet or so in the wall opposite the tee joints. These are closed with easily removable sheet metal covers, to minimize the number of openings in the wall.



Steam Header Anchor.

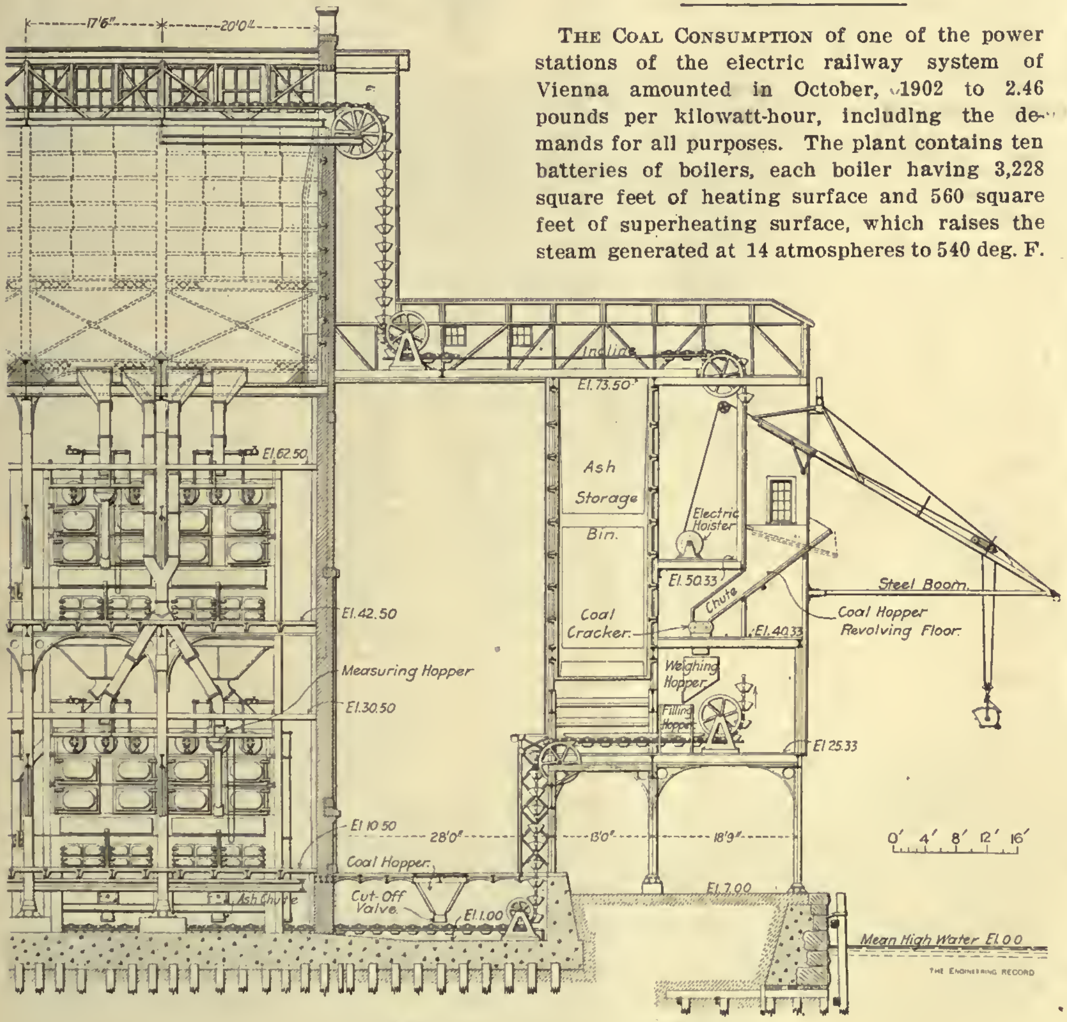


Expansion Support for Main Steam Header, Manchester Street Power-House

Generating Units.—The engine-room plan shows five direct-connected units, two with horizontal and three with vertical engines, and all cross compound. The vertical unit at the end of the room is not yet installed and the third is at present occupied by a horizontal set which it is shortly to replace. The horizontal units are Filer & Stowell engines 32 and 64x54 inches in cylinder size, with General Electric generators, two giving an alternaing current output of 1,500 kilowatts at rated load and the other a direct current output of 1,600 kilowatts. The vertical unit consists of a Westinghouse engine, of 42 and 86-inch cylinders with 60-inch stroke, and a General Electric railway unit of 2,500 kilowatts capacity. The alternators are operated at about 94 revolutions per minute and give current in three phases at 25 cycles and 11,000 volts, and the engines, which, it may be noted, are operated with automatic cut-off for both cylinders, are equipped with a ⅛-horse-power Browning motor by which the generators can be brought into synchronism by controlling the engine governors from the switchboard. The present horizontal railway unit runs at 90 revolutions and the vertical unit at 75 revolutions. The steam pressure is 150 pounds and the vacuum normally 26 inches. For the alternators there are two motor-driven and one steam-exciter unit, the last for use when no alternating current is available, as the motor-generators employ induction motors. The steam unit is a General Electric marine set with an 11x8-inch engine and a 30-kilowatt 125-volt dynamo, while the others consist of 440-volt 75-horse-power motors and 125-volt 55-kilowatt dynamos, each set capable of exciting both alternators.

(To be continued.)

THE COAL CONSUMPTION of one of the power stations of the electric railway system of Vienna amounted in October, 1902 to 2.46 pounds per kilowatt-hour, including the demands for all purposes. The plant contains ten batteries of boilers, each boiler having 3,228 square feet of heating surface and 560 square feet of superheating surface, which raises the steam generated at 14 atmospheres to 540 deg. F.



Part Longitudinal Section of Boiler Room.

New Cement Works at Portland, Colo.

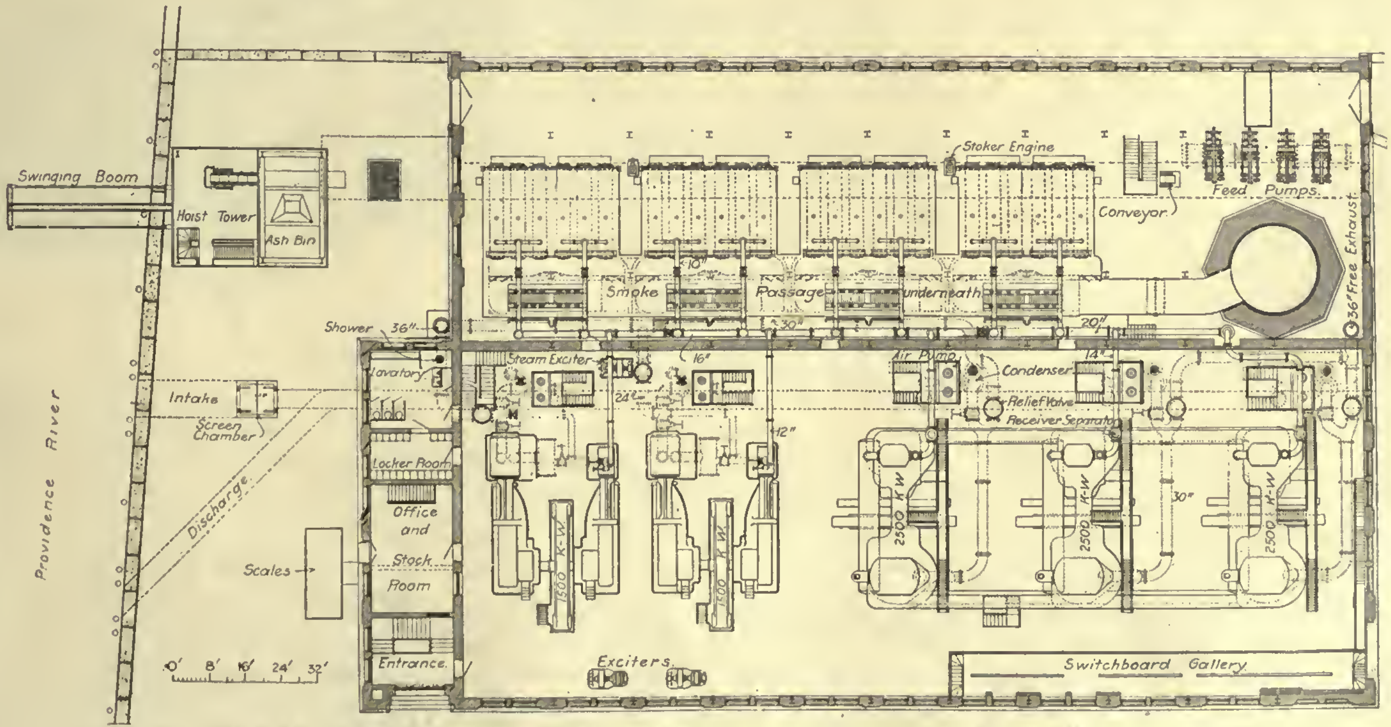
By James D. Schuyler, C.E.

PART I.—LOCATION AND RAW MATERIALS.

The demand for artificial Portland cement has become so enormous in the United States, in the past ten years, that it has given wonderful stimulus to its manufacture, and although new cement factories have been started in great numbers, and the production increased from 547,440 barrels, in 1892, to 16,875,500 barrels, in 1902, the importation of cement has not diminished, but is greater than ten years ago. One of the recent plants, constructed in 1902, on the Arkansas River, six miles below Florence, Colorado, was recently visited by the writer, in the course of his professional work, and he became so interested in the process of manufacture that the following description of the plant has been prepared for publication, as a matter of probably general interest:

Geology.—For a distance of some thirty miles, between Florence and Pueblo, the Arkansas River has been cut down through beds of limestone and shale a depth of 100 to 500 feet below the general level of the table-land on either side. The canyon is one-quarter to one-half mile in width, with vertical cliffs on either side, and the river meanders back and forth across the valley between them. The blue shale beds in the neighborhood of the plant are very extensive, covering many thousands of acres, all of which is material available for cement manufacture. The shale contains not only the silica and alumina of ordinary clay, but also from 60 to 80 per cent. of carbonate of lime. Some of the strata of the cliff are richer in lime than others and require no addition of lime before being converted into Portland cement. The quarry now being worked has a layer of some 30 feet of this class of shale, lying about 75 feet above the level of the valley. Overlying this is a lighter and more friable shale, containing less lime. It would be expensive to strip off this upper stratum to get at the perfect material, and in practice therefore, everything above the quarry floor, up to the grass roots, is quarried out together and ground up. This picture necessitates the addition of pure limestone to the mixture to bring it all up to the desired percentage of lime.

A plant of 400 barrels daily capacity was started at this site in 1899, but this was absorbed by the new company, and in the new construction the old machinery has been largely



PLAN OF THE MANCHESTER STREET POWER STATION OF THE RHODE ISLAND COMPANY, PROVIDENCE.

discarded and replaced by the newer and improved appliances necessitated by the modern processes. The new plant was installed in December, 1902, with a daily capacity of 800 barrels, and has since manufactured about 200,000 barrels of high grade cement. It is being enlarged to a capacity of 1,200 barrels daily, as a result of the demands of the market.

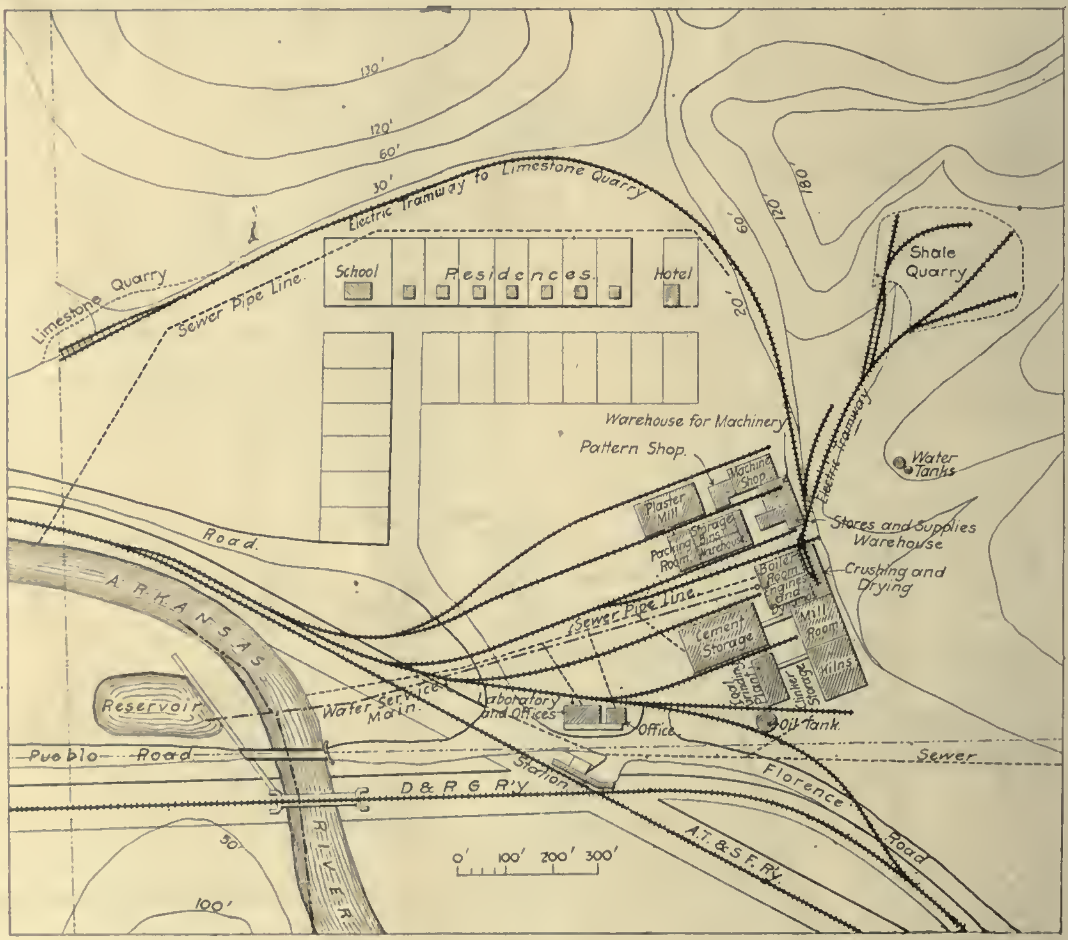
Preparing the Raw Materials.—The shale and limestone are brought to the works by cars operated by an electric locomotive, and crushed separately by a No. 6 Gates crusher, to a size which will pass through a 2-inch ring, the crusher being supplemented by corrugated rolls for breaking thin slabs of shale that may slip through the crusher. After crushing, the shale is elevated to a bin over a cylindrical dryer, from which it is fed into the dryer. The latter consists of a sheet-metal cylinder, 54 inches in diameter 50 feet long, set on an incline of 3.75 feet in its length, mounted on rollers, and revolved at a speed of 7 revolutions per minute. The temperature of 500 degrees Fahrenheit in this dryer is maintained by pulverized coal, automatically fed into it under a strong draft. After passing through this cylinder, the shale has lost all of its moisture and is in condition to be ground. It is then conveyed by an elevator to steel bins over a series of three machines called Lindhard's kominutors, into which it is automatically fed.

These kominutors are steel cylinders, 6 feet long, 75 inches internal diameter, protected inside by heavy armor plates, 2½ inches thick, arranged in 12 steps of 5 inches each. Each machine contains 5,500 pounds of chilled steel balls of great hardness, the balls being from 3 to 4 inches in diameter, weighing from 4 to 18½ pounds each. As the machine revolves at a speed of 22 revolutions per minute, the balls drop over the steps and rapidly crush the particles of shale with which they are intermingled to such a fineness that 45 per cent. will pass through a 100-mesh sieve, and all will pass a 16-mesh sieve. The material feeds into the machine continuously, and leaves as it reaches the degree of fineness which will permit its passage through the fixed sieves at the outlet of the machine. As it leaves the kominutors, the pulverized shale passes down through a hopper to a screw conveyor in the floor, which transfers it to an elevator, by which it is lifted to a steel bin over the proportioning scales, where it is mixed with the high lime.

The limestone is treated in a somewhat different manner. It is first crushed in the same large Gates crusher, which will take in stone of any size that can be loaded into the cars by hand, and reduced to 2-inch cubes, or less. It is then elevated to a bin over the high lime dryer, where it is fed into the long cylindrical dryer, 54 inches x 50 feet, where it is subjected to heat of about 300 degrees Fahrenheit, passing through the cylinder at the same rate of speed as that of the shale dryer, 7 revolutions per minute. From the dryer the limestone discharges directly into a machine called the Williams pulverizer, No. 3, requiring 60 horse-power to drive it, at a speed of 1,000 revolutions per minute. This ingenious mill contains sixteen hammers, each weighing 20 pounds, hung loosely at the end of a short arm. When running at full speed, these hammers straighten out so as to reach within ¼ inch of a plate, corrugated at the top and barred at bottom and sides for screens. These plates have openings of 1/16 inch, extending the full width of the mill, about 2 feet inside. By this process, the limestone is reduced to a maximum of 1/16 inch diameter, while 50 per cent. of it is still finer and will pass through a 100-mesh sieve.

After leaving this machine, the limestone drops to a screw conveyor, by which it is carried to an elevator and dropped into a steel bin over three 30-inch Griffin mills, made by the Bradley Pulverizer Company of Boston. It is an intricate mechanical device, difficult to describe, but chiefly consisting of a muller whirling at the lower end of a shaft some 6 feet long, which is hung from a rollhead, in a 30-inch pan, and making 300 revolutions per minute. When it leaves this mill, the limestone is pulverized to such a degree of fineness that 96 per cent. will pass through a sieve of 100 meshes per linear inch. Thence it falls to a conveyor, and is delivered to an elevator which drops it into the high lime bin, over the proportioning scales, alongside the pulverized shale.

From this point the two ingredients are ready to be mixed in proper proportions by a Fairbanks ingredient and hopper scale. The hopper of this scale has two compartments, the larger of which is three times the capacity of the smaller. The proportions of shale and lime can be very nicely adjusted by this device, and the scales are set from time to time by the chemists, as they determine from constant tests of the respective materials the proportion of each desired. Usually about 400 pounds of limestone is added to each ton of shale. As each hopperful is weighed, it is dumped into a rotary mixer directly underneath. The mixer is provided with curved paddles, running at a speed of 80 revolutions per minute, which throw the material right and left, back and forth, until it is all thoroughly mixed. Each charge is thus treated for about five minutes, and a most intimate mixture is thus obtained.



Map Showing the Properties of the Portland Cement Company, at Portland, Colorado.

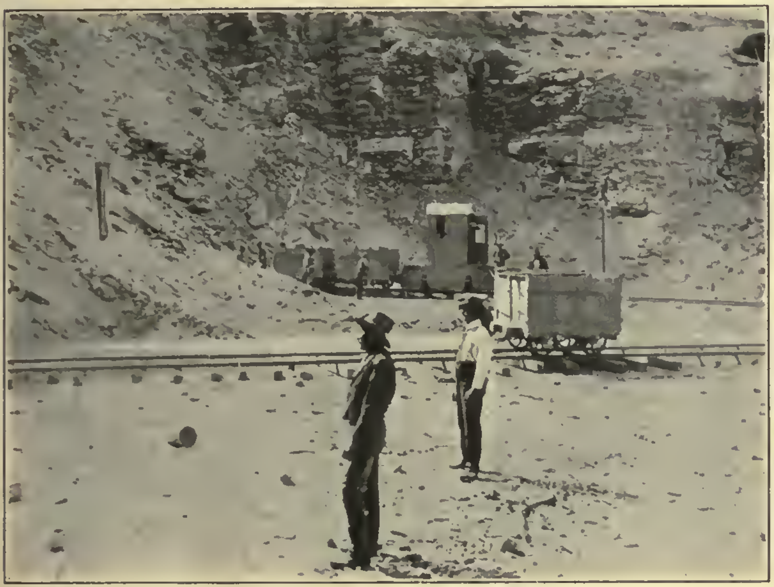
From the mixer the raw material drops into a screw-conveyor, with mixing blades, delivering it into an elevator, which dumps it into steel bins over the tube mills. From these bins it is fed automatically by screw-feeders into three No. 16 Smidth tube mills, which consist of cylinders 21 feet long, 65 inches inside diameter, lined with chilled cast-iron plates or bricks of iron, curved to the radius of the cylinder, each 4x8 inches in size, 1¼ inches thick, set in Portland cement. The interior of these cylinders is perfectly smooth. They are filled to within three 3 inches of half their diameter with pebbles or large gravel stones, from the size of a small egg to that of a man's fist, the weight of pebbles in each mill being about 24,000 pounds. These pebbles are of hard granite and are picked up on the ground, or nearby, at a cost of $3.50 to $4.00 per ton. They are found to be quite as efficient in grinding as the flint pebbles formerly imported from Iceland at a cost of $30 per ton. The raw cement material is fed into these cylinders at one end, and each cylinder contains about 7,000 to 8,000 pounds of cement at a time, which is just about sufficient to fill the voids in the gravel pebbles. As the cylinders slowly revolve, at a speed of 24 revolutions per minute, the pebbles grind the cement material to a still greater degree of fineness than it has attained in the previous processes, and it is discharged at the lower end through bars, set closely enough together to prevent the pebbles from rolling out. Each of these tube mills requires 95 horse-power to operate it, and all are revolved by electric motors. It requires about two hours for the cement to pass from one end of the cylinder to the other.

A single screw conveyor receives the discharge of all three tube mills, delivering it to an elevator, which discharges into a second conveyor traveling the entire length of the kiln-bin near the top of the works. This bin is a huge steel affair, 96 feet long, 12 feet wide and 30 feet deep. From it the raw material is fed into the kilns through 9-inch screw conveyors, bolted on to the bottom of the bin opposite each of the six rotary cylindrical kilns, the feed being automatically regulated to coincide with the speed of the kilns. Before reaching the kilns, however, these conveyors first deliver the material into small pug mills, where sufficient water is added to it to form the powdered lime and shale into small balls, about ¼ inch diameter. This last process is necessary to permit the cement material to pass through the kilns without loss, as it would be impossible for it to be burned in its dry powdered form without some portion being drawn up the chimney by the strong draft.

The cement is now ready to be burned, and is fed into the kilns by revolving conveyors at each kiln. These conveyors are cylinders, or pipes, about 8 feet long, 8 inches diameter, set at an angle of 3 inches to 1 foot, thrust into the upper end of the cylindrical kiln, at its center, and protected from the intense heat of the kiln by a cast-iron jacket surrounded with fire-brick. Four of the kilns were manufactured by the American Clay Working Machinery Company, of Bucyrus, O. The other two were made by the Gates Iron Works, of Chicago. They are 60 feet in length, 72 inches in diameter, and are lined for the lower 30 feet, where the heat is most intense, with special first-class highly basic fire-brick, and with local fire-brick for the upper half. They are set at an inclination of ¾ inch per foot, and require about 10 horse-power each to drive them, including the power for the pug mill and feed. The speed of rotation of the kilns is normally about 1 minute 35 seconds per revolution, but this can be varied at will from ¾ minute to 3 minutes per revolution. It is regulated by the Mosser variable speed countershaft device.

The temperature in the kilns is kept at 2,800 to 3,000 degrees Fahrenheit. It requires about one-half hour for the cement to pass from one end of the kiln to the other, and the clinker is discharged in granular form, of the size of hazel nuts or peas. It quickly cools to 300 degrees, and within two or three hours to 150 degrees Fahrenheit, which temperature it holds in the pile indefinitely. The clinker sometimes melts together in heavy masses, forming rings that would completely choke the kiln, unless the mass were loosened and the gorge removed. Ordinarily this can only be done by permitting the cylinders to cool off sufficiently to allow the clinker to be chipped out. This difficulty has been overcome at these works by an invention consisting simply of a long poker made of gas-pipe, to which water is applied under pressure by a flexible hose attachment. The sudden chill of the water jet applied to the gorge contracts the molten mass suddenly and causes it to break up and loosen. The water poker is worked by two men. From the kilns the clinker passes out through a 10x12-inch hole in the bottom of the hood at the lower end to an elevator (one elevator for each two kilns) by which it is lifted 60 feet above the floor level and dumped into a spout that discharges it outside the building into a pile, on a cement floor provided with openings into a tunnel.

(To be continued.)



The Shale Quarry and Electric Tramway.

The Limestone Quarry Showing Forty-Foot Ledge of Exposed Lime Rock.

Magnalium, a New Alloy containing 86 per cent. aluminum and 13 per cent. magnesium, has a specific gravity of only 2.5. Among its uses is the application to the parts of scientific instruments.

The Civil Service Commission has been requested by the Secretary of the Interior to hold an examination as soon as possible for constructing engineers in the U. S. Reclamation Service. This examination is to be similar to that held for consulting engineers last August. Competition is to be confined to men who have had responsible charge of large hydraulic works, such as dams and canals. The positions pay from $3,600 to $4,800 per annum, and applications for particulars should be made to the Civil Service Commission, at Washington.

The Vicksburg Harbor and the Yazoo River Diversion Canal.

By Walter H. Polk, Assistant U. S. Engineer, Vicksburg, Miss.

The diverting of the mouth of Yazoo River may now be considered an accomplished fact; the river, which has a drainage basin of 6,650 square miles, with a minimum discharge of over 2,400 cubic feet per second, has been made to follow a new course for a distance of 9.3 miles. Eight hundred miles of navigable river have been made accessible at all seasons of the year to boats which formerly could not enter through its mouth at its lower stages; a city which for over a quarter of a century has been fronting a deserted river channel, has been given new life by having a river turned by its doors once more.

The earliest information that can be obtained shows that the Yazoo emptied into the Mississippi River in the bight of a bend, the neck of which was eventually cut off by the caving in of its banks about a century ago. The lower end of this river silted and became dry, leaving the Yazoo to find its way to the Mississippi through the upper arm, which became known as the Live End of Old River; the other arm was called the Wrong End. In course of time the bed of the live end filled with a deposit of silt from the overflow water of the Mississippi, and as the main channel of the great father of waters receded to the South, due to eroding of its banks, it left the outlet of the Yazoo on the bar side of the river. A bar of sand formed across the mouth of the outlet after every high water. The cross-sectional area of the old Mississippi River bed was so large that the small discharge from the Yazoo at low water was unable either to remove the silt or to keep a satisfactory channel through the bar at the mouth. From these causes navigation in the Yazoo became interrupted for a considerable portion of each year.

Previous to the year 1876, the main channel of the Mississippi River flowed around a long narrow point, and in front of the city of Vicksburg, which then had an excellent harbor for boats at all seasons of the year. On April 26, of the Centennial year, 1876, this narrow neck of land was breached, and in a very short while the river had formed a new channel, leaving Vicksburg on a dead arm of the river, which was given the name of Lake Centennial. As the breach widened to the south, the shore of the river continued to recede; the lower arm of the lake rapidly filled with sediment from the Mississippi River, and afforded navigation to the city front only at higher stages. With the exception of a narrow, crooked outlet, known as West Pass, the upper arm of the lake was also closed by deposit. It became evident to the merchants of Vicksburg that something must be done both to restore the harbor and to open the mouth of the Yazoo River to navigation. A board of army engineers was convened in January, 1878, to consider the situation and recommend that the work for the protection of the harbor should be carried out in the following order: First, The protection of about 7,000 feet of the shore above Delta Point by brush mattresses; second, the construction of a bar dike in prolongation of the line of De Soto Island to cut off the eddy current from the harbor; third, the dredging of the inner harbor; and fourth, the diversion of Yazoo River into Lake Centennial.

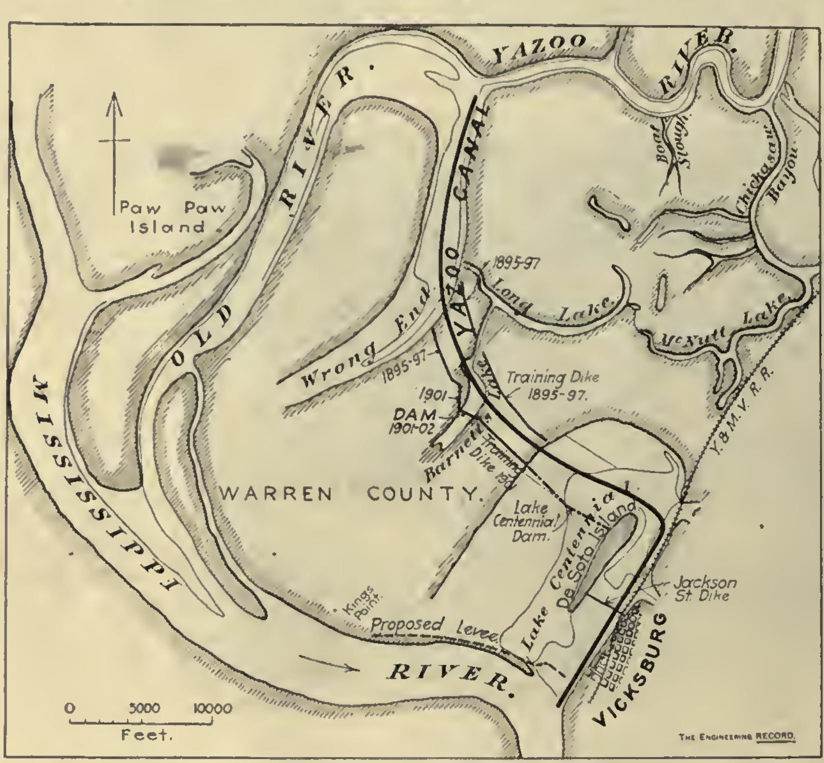
The first part of the work, the revetment of the Delta Point, was commenced the following season, 1878; this was intended to prevent the further recession of the river bank which had been caving continuously since the cut-off. This work was prosecuted as appropriations became available, until 1890, when about 10,700 feet of the bank had been thus revetted. Since 1890 the work already done has been kept in repair, and a paving of stone above the low water line has been substituted in place of the revetment. The bank protection work has successfully performed the service for which it was intended.

The second feature, the construction of the bar dike, was not begun until after dredging operations along the city front had commenced, as it was thought that the bar in prolongation of De Soto Island had by this time gained a sufficient height to prevent the eddy current from carrying silt into the canal, but it was found that a large deposit was made annually, so in 1888, permeable dikes were constructed across the head of the canal from Jackson Street to the island opposite, and from the south end of the island to a point near the lower end of the proposed canal. As the earlier dredging operations proceeded a large portion of the material was scowed to the Jackson Street dike and there deposited until the dike had reached an elevation from 25 to 35 feet above the zero of the Kleinston gauge. Work on the Jackson Street dike was finally stopped by the approval of a plan to divert the Yazoo River through Lake Centennial and past the city front of Vicksburg.

The third feature of the recommendation of the board of army engineers, the excavating of the harbor canal, was begun in 1883, when 350,000 cubic yards of deposit were removed by contract, after which the work was carried on as appropriations became available, until May, 1893, when it was deemed advisable to do no further work until the Yazoo River diversion scheme had been brought to a conclusion. The first estimate for the harbor work was for a channel 250 feet wide to a depth of 15 feet below low water, and amounted to 2,235,555 cubic yards. Up to the time of discontinuing the work in May, 1893, 2,010,842 cubic yards of material had been removed and the canal excavated to a depth of zero on the Kleinston gauge. During the progress of the work, there had been deposited in the canal, approximately, 1,000,000 cubic yards of material, due to the eddy current from the Mississippi River, which the dike construction had been unable to entirely prevent.

The fourth and last recommendation of the board of engineers was not undertaken until it was demonstrated that the dredging of the inner harbor was an unfinished task, and that the annual deposit of silt, during the higher stages of the Mississippi was so great that it would be necessary to dredge almost continuously during the available working season. An act of Congress approved September 19, 1890, made $5,000 available for a survey of Yazoo River from the railway bridge, about 17 miles above the mouth of the river, to its mouth, for the purpose of determining in what manner the mouth of the river could be improved, and also for an investigation into the feasibility of making a new mouth or outlet for the river by way of Chickasaw Bayou, or otherwise.

The route adopted was from the junction of the Yazoo with Old River, through the dead end of Old River, 2.7 miles; then the Main Cut, from Old River through Barnett Lake to Lake Centennial, 3 miles; then through Lake Centennial to head of harbor canal, 1.6 miles; and finally through the harbor canal past the city front of Vicksburg to the Mississippi River at Kleinston, 2 miles, making a total distance of 9.3 miles. The distance to Kleinston by the old route is 14.5 miles. After the final location of the canal, the purchase and marking of the right-of-way, the ground was thoroughly cleared and grubbed and some 388,000 cubic yards of scraper work was done on the more elevated portions of the ground, so that the dredges might operate at high stages throughout the whole cut; the material thus excavated was placed on either side of the line of the canal and raised to uniform grade and slopes. On February 11, 1897, Major J. H. Willard, the engineer officer in charge of the work at that time, submitted a project which was approved February 1, 1898. The work to be let was to cover excavation by any method, some of the material was to be deposited behind the embankments already raised; some in the Wrong End of Old River below the line of the canal; and a part across Lake Centennial, below the line of the canal, from the west shore of the lake to a point near the north end of De Soto Island.

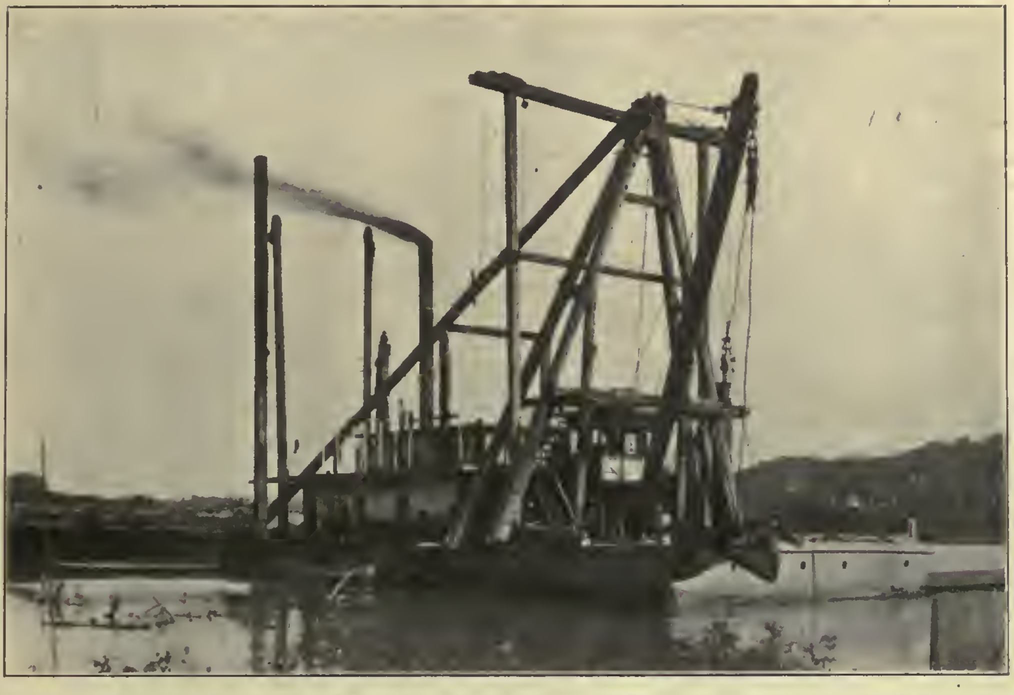


Map of Yazoo Canal and River Improvements near Vicksburg.

Site of the Canal along the Water Front of Vicksburg before Dredging.

A contract was entered into June 14, 1899, with the Sand, Stone & Gravel Company for the removal of 7,500,000 cubic yards of material at 8.49 cents, and the dredge John Gaston began excavating on the second of the following September; but after removing 73,106 cubic yards of material, all work was stopped December 20, 1899, and on account of the lack of the necessary plant to attain the output contracted for, the contract was annulled March 7, 1900. Through the efforts of the Board of Trade of Vicksburg, the Mississippi River Commission dredge Gamma was sent from West Memphis and commenced operations at the mouth of the harbor division of the canal on March 10, and worked until April 4, 1900, having removed 42,100 cubic yards. The Gamma was designed for removing the sandbar formation in the channel of the Mississippi River, and was equipped with hydraulic jets for loosening the material at the mouth of the intake pipes. It is thought that had she been equipped with a rotary cutter that the result would have been better. Bids were again received June 28, 1900, for the full 7,500,000 cubic yards, the Atlantic, Gulf & Pacific Company, of New York, being the lowest bidder at 12.4 cents, were awarded the contract.

With the cross-section at first adopted for this contract it was figured that there would be a depth of 6 feet and a velocity of 3.3 feet per second to pass the minimum discharge of 2,430 cubic feet per second. The final elevation adopted was 6.27 feet below low water at the mouth of the canal, and 6.57 feet at Old River. A total fall of 6 feet was evenly distributed throughout the excavated portions of the canal, there being no slope provided for in Old River and Lake Centennial on account of the large cross-sectional area. The final cross-section of the canal gave a reduction of 25 per cent. in yardage from that first adopted and consisted of an upper cut 220 feet wide at bottom in all recent deposits, and 190 feet wide at bottom for the older formations, and extending from natural ground surface to within 16 feet of grade; and of a lower cut 80 feet wide at bottom, and extending from grade to bottom of upper cut. All side slopes were one and one-quarter to one. The object of this cross-section was to provide a channel wide enough to guard against choking up by sloughing of banks, and deep enough to afford free ingress of the Yazoo River at the lowest stages of that stream.



The Clamshell Dredge, California, Used in the Vicksburg Harbor Improvements.

There were used two centrifugal hydraulic dredges, and one clam-shell dredge. The hydraulic dredges were practically alike, both having 20-inch intake and outlet pipes, with an average capacity of 275 cubic yards per hour. The capacity of the clam-shell was about 60 cubic yards per hour. In order to facilitate the dredging it was decided to impound the water in Lake Centennial, by building a levee on top of Jackson street dike; building a dike along the willow flat approximately along the line of the original permeable dike; and closing the outlets at West Pass. The dike along the willow flat was constructed by the hydraulic dredges with material piped from the harbor division of the canal; the levee on the Jackson Street dike thrown up with shovels, and the outlets at West Pass were closed with scrapers and wheelbarrows, while the river was at a low stage. Two spillways were constructed to regulate the pool height at about 27 feet on the gauge. Towards the end of the work, when the canal was ready, the Jackson Street dike was breached by the dredge California, aided by dynamite. The material was stiff blue "buckshot" mud.

The general plan adopted was to excavate the harbor division with the hydraulic dredges, and to excavate the top prism of the main cut with the same machines, leaving the lower portion to be excavated by the clam-shell dredge California. A photograph of this dredge, which was built at Vicksburg, for the work, accompanies this article. Dredging operations commenced November 19, 1900, and were completed September 5, 1903. A total of 5,836,366 cubic yards were removed from the canal, of which about 1,000,000 cubic yards had been placed on the sub-aqueous dam across Lake Centennial.

In addition to the project of Major Willard it was found essential to construct a levee from the mouth of the canal along the narrow strip of land between Lake Centennial and the Mississippi River to the high ground at King's Point about 9,500 feet of levee to be built 4 feet above the extreme high water, having a crown of 8 feet and side slopes of three to one, with a total of about 450,000 cubic yards. The object of the levee now under construction is to prevent the breaching of the narrow neck of land at or near West Pass, which should a breach occur, might divert the Yazoo River down the west arm of Lake Centennial, instead of the east arm in front of Vicksburg, and to prevent the eddy current from flowing past the city front, around the north end of De Soto Island, and out at West Pass. About 4,600 feet of this levee have been completed and protected from wave wash by a plank and post bulkhead for nearly its entire length. The north end has been bulkheaded, and the south end covered with a willow mat weighted with stone, thereby protecting the ends from the action of the current.

The Canal along the Water Front of Vicksburg after Completion.

The inflow current of the canal was caused by the eddy current of the Mississippi River, which starts a short distance below the mouth of the canal, and extends about 8,000 feet up the left bank of the river. Whenever the river is high enough to overflow the low ground of the narrow neck between the lake and the river, a reverse current is started through the canal, and around the island, and out West Pass. To this eddy current has been due the deposit in the canal of a large amount of material from time to time throughout the whole work. A survey at the old mouth of the Yazoo, made during last August, found a fill across the mouth sufficiently deep to entirely stop the flow of water at a stage of 15 feet on the Kleinston gauge.

The canal is now carrying the full discharge of Yazoo River, and the banks seem fairly stable. During December the river reached a stage of 6 feet above low water. Soundings taken at this stage indicated a scour throughout the whole canal, and gauge readings showed a slope of 8 feet, about equally distributed between the main cut and the harbor division of the canal, with a velocity of 4 feet per second. The indications are that the work will be a success. The steamboat interests report a better stage in the lower Yazoo than previously for a corresponding low-water gauge reading at Kleinston.

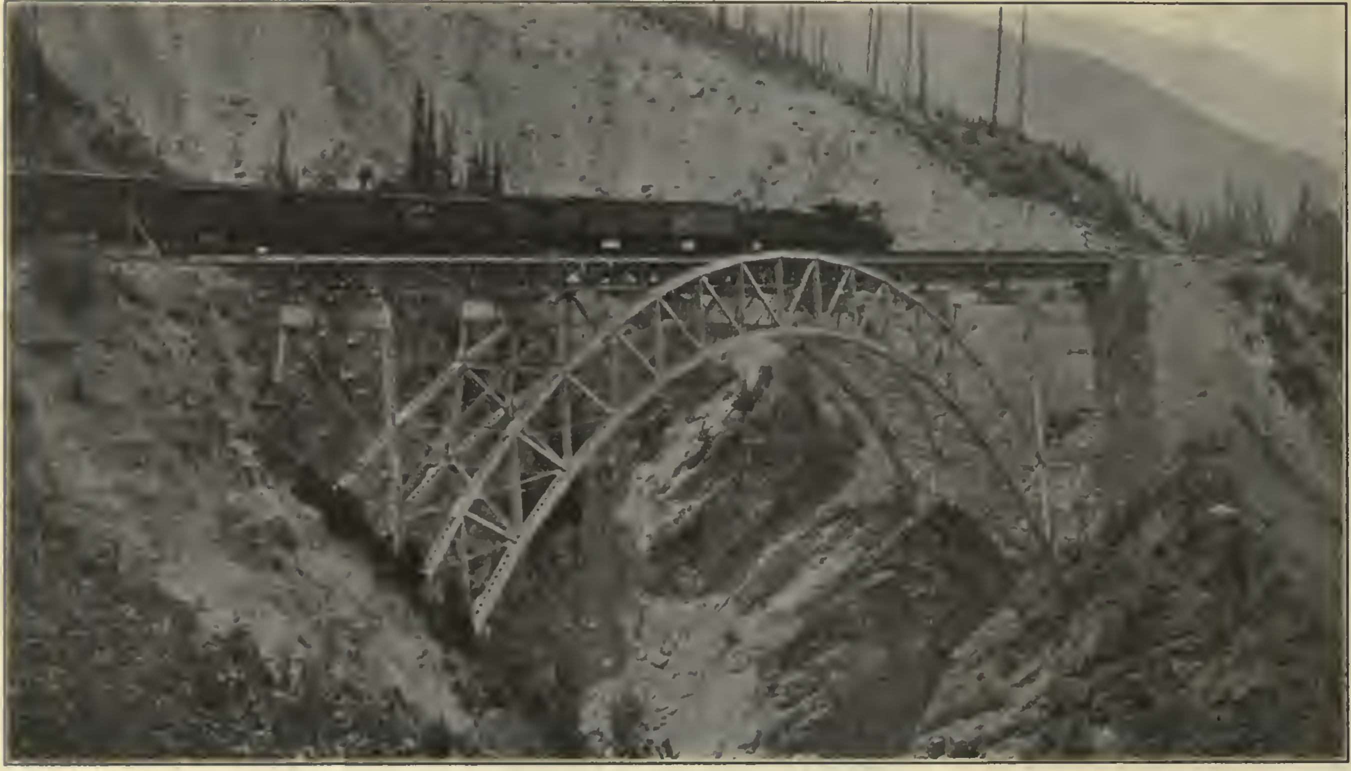
The army officers in charge of the work previous to the diversion scheme were: Major W. H. H. Benyaurd, Captain W. L. Marshall, and Captain William T. Rossell; the local assistant engineers being Major T. G. Dabney and Mr. H. St. L. Coppee. The latter work has been carried out under the direction of Major J. H. Willard, Major Thomas L. Casey, Captain Charles L. Potter, and Captain Charles S. Bromwell, with Assistant Engineers H. M. Marshall and T. C. Thomas in charge of local construction, Mr. John Ewen and the writer being assistant engineers also connected with the work. In the preparation of this article considerable information was obtained from the reports of the Chief of Engineers, U. S. Army.

Types and Details of Bridge Construction.—XIX.

By Frank W. Skinner, C. E.

TRUSSED ARCHES.

The Canadian Pacific Railway crosses Stony Creek, in the Rocky Mountains, with a single-track arch truss of 336 feet span. The bridge is remarkable for its graceful proportions, the picturesque surroundings and the great depth of the gorge, which makes the structure one of the highest of its length in the world. The chasm is so deep that the lowest point is about 340 feet below rail level, and its sides are so precipitous that the total length of the bridge between the faces of the abutments at grade is only 486 feet, including 75-foot approach spans at each end seated on abutments about 40 feet high which set as retaining walls. The ground is so rocky that it affords excellent footings for the skewbacks, allowing them to be seated at such a height as to give a satisfactory rise to the arch. The conditions permitted the designer to select an ideal construction for the main span, utilizing the natural resistances for his compressive stresses and building an economical structure with attractive lines.



Stony Creek Two-Hinge Steel Arch Bridge on the Canadian Pacific Railway.

The chords of the pin-connected trusses are chords of eccentric circular arcs with a versed sine of 100 feet for the bottom chord. The trusses are, in round numbers, 20 feet deep at the crown, 30 feet deep at the skewbacks and are battered 1:10, so that they are 43 feet apart at the springing line and 19 feet apart at the center of the top chord. They are divided by vertical posts into sixteen 21-foot panels with a single riveted diagonal in each. The top and bottom chord pins at the crown engage full holes in all connected members so that there is no crown hinge, and each truss is a two-hinge arch which carries the railroad track on five riveted deck spans 63 and 84 feet long with trusses 9 feet deep and 9 feet apart on centers.

The arch top chords are made with two built channels, latticed top and bottom, and have a maximum cross-section of two 18½x⅝-inch web plates and four 3x3½x½-inch flange angles at the haunches. The minimum sections, at the crown and ends, are the same, except that the thicknesses of all pieces are 5/16 inch and ⅜ inch, respectively. Their center lengths diminish from 28 feet 3¾ inches at the ends to 21 feet ¼ inch at the crown. The construction is peculiar in that each panel is shop-riveted and shipped in three sections, which are field-riveted together with web and flange splice plates. The two end sections of each panel are about 2 feet long on the lower edge and have the pin hole bored in the center. The flanges and the edges of the web plates are bent to the required angle on the radial lines. The top flanges have full-length cover plates, which project at each end to form splices with the ends of the intermediate sections of chord, and the lower flanges are spliced with batten plates.

The intermediate sections of chords have both ends planed square on radial lines and have long splice plates riveted to their webs. In the two panels at the crown the short section of chord is omitted and the intermediate sections are longer than in the other panels and terminate in jaw plates which overlap and engage the same pin at the center point. The top chord pins have a uniform diameter of 6 inches and their inner ends engage U-plates with horizontal wings which are riveted to the top and bottom flanges of I-shaped lateral transverse struts 14 inches deep with I-shaped cross-sections made of two pairs of angles back to back, latticed. The single diagonal rods have sleeve-nut adjustments and loop eyes engaging pins through the horizontal flanges of angle clips riveted to the top chord webs.

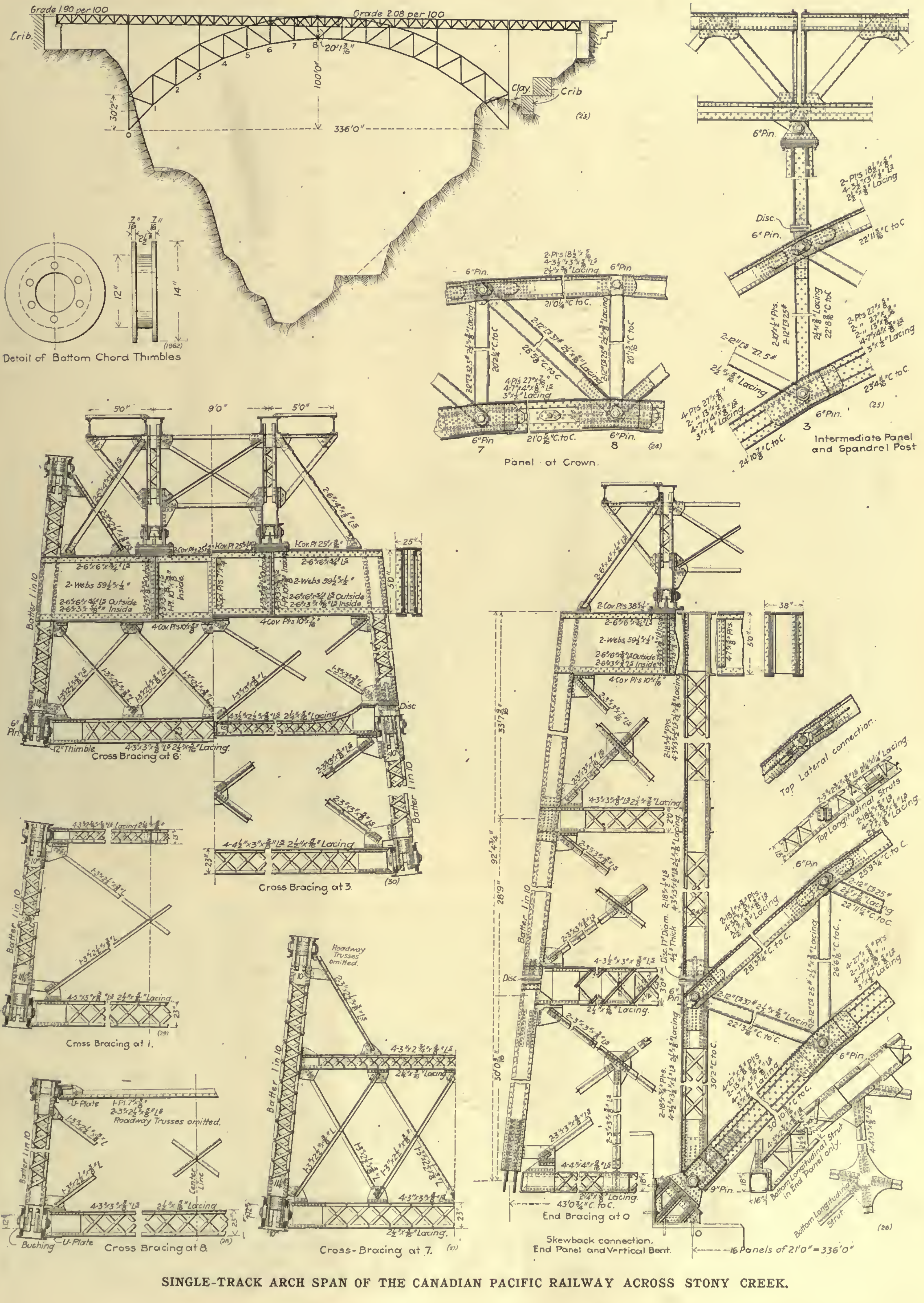
The bottom chord is similar to the top chord except in the splices, and has a maximum cross-section at the haunches with two 27x⅝-inch, two 27x9/16-inch, and two 13x⅜-inch web plates and four 7x4x⅝-inch flange angles. The minimum cross-sections are at the crown and skewbacks, where they are respectively composed of two 27x7/16-inch web plates and four 7x4x⅝-inch angles and of four 27x⅝-inch and two 13x 9/16-inch web plates and four 7x4x⅝-inch angles. Each section is of the full panel length with the joints planed radial and having full end bearings without clearance and with half holes for the pins. The only splice plates are the bent covers on the top and bottom flanges. The pins are 6 inches in diameter, but have special bushings to give them 12-inch bearings on the chord webs. The bushings are made of three pieces of rolled steel plates riveted together so that the outer pieces form flanges locking them in position.

The bottom lateral system consists of transverse struts and X-braces all with I-shaped cross-sections made with two pairs of angles back to back, latticed. The diagonals have the same depth as the bottom chords, and are field riveted to flange connection plates on it. The transverse struts are riveted to U-plates on the chord pins, and to vertical plates which are also riveted to the feet of the vertical posts and receive the ends of the sway brace diagonal angles. These plates are notched to clear the chord flanges and are connected to both flanges of the diagonal angles.

All bottom laterals are cut to clear at intersections, where they are spliced by top and bottob ⅜-inch flange plates with the edges trimmed concave. In the end panel a longitudinal strut is run from the intersection of the diagonals to the center of the skewback transverse strut, to which it is connected by a notched flange, as shown in the detail. A similar center longitudinal strut braces the cross struts at the five panel points nearest each of the top chords.

All web members are made with pairs of 12-inch channels, latticed. All vertical posts have their flanges turned out, and all diagonal posts have their flanges turned in. The 9-inch skewback pins engage half holes in the chords and in the riveted shoes, and full holes in the feet of the heavy end posts. The shoes have ordinary double webs corresponding with those of the chords, but differ from those in ordinary trusses in having their base plates grooved to receive six horizontal transverse 2x1-inch solid steel keys which lock them to the top plate of the pedestal. The pedestal has a 2x4½-foot cap plate 1½ inches thick, which is inclined longitudinally and transversely so as to be perpendicular to the axis of the bottom chord, and is supported on two longitudinal vertical webs in the planes of the chord webs, which are connected by transverse webs and stiffened by pairs of outside angles parallel with the chord flanges. It has vertical and horizontal sole plates with a combined beaming of about 16 square feet on the cut stone masonry, to which it is secured with eight anchor bolts.

The roadway spans have deck trusses with lower chord pin bearings on rocker bents at



SINGLE-TRACK ARCH SPAN OF THE CANADIAN PACIFIC RAILWAY ACROSS STONY CREEK.

panel points 0 and 3 of the arch trusses, and on transverse girders at points 6. Bents 3 and 6 are similar except that the former has one and the latter has two vertical panels. The columns have their axes coincident with those of the truss verticals and are braced together by horizontal and diagonal transverse struts, flange-connected to their webs. The columns are seated on spherical discs, through the centers of which vertical anchor bolts pass which have nuts on the upper ends bearing on horizontal diaphragms in the columns and eyes on the lower ends engaging the top chord pins. The discs are convex on both sides and engage spherical holes in the thick horizontal end plates riveted to the feet of the columns and to the tops of the truss vertical posts which project through and beyond the upper sides of the top chords.

The upper ends of the columns are connected by deep double-web transverse plate girders like floorbeams with ordinary shoes riveted to their top flanges to receive the bearing pins of the trusses. These pins engage interlocking jaw plates projecting from the ends of the webs of the lower chords of adjacent spans. The truss bearings over this arch are all fixed and expansion bearings are provided at both abutments to which temperature movements are transmitted through the rocking of the vertical bents.

The top chords of the roadway trusses are at about the same height as those of the arch trusses at the crown and the lower chords are at the same height as the truss top chords at panel points 5. Therefore at panel points 6, 7 and 8, the arch truss sway bracing is depressed, as shown in the special cross-sections, to clear the roadway trusses. At panel points 6 the roadway trusses are supported on double-web transverse girders riveted to the vertical posts of the arch trusses to correspond with those of the rocker bents, at the haunches and ends of the arch. Here the top lateral transverse arch struts are omitted and the arch top chords are kneebraced to the transverse girder top flanges with pairs of angles passing between the pairs of angles which kneebrace the top chords of the roadway trusses to ends of the transverse girders. These latter braces are peculiar in having pin-connected ends. The deck is made with very heavy ties 20 feet long spaced close together and seated on the top chords with their overhanging ends carried by 15½-inch plate girders on the ends of cantilever brackets, 5 feet long and 10½ feet apart at panel points. The bridge was built of soft steel throughout, weighs 1,021,420 pounds and was designed in accordance with the specifications of the Canadian Pacific Railway for two locomotives with 120,000 pounds each on driving wheel base of 14 feet 8 inches, followed by a train load of 4,000 pounds per linear foot. It was erected on trestle falsework built up from the bottom and sides of the gorge, which were in some places terraced to give horizontal seats for it. This falsework was one of the highest ever built and was composed of long and heavy fir timbers cut in the vicinity. The bridge was designed by Mr. H. E. Vautelet, principal assistant engineer of the Canadian Pacific Railway, of which Mr. P. A. Peterson is chief engineer. The Hamilton Bridge Company, Mr. McNichol chief engineer, and Mr. E. A. Rhys-Roberts, assistant engineer, was the contractor for building and erecting it.

A New Water Power Development at New Milford, Connecticut.—II.

By Walter Scott Morton.

The Canal.—From the dam to the forebay, measured on the line of the canal, is a total distance of 10,000 feet. Of this 8,400 feet is canal proper, the balance being in the reservoirs before mentioned. With the exception of the lower 2,000 feet, the canal is largely excavated in rock.

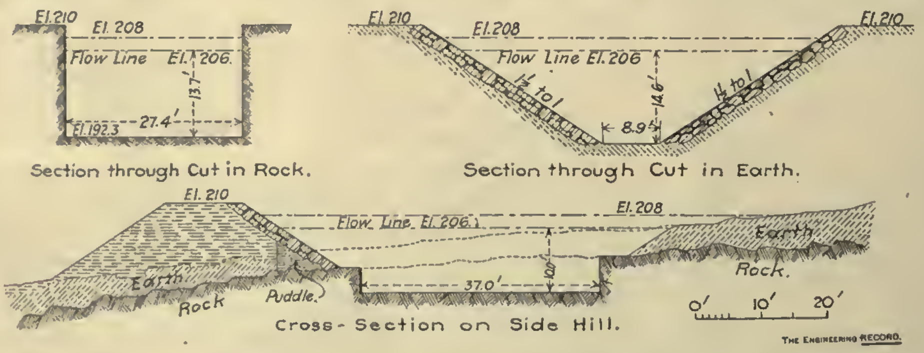
Starting from the dam, the flaring entrance of the canal is separated from the east end of the dam by some 30 feet of solid rock ledge, the line of canal at this point being a continuation of the easterly shore line of the river. From here to the waste gates, some 550 feet below, the canal runs through solid rock from 18 to 40 feet deep, cutting off a bend of the river and encircling the river gorge before mentioned. At the waste gates the river is but a short distance away, the waste gates discharging below Bull's Falls and directly into the river bed, the gates themselves being placed on a solid rock ledge, with a steep pitch into the river below their outlet. The canal in the upper section has a bottom width of 25 feet and the side is more or less flaring on account of the nature of the rock. A slope of one foot from the dam to the waste gates, was given the bottom to accelerate the discharge of the river through the waste gates during construction, which at the lower end places it 2.3 feet below the true bottom of the canal, the change from one elevation to the other being made on a gradual slope.

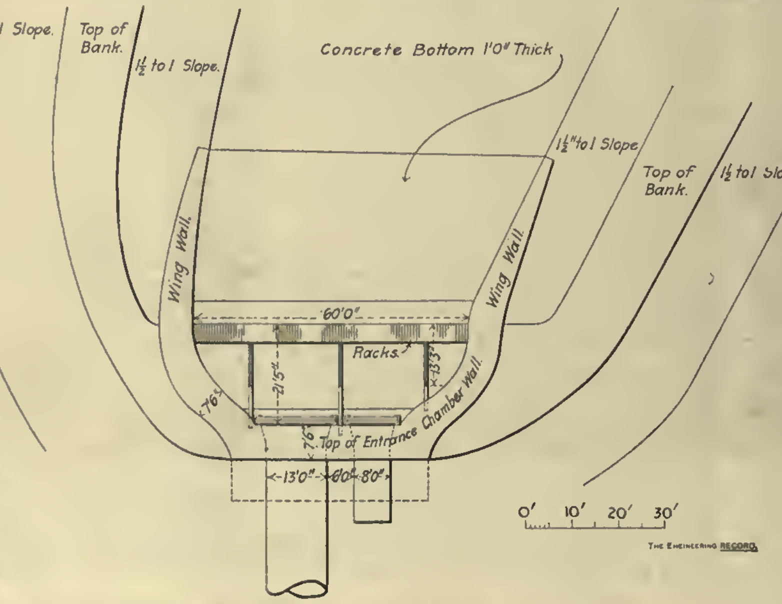
For a distance of 200 feet above the waste gates the river bank of the canal was at a slightly lower elevation than the flowage line. This was taken advantage of to form a spillway. A masonry wall, constructed with Portland cement mortar, was laid on the river edge through this 200 feet with its top at the elevation of the crest of the dam, creating an automatic safety valve for the canal and aiding in the reduction of the flood level of the pond itself.

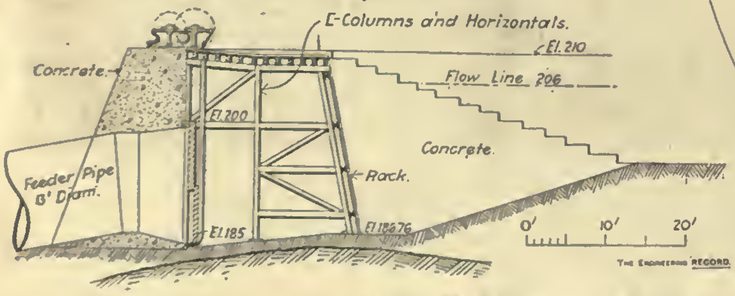
A natural depression in the rock formation at the site of the waste gates was taken advantage of to form the real entrance to the canal. An entrance chamber was excavated in front of the waste gates and for a short distance below to receive the entrance gates. Between the entrance gates and the waste gates on the river side is an opening 16 feet long in which travels a sliding gate whose top can be raised to the same elevation as the dam and which can be lowered some 2½ feet, thus forming a flush gate for the purpose of getting rid of ice and debris which may collect in front of the entrance gates. The canal from above the waste gates to the entrance gates is widened on gentle curves from 25 feet to 38 feet 2½ inches, making an easy flow for the current without loss of head.

From the entrance gates south, a distance of some 300 feet, standard rock section of the canal is constructed, being 27.4 feet in width by 13.7 in depth. Through nearly this entire distance another spillway one foot higher than the dam was built as an additional precaution. At the lower end of this the canal crosses Bull's Bridge road and immediately below widens out into a section 40 feet in width with a corresponding reduction in depth. From here for the next 400 feet, the canal contains this wide section with an earth bank on the river side and with but comparatively small rock excavation. Thence into the first reservoir, some 500 feet, a thorough cut is made through a hill, part earth and part rock, where the canal is changed again to normal rock section, its entrance into the pond being flared to avoid loss of head.

The reservoir is practically divided into two ponds by an earth fill constructed to carry the main wagon road, the connection between the



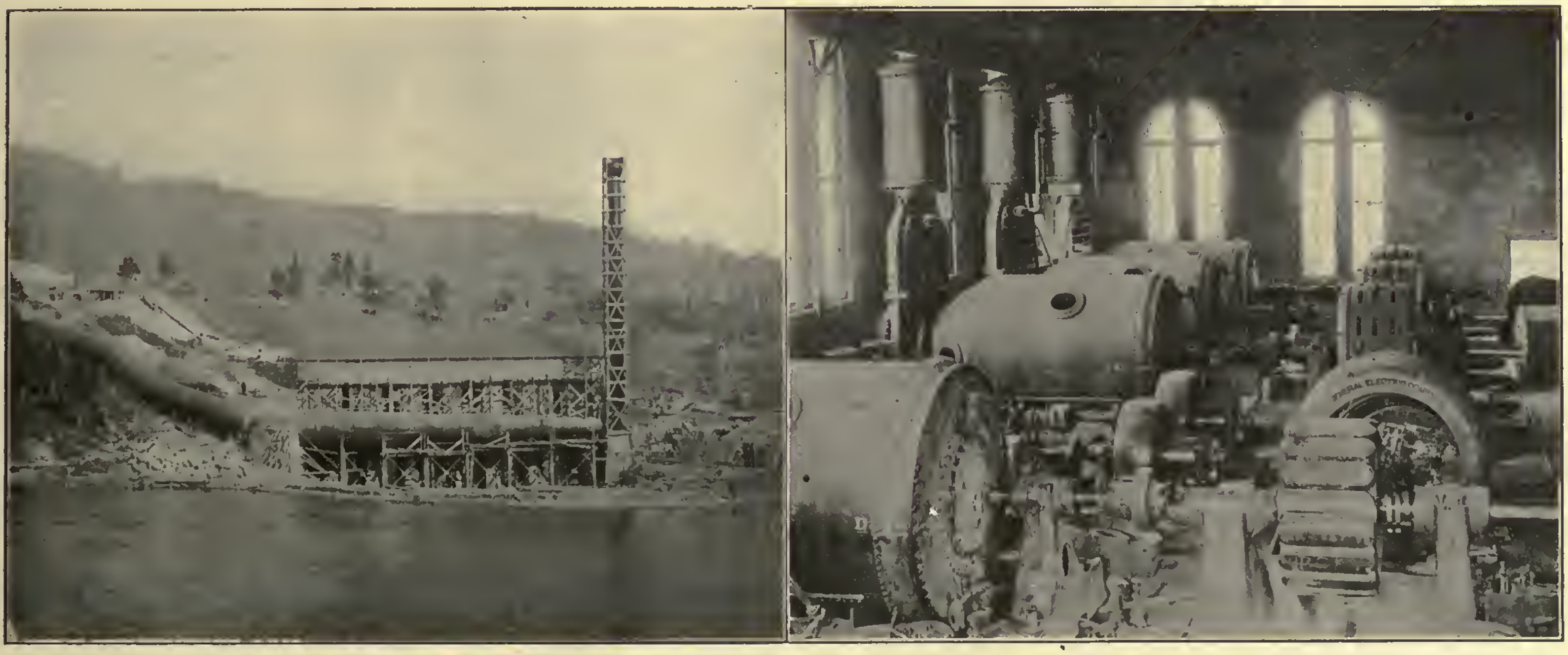




Plan and Cross-Section of the Forebay and Typical Sections of the Canal, New Milford, Conn.

two ponds being under a bridge 110 feet long with a section area of about 1,000 square feet. The canal leaves the reservoir at its southeast corner, the entrance being flared as in the preceding cases. The standard section is then used for some 300 feet where the canal again widens with corresponding reduction in depth. Thence for the next 1,700 feet the construction is substantially as last stated. Through this portion the canal being on the side hill, the lower side is formed by a heavy earth embankment backed by the rock taken from the bottom of the excavation, it being necessary, to get section area, to excavate more or less rock which was utilized to strengthen the banks.

From here to the next reservoir, some 3,000 feet, the canal is substantially rock cutting all the way, a small earth bank being necessary on the down hill side. The entrance into the second reservoir is flared as before. The further continuation of the canal leaves the second reservoir at its southeast corner with a flared entrance and thence for the next 1,100 feet goes along a steep hillside, partly in rock and partly in earth, the canal, however, below the water line, being made entirely in excavation. A bank 4 feet in height is placed on the lower side heavily backed with rock taken from the excavation. The canal at this point is narrowed to a bottom width of 25 feet and a depth of 18 feet. From here to the forebay the canal runs entirely in earth and along a sidehill, being so located as to make the cut and fill balance. At its lower end it very gradually widens into the forebay. The slopes were carefully calculated through each particular section, Kutter's formula being applied and the sectional area increased to correspond with the loss in surface slope. In the rock sections 0.035 was assumed for the degree of roughness and in the earth sections 0.025 was assumed. This substantially gives a loss in head of 0.3 per thousand feet in the rock sections and 0.2 per thousand in the earth sections.



New Milford Power Development: Exterior and Interior Views of the Power-House.

The details of canal construction are shown by the accompanying sections. In all cases where the junction was made between the bank and the rock ledge, a puddled trench was excavated and carefully filled with puddle to prevent the water flowing between the earth and rock. The rock surface being rough and irregular made this admissible. The puddle was formed of 25 per cent. of clay and 75 per cent. of a natural mixture of coarse sand and gravel. This was laid in layers of 1 inch in thickness, then rolled by wheel-barrows and platforms constructed on wheel-barrow wheels with handles at each end and weighted with rock or earth. This proved very effective, making a puddle compact and exceedingly watertight as constant tests demonstrated. The clay and gravel were thoroughly mixed so as to fill the interstices of the gravel with the clay. The whole was slightly dampened while being rolled.

The earth banks were given a top width equal to their height plus 2 feet. Thus a 13-foot bank has a top width of 15 feet, a 10-foot bank 12 feet. This is in excess of the usual top width given embankments. Trautwine recommends 2 feet plus twice the square root of the height and Turneauré and Russell one-fifth the height plus 5 feet. By the former a 10 feet bank would have a top width of 8.3 feet and the latter a 7-foot top. The banks generally have a slope of 1½ to 1. In certain portions the slope was made 2 to 1. The forebay banks, some 12 feet high, have a top width of 16 feet. The minimum canal radius adopted was 250 feet. At one place a right angle turn was necessary. At this point the canal was enlarged into a basin to decrease the velocity, thus avoiding any loss in head. At several points vertical, masonry walls, laid in Portland cement, were constructed and given a strong backing of rocks taken from the cuts.

The earth banks were built up in horizontal layers. The material was spread out very thin, from one to two inches in thickness, and well rolled by carts and wagons and tramped by horses. The packing, by using such very thin layers, showed excellent results. The material in general was a gravelly clay or earth and some sandy clay. The ground under all banks was first carefully stripped of sod and lightly plowed to insure a good bond between the ground and the new material, when near rock a trench being first constructed under the toe to rock and refilled with puddle material. Wheel and drag scrapers, wagons and carts and wheel-barrows were used in building the earth banks, wheel-barrows and drag scrapers preferably in the side work, wheelers in the medium hauls and wagons in the extreme hauls. The rock work in the shallow cuttings was done with teams and stone-boats, but for the vast majority of rock excavation, guy derricks with double drum steam hoists were used. When the rock had to be moved any distance the derricks dumped directly into three yard dump cars, run on 16-pound rails, or into a hopper discharging directly into carts. Steam drills were used throughout, boiler capacity being supplied sufficient to run both derricks and drills. Portable derricks were used to some extent, but the guy derricks with the large booms (40 to 45 feet), proved more efficient. The rock throughout the entire line of canal was largely limestone of varying degrees of hardness. The canal was filled with water on December 10 and 11, and was practically watertight, no leaks showing of any moment.

Forebay and Penstocks.—The forebay entrance chamber containing the racks, gates and entrance to the penstocks, is large and substantial, the foundations running down to solid rock. The racks are placed some distance in front of the head gates, 21½ feet, to insure a more uniform velocity of water through the racks. The sides are all built on reverse curves so as to give an easy entrance to the penstocks. The wing walls to make junctions with the earth banks are of concrete as well as the chamber walls themselves. The walls are given a top width of 7½ feet, the base at the bottom of the pipe being 18 feet. The wall around the 13-foot pipe is carried 6 feet farther down the hill in order to increase the anchorage of the large steel pipe.

The penstock, 13 feet in diameter with a bell entrance 15 feet in diameter, is made of steel, ⅜, 7/16 and ½ inch, double riveted and supported on concrete piers, closely following in its incline the rock surface down the hill. The turn at the bottom to a line parallel with the power-house is at an angle of 50 degrees. It reduces in size as the feeders lead to the wheels. The work was well constructed and showed no appreciable leakage under pressure.

Power-House.—The power-house is formed into one main building, 115 feet long by 48 feet wide, and an annex in the back and at the center, 44x48 feet. In the main building are placed the wheel cases, hydraulic valves, governors, generators and exciters, while in the annex, forming a part of the main building, is found the switchboard, oil switches and electrical connections. In the rear of the annex and separated by a concrete partition wall a space 18x48 feet is devoted to the transformers and lightning arresters. The walls are 30 feet high above the foundation.

The power-house is built entirely of concrete and steel. The foundation, in all cases carried to solid rock, is built of concrete, the sides and partition wall of the same material. The main building has its roof and the traveling crane supported on steel, the ends of the purlins resting on concrete gables. The draft tubes discharge through arched openings, the generators resting on solid concrete piers. The switch board is placed on a raised platform in the center annex, the platform being of concrete, granolithic flooring with expanded metal, resting on steel supports. The flooring of the power-house is formed of 10-inch concrete with a granolithic top 2 inches thick. A concrete retaining wall separates the draft tube chambers from the rest of the building.

The wheels used, 31 inches in diameter, are the most recent high-head type produced by the Stilwell-Bierce & Smith-Vaile Company. They are placed tandem and directly connected to the generators and governed by Lombard governors. Each pair of the wheels has a capacity of 1,750 horse-power, making a total for the six units of 10,500 horse-power. The generators are rated at 1,150 volts, 503 amperes with three-phase current at 60 cycles and have a capacity of 1,000 kilowatts. They can be overloaded 50 per cent. for a short time and are guaranteed for 25 per cent. overload for several hours. The voltage is stepped up in six oil transformers in banks of three to 33,500 volts for transmission on a double-pole line, each carrying three seven-strand aluminum wires. Six complete wires are installed. The lightning arresters are in two sets, one for each line.

The hydraulic machinery and that portion of the penstock in front of the power-house were furnished by the Stilwell-Bierce & Smith-Vaile Company, which also furnished the plans for the power-house above the foundation walls, the plans for the foundation walls being made by the writer. They also designed the steel structure at the entrance gates. The electrical machinery was designed by the General Electric Company in collaboration with Mr. H. R. Leyden, the electrical engineer of the New Milford Power Company, formerly manager of the Hamilton Electric Light & Cataract Power Co., the machinery itself being built and installed by the General Electric Co. The penstock from the forebay to the power-house was built and erected by the Riter-Conley Manufacturing Company, of Pittsburg. The Berlin Construction Company, of Berlin, Conn., furnished and built the steel work for the power-house and entrance gates. The dams, waste gates, etc., forming the rest of the work, were designed by the writer.

The contractor for the entire work exclusive of the installation of the machinery and steel work was Mr. D. L. Emanuel, of Pennsylvania, who was represented by Mr. L. I. Fletcher, of the same State. Some 1,100 men were employed and 15 derricks and hoists, a cableway, 15 steam rock-drills in addition to the regular contractor's plant.

The assistant engineers were Messrs. W. A. Thompson, Eugene Underwood, W. G. Fox, A. Gideon, W. S. Thomson, F. E. Toquet, J. T. Harrington, F. N. Fowler, Jr., and C. H. Beach, graduates of Yale, Harvard, Rensselaer, Cornell and Massachusetts Institute of Technology.

In addition to Mr. King, before mentioned, were associated in the company, Mr. Charles Sooysmith, of New York, M. Am. Soc. C. E., an engineer of high standing, also Mr. J. W. Ogden, a leading financier of New York City. The writer wishes to express acknowledgment to Mr. Sooysmith and to Mr. E. L. Abbott, his associate, M. Am. Soc. C. E., for counsel and advice.

[In the cross-section cut of the main dam, given last week, the apex of the formation triangle should have been shown 8 feet above the dam crest.]

Test of a Large Steam Turbine for the New York Subway Lighting System.

From the advance proofs of an article by Mr. Asa M. Mattice for the "Electrical World and Engineer" the following account has been taken of a series of tests conducted at the builder's works on a 1,250-kilowatt Westinghouse-Parsons steam turbine generating unit, the first of three units selected by the Interborough Rapid Transit Company for the illumination of the New York subway. The tests were executed on October 12-15, 1903, under the general supervision of Mr. Julian Kennedy, of Pittsburg.

The turbine is of the two-cylinder tandem-compound type and the generator of the revolving-field type, delivering three-phase 60-cycle current at a pressure of 11,000 volts. The unit operates at a speed of 1,200 revolutions per minute and has a 25 per cent. continuous and a 50 per cent. intermittent overload capacity. According to the contract it was provided that with 175 pounds steam pressure at the throttle and 27 inches of vacuum, the steam consumption should not exceed the following:

Guaranteed Steam Consumption in Pounds per Electrical Horse-Power Hour.

Steam.	Dry saturated.	Superh't'd 75 deg. F.
Full load	15.7	13.8
Three-fourths load	16.6	14.6
One-half load	18.2	16.2
One-fourth load	23.2	20.8

During the superheated-steam tests, the steam was superheated by an independent gas-fired superheater, which forms part of the permanent testing outfit in the Westinghouse turbine shop. The exhaust steam was condensed in an Alberger counter-current surface condenser, provided with separate dry and wet air pumps, the former being of the two-stage type with Corliss gear. This condenser is one of several employed only for testing purposes. It was tested for leakage immediately before and after the tests, and the correction applied to the observed steam consumption of the turbine.

The electrical load was applied by means of a large adjustable water rheostat, which also forms part of the regular testing outfit. As the generator pressure of 11,000 volts might prove a source of danger to the attendants if passed directly into a water rheostat, the voltage was reduced by step-down transformers to about 550 volts. All electrical measurements were, however, made between the generator and the transformers. Voltage was measured by two voltmeters, one being used as a check on the other, the pressure on the instruments being reduced by potential transformers having a ratio of 100 to 1. Each of these voltmeters was arranged so that it could be plugged in between any of the three terminals of the generator.

Current was measured by a duplicate set of long-scale, dead-beat ammeters. In each of the three phases were inserted two-current transformers, in series, each connected to a low-voltage ammeter. In addition to the two ammeters in each phase, a carefully calibrated Siemens dynamometer was plugged into the various phases at each reading. The dynamometer readings alone were used in the case of the lightest loads, by reason of the difficulty in reading the ammeters with sufficient accuracy for the purposes of the test. At each reading three successive observations were taken.

The speed of the turbine was ascertained from the speed of the oil pump, which is geared to the turbine in the ratio of 31 to 4. A tachometer was used to detect sudden small variations of speed. At the conclusion of the economy tests, a load of 1,309 kilowatts was thrown off by opening the exciter circuit, with a resulting increase of 2 per cent. in speed. A load of 1,342 kilowatts was then thrown on and a speed

TESTS OF A 1250-KILOWATT WESTINGHOUSE-PARSONS STEAM TURBINE FOR THE INTERBOROUGH RAPID TRANSIT COMPANY, NEW YORK.

	Dry Saturated Steam and 27" Vacuum.								75° F. Superheat and 27" Vacuum.					Dry Saturated Steam and 28" Vacuum.			75° F. Superheat and 28" Vacuum.			
Test number	20	10	9	8	6	22	23	24	19	16	15	14	12	21	7	5	18	17	13	11
Steam pressure outside of throttle, lbs. per square inch, gauge	150.3	151.4	146.8	146.5	147.1	148.0	144.5	141.8	151.8	151.9	151.0	147.7	146.3	151.0	146.8	146.1	151.8	150.8	147.6	146.0
Vacuum at outlet of L. P. cylinder, referred to 30" mercurial barometer, inches..........	27.08	27.11	27.1	27.11	27.11	27.05	27.05	26.79	27.15	27.07	27.15	27.1	27.1	28.05	28.1	28.08	28.05	28.05	28.1	28.1
Superheat, degrees Fahrenheit..............	...	...	...	...	...	...	...	...	76.6	77.2	77.0	76.15	76.0	...	...	...	75.5	77.4	76.5	78.25
Quality of steam	0.999	0.999	0.999	1.000	0.999	0.999	0.999	0.999	...	...	...	...	...	0.999	0.999	1.000	...	...	...	..
Revolutions per minute	1201.0	1201.2	1199.4	1197.4	1195.6	1201.0	1200.0	1197.4	1201.0	1212.9	1209.0	1205.1	1200.6	1198.0	1200.6	1197.4	1217.0	1214.4	1203.8	1199.4
Load in kilowatts	196.95	342.73	655.98	989.53	1321.46	1489.4	1713.5	1988.9	191.0	333.55	664.67	986.23	1293.9	334.78	972.0	1363.95	198.4	333.15	977.64	1274.2
Load in electrical horse-power............	264.0	459.42	879.33	1326.5	1771.4	1996.5	2297.1	2666.0	256.0	447.1	891.0	1322.04	1734.9	448.74	1303.0	1828.3	266.1	446.6	1310.5	1708.0
Total weight of steam consumed per hour, lbs..	7155.0	9732.0	15074.0	20254.0	25712.0	28208.0	33036.0	40547.0	6734.0	9170.0	14181.0	19108.0	23903.0	9295.0	19334.0	25639.0	6300.0	8420.0	18180.0	22504.0
Lbs. steam per kilowatt-hour	36.32	28.4	22.98	20.46	19.47	18.95	19.28	20.39	35.25	27.58	21.33	19.39	18.48	27.78	19.99	18.79	31.76	25.39	18.59	17.66
Lbs. steam per electrical horse-power-hour....	27.08	21.18	17.14	15.27	14.52	14.13	14.38	15.21	26.3	20.51	15.9	14.45	13.78	20.71	14.91	14.02	23.68	18.86	13.87	13.17
Load in terms of nominal full rated load......	0.157	0.276	0.525	0.790	1.060	1.190	1.370	1.590	0.153	0.267	0.531	0.790	1.038	0.268	0.778	1.091	0.159	0.266	0.780	1.020
DEDUCTIONS FROM THE ABOVE TEST RESULTS.																				
Lbs. steam per equivalent I. H. P. of a reciprocating engine, assuming 90% combined efficiency of engine and generator, with losses constant at all loads....................	15.89	15.08	14.14	13.39	13.14	12.93	13.30	14.21	15.22	14.48	13.16	12.66	12.44	14.64	12.99	12.73	13.93	13.30	12.15	11.89
Ditto, assuming 85% combined efficiency......	12.78	12.89	12.82	12.49	12.44	12.31	12.74	13.69	12.21	12.34	11.94	11.81	11.77	12.48	12.09	12.07	11.22	11.33	11.31	11.23

variation of 2.2 per cent. in the opposite direction was shown. This load on being thrown off showed a speed variation of 2.07 per cent. The speed of the turbine was increased by holding down the main governor lever, thus preventing the governor from controlling the speed. At 1,372 revolutions or 14.35 per cent. above normal speed, the safety stop operated and brought the turbine to rest.

The results of the tests for steam consumption are shown by the accompanying table. The tests from light loads to full rated load with 27 inches vacuum, were made to determine the fulfilment of the contract guarantees, but the overload tests and those on 28 inches vacuum were made for general information.

With saturated steam the results were considerably better than the guarantees, the difference at full load being about 7 per cent. of the guaranteed steam consumption. This economy was obtained, moreover, with steam of only 147 pounds pressure, instead of under the contract condition of 175 pounds pressure, as the higher pressure was not available.

With superheated steam at the same pressure, the tests showed an economy close to the guaranteed results.

An important result shown is the effect of the by-pass on overloads, by which high-pressure steam is admitted to the second stage. The by-pass valve was opened by hand at the various loads only sufficient to maintain normal running speed. Thus the by-pass steam is approximately proportional to the overload.

From the results it might at first appear that the steam consumption of the turbine is high at light loads, as compared with that of a reciprocating engine of corresponding size. Take for instance the results obtained under 75 degrees superheat and 28 inches vacuum. The steam consumption at full load is 13.25 pounds, and at one-quarter load 19.25 pounds per electrical horse-power, these figures obtained from a curve drawn from the tabulated data. If, for comparison, a combined efficiency of 90 per cent. be assumed for the piston engine and direct-connected generator, the steam consumption of the turbine per equivalent indicated horse-power would be 11.9 pounds at full load, which rivals the best modern steam engine performance. The most marked economy of the turbine, however, in comparison, occurs at light loads.

The superior efficiency of the turbine, Mr. Mattice believes, finds explanation in the fact that expansion is approximately adiabatic; that the cylinder remains constantly at the temperature of the working steam and is not alternately heated and cooled as in the piston engine.

For Hot Water Heating 6 to 8 pounds of water per hour per square foot of radiation are ample to furnish all the heat required by the surface during the average temperature of the heating season, according to Mr. W. H. Schott, of Chicago, in a paper on central station heating, read before a recent meeting of the Northwestern Electrical Association; but when the temperature is 20 degrees below zero, 12 to 18 pounds are required. Where a steam distribution is in use he found that in a building where the radiation was equipped up to the requirements as against one where the radiation was set on a 52 per cent. basis, a change of 34 per cent. in outside temperature varied the condensation in the former building 13.72 per cent., but in the latter 24.24 per cent. With the wind at 10.3 miles per hour and the outside temperature at the average of 30 degrees, the condensation in the first case was 0.158 pound per square foot per hour and in the second, 0.365 pound, or 22 per cent. more condensation, attributable, in the opinion of the author, to the fact that the radiation was not set to requirements.

The New Henry R. Worthington Hydraulic Works at Harrison, N. J.

Part III.—Pattern Building and Toilet Accommodations.

Pattern Building.—The 75x550-foot four-story pattern building is of entirely different character from the other buildings of the plant. It has self-supporting brick walls and solid wooden columns, beams, girders, floors and roof, of the mill or slow-burning construction, especially designed to secure the maximum resistance to fire and to conform to all requirements of the Underwriters' Association. The building is divided by transverse brick fire walls into three sections about 150 feet long and one section 101 feet long. The former are intended for a pattern warehouse and a pattern shop, and the latter for temporary office use. In the warehouse and shop sections 18x25-foot elevator wells with brick walls are built in the front of the building at two of the fire walls and have doors opening into both sections. Adjacent to the office section there is also an 18x20-foot fireproof vault with double walls and concrete floors which extends from cellar to roof, and has two floors in the upper story. In the warehouse sections the columns are spaced 10 feet apart longitudinally and support transverse beams only. In the pattern shop the columns are 15 feet apart longitudinally and support transverse girders and longitudinal beams. In the office part the construction is similar to that in the pattern shop, but the columns are 20 feet apart longitudinally.

Over the pattern shop and warehouse the roof has beams and girders corresponding to those in the floors below and is pitched about 1:10 both ways from the longitudinal axis. Over the office the roof is of the saw-tooth type with steeply inclined skylights facing north supported on triangular wooden trusses spanning from column to column. Throughout the building the columns are made of square timber with chamfered corners and decrease in size from the first floor upwards. All have 1½-inch ventilation holes bored through them from end to end on the center line, except in the upper tier where the hole is 1¼ inches in diameter. The ends of the columns are fitted to the horizontal flanges of the cast-iron caps and bases which are centered upon them with spurs or dowels projecting into the ventilation holes. The castings receive the transverse girders on their lower horizontal flanges, and their upper flanges are seated on the floor boards so as to receive the foot of the upper column section and to support it far enough above floor level to prevent the collection of moisture there.

In the first story the pattern shop and office columns are 16 inches square and the warehouse columns are 14 inches square. In the second story the columns are respectively 14 and 12 inches square, in the third story 12 and 10 inches and in the fourth story 10 and 8 inches. The first floor of the office is carried on transverse girders seated on concrete piers. The earth under the piers was excavated to a depth of 5 feet. In the other parts of the building the first floor is of concrete laid on the rammed surface of the fill made by the excavation under the office. In the upper floors of the office the transverse girders are pairs of 6x16-inch beams bolted together with cast-iron washers 2 inches thick and carrying 8x12-inch beams about 4½ feet apart which rest on their upper sides and make butt joints on the center line. These beams are covered with 1¾-inch tongued and grooved yellow pine, tar paper and ⅞-inch maple flooring, and are proportioned for live loads of 100 pounds per square foot. In the pattern shop the transverse girders are pairs of 6x16-inch timbers and the longitudinal beams are 8x12-inch timbers 4½ feet apart covered with a single layer of 1¾-inch tongued and grooved yellow pine. The 1⅜-inch tongued and grooved yellow pine roof boards are covered with composition, and are supported on 4x10-inch purlins 6 feet apart carried by single 10x12-inch transverse beams.

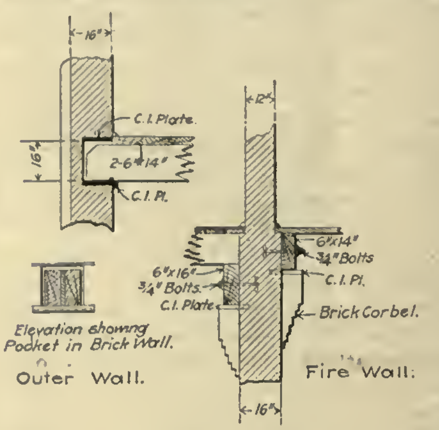
In the warehouse the 2¾-inch flooring is carried directly by the transverse girders, which consist of pairs of 6x14-inch timbers separated by a 1½x14-inch spacing piece. The floors are proportioned for a live load of 150 pounds per square foot. The roof covering and sheathing are the same as in the pattern shop, but the boards are carried directly by the 10x12-inch transverse timbers. The ends of the transverse beams project into recesses in the brick walls, where they are seated on cast-iron plates with small transverse ribs on the upper surface. The beams are notched over these ribs so as to be held in place. The upper corners of the beams are beveled and a clearance of 2 inches is left above them so that in case of fire the beam can revolve over the bearing plate and fall clear of the wall without pulling the latter after it. T-shaped cast-iron lintels are built into the wall to carry the brickwork over these recesses. On the end and fire walls brick brackets are corbeled out to carry 6x16-inch longitudinal timbers that are anchored to the wall by horizontal bolts and support the ends of the floor-beams. The skylight trusses are simple triangular frames with inclined 10x10-inch timbers meeting at right angles in the apex, where they are bolted together with short sections of angle iron. At the feet they are seated on special angle blocks integral with the post caps, which also serve as connections for the horizontal bottom chord angles with screw ends, as shown in the detail. The intermediate column castings have vertical and longitudinal webs forming cruciform cross-sections and horizontal top and bottom flanges, the latter being pierced with holes for screws to connect the ends of the transverse girders. The caps for the upper ends of the columns have sockets receiving the columns and have flanges and inclined seats for the sloping roof beams. The lintels over the large doors are made with an I-beam and two channels riveted together with top and bottom tie-plates. The building is lighted by four tiers of windows in the side and end walls which occupy about 30 per cent. of the wall area. The large doors in the front and partition walls are made with vertical and diagonal boards covered with bright tin and are hung on overhead rollers. The building is equipped throughout with a sprinkler system, and has fire hydrants and hose reels about 100 feet apart.

Considerable care, it may be added, has been devoted to the arrangement and location of the lavatory and toilet accommodations throughout the plant, and separate provisions have been made for the different main buildings. In the pattern storage building, one end of which is also to be used temporarily for office purposes, there is a toilet room and lavatory in every story, both of the office part and the pattern shop section. In the foundries there are centrally located toilet rooms for the men and also for the female employes in the core shops. There is a one-story wash room wing connected to the main foundry which contains lavatories and lockers for the accommodation of about 200 men who will be employed in this building.

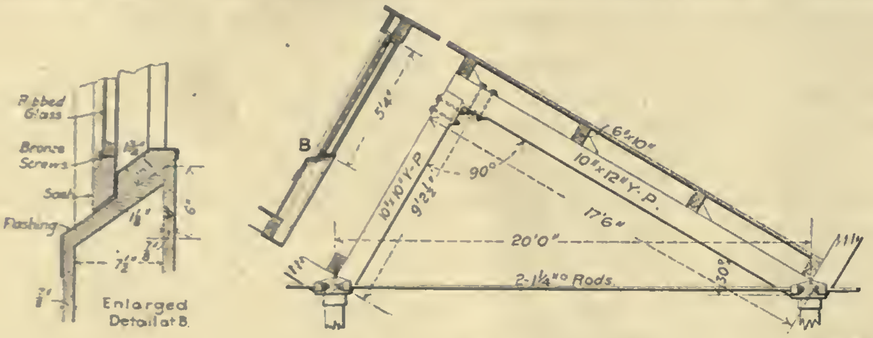
The machine shop and erecting shop practically form one very large building with two long U-shaped open courts, in which there are located four small buildings for toilet and lavatory purposes, and a fifth one is located near the center of the outer wall. These buildings are arranged to divide the distances between the shops, so that one of them can be reached within about 200 feet from any part of the buildings. These structures are 20 feet wide, 38 feet long and two stories high, of fireproof construction with brick walls and steel-concrete floor. Each story is divided into two parts, one of which contains two long enameled sinks, with hot and cold water, and 120 lockers. This room is kept locked during working hours and will be in charge of a uniformed attendant to care for the clothing and keep it in order. The system not only provides for the comfort of the employes, but serves as a check on their entrance and exit, and by making it impossible for them to commence toilet operations before the close of working hours will doubtless effect a material saving of time. The other room in each partition is always open and contains nine water-closets and a large slab urinal. The upper stories of these buildings are connected with the main building by covered bridges so as to be conveniently accessible from the galleries. Throughout the machine shop and foundry there are at frequent intervals standard porcelain urinals enclosed by sheet-iron screens about 4 feet high, on the outside of which there are sinks with drinking water.

Messrs. Burt L. Baldwin & Company, of Cincinnati and New York, are the engineers and architects for the structural work. Messrs. V. J. Hedden & Sons Company, of Newark and New York, are the general contractors for superstructures and foundations. The American Bridge Company is the contractor for the steel frameworks, and Messrs. Greene & Tierney are the contractors for the grading and sewer system.

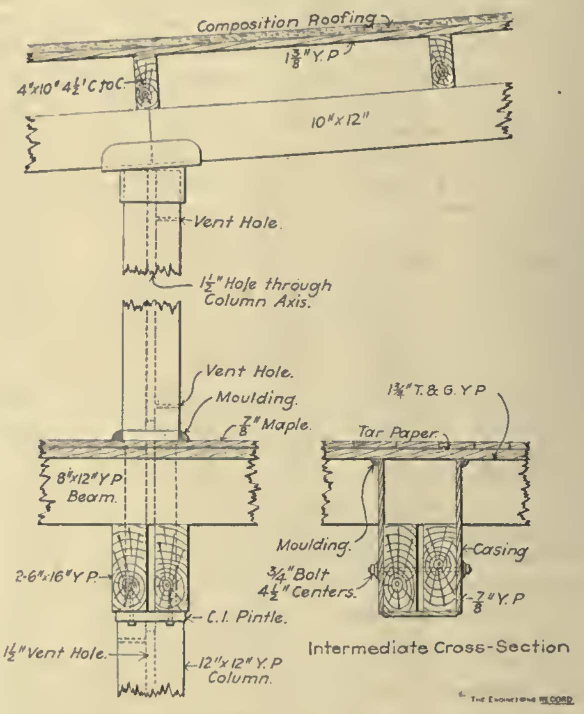
A Heavy Floor Loading has been adopted for the new shops of the Capewell Horse Nail Company in Hartford. The second floor has been proportioned for 500 pounds per square foot live load and the third floor for 300 pounds. The columns were designed to support the full load of both floors, without reduction. The steel frame was designed and built by the Berlin Construction Company. The floorbeams are on 10-foot centers and carry a floor of concrete reinforced by expanded metal. The building will contain heavy machinery and stores, and the loading was specified by the owners.



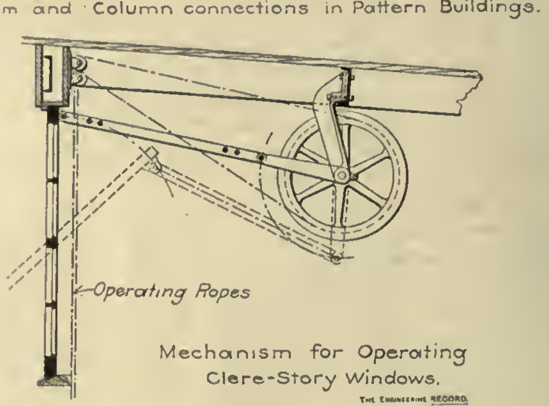
Support of Floorbeams and Brick Wall in Pattern Building.



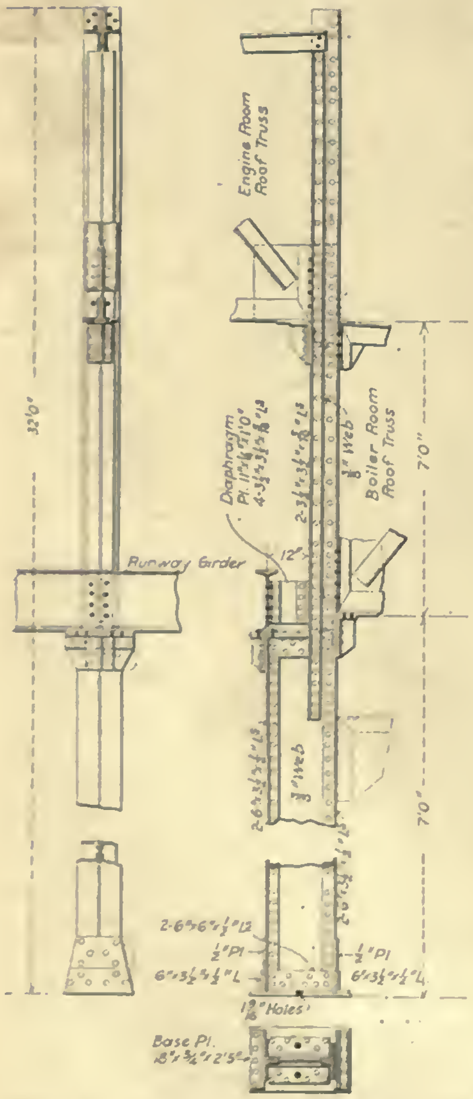
Skylight in Pattern Building Roof.



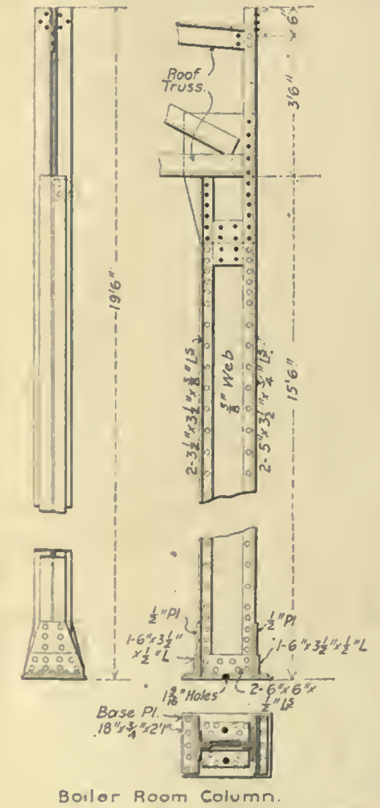
Beam and Column connections in Pattern Buildings.



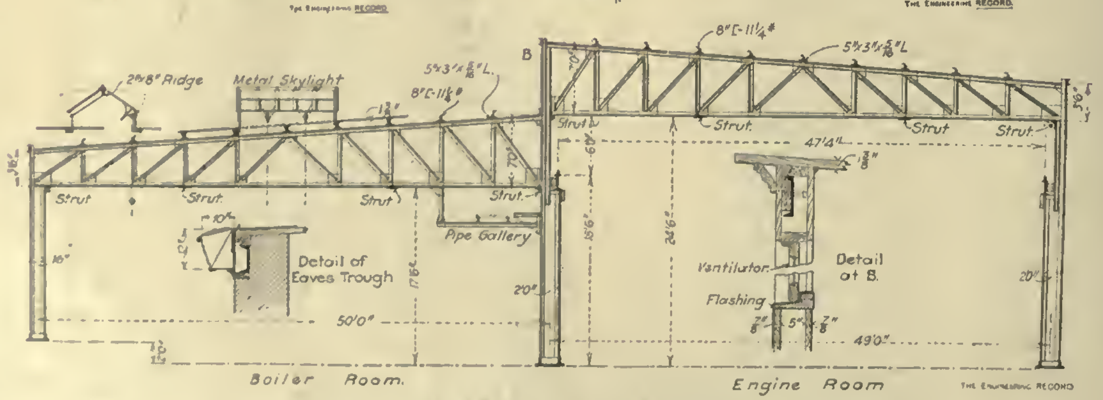
Mechanism for Operating Clere-Story Windows.



Center Columns in Power House.



Boiler Room Column.



Cross-Section of Power House.

HENRY R. WORTHINGTON WORKS: STRUCTURAL DETAILS OF POWER-HOUSE AND PATTERN BUILDING.

Letters to the Editor.

Relative Growth of the National Engineering Societies.

Sir:—I am enclosing a diagram indicating graphically some interesting points relating to the growth of the four national engineering societies. The diagram also contains curves showing the relative increase in the number of engineering graduates with degrees in civil, mechanical, electrical and mining engineering. These latter curves are only approximate, since they represent only 75 per cent. of the total number of graduates, it being assumed that only this percentage follow their profession. These curves are determined by only three plotted points. They clearly indicate, however, the general increases without showing the annual variations. The curves relating to the engineering societies show the annual variations in membership. A study of this diagram affords much that is interesting. I shall only endeavor to emphasize a few pertinent points, which should be carefully considered in their bearing upon the union building project.

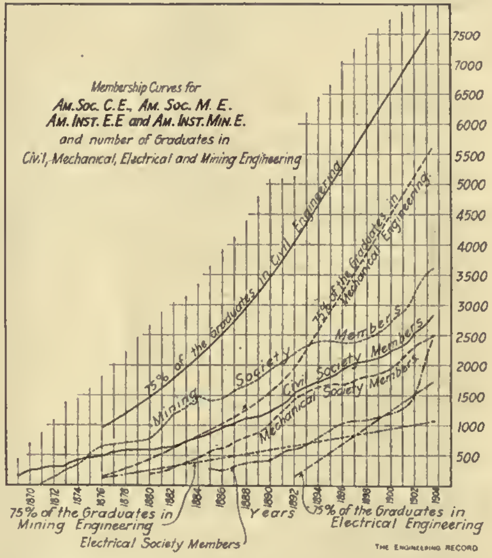
The relation between the civil and mechanical graduate and society curves differs entirely from that between the corresponding electrical and mining curves. The former show the society membership always less than the number of graduates, while the latter indicate a membership always in excess of the number of graduates. It is well known that membership in the mining society is not restricted exclusively to technical men. The other three societies are more representative technical societies. It may be noted that the number of members in the mining society has always been much greater than in any of the other societies.

In 1888 the number of members in the Am. Soc. C. E. was equal to about 37 per cent. of the total number of civil engineering graduates, while for the mechanicals the membership was 58 per cent. of the graduates. At this time the Institute of Electrical Engineers had only just been started. After fifteen years—in 1903—the corresponding percentages for the civil and mechanical engineers were 36 per cent. and 46 per cent., respectively, while for the electrical engineers it was 131 per cent. A great many mechanical graduates have specialized along electrical lines, and this probably accounts for the large electrical percentage. The corresponding percentage for the mechanical and electrical engineers combined, for 1903, is 67 per cent. It is, therefore, apparent that these combined societies are growing much more rapidly than the civil society. Using the above rates of growth (though statistics indicate that the mechanical and electrical rates will increase considerably and the civil fall off), it is found that ten years hence the membership in the societies should be approximately as follows: Am. Soc. C. E., 3,900; Am. Soc. M. E. and Am. Inst. E. E. combined, 7,700; or, Am. Soc. M. E., Am. Inst. E. E., and Am. Inst. Min. E. combined, 12,700. Therefore—based upon a most conservative estimate—within a decade the membership of the Am. Soc. C. E. will only amount to about one-fourth of the total number of members enrolled in the four national societies—probably not more than one-tenth! Does it seem likely, under such circumstances, that the prestige of the Am. Soc. C. E. will remain unimpaired?

Yet this is not the complete statement of the situation. Not only are engineers specializing in many directions, but in answer to the demands made upon them our technical schools are offering each year more specialized courses. The result will be that in a few years there will be a large number of technical graduates to whom membership in the existing societies can offer no inducement. Other societies will then be established for these several specialists. These societies must inevitably attract members at the expense of the civil society, thereby still further impairing its prestige and destroying its usefulness.

The term "civil engineer" has become obsolete. It is no longer specific enough in designating an engineer's particular functions. Its lack of comprehensiveness has already been the cause of four national engineering societies instead of one. Is it to be the cause for further separation among engineers?—of ten or twenty engineering societies?

A recent circular sent out to members of the Am. Soc. C. E. gives the following as the reason why the society should not participate in the union building project: "The undersigned, after careful consideration, feel very strongly that neither the professional nor financial interests of the American Society of Civil Engineers will be benefited by the acceptance of the proposition." How unselfish a view to take of the situation! What about the profession of engineering as a whole? The above quotation seems to sum up the whole argument that has been advanced against the proposition on the part of our society. It should be the pleasure and privilege of the Am. Soc. C. E., as the oldest, best established and most representative society, to do all in its power to further the interests of engineering, even if it has to make some individual sacrifices.



The opinion has been expressed a number of times that a great "American Society of Engineers" would be a happy solution of the problem. Such a society would include all engineers, whatever their specialties might be now or become in the future. Its standard should be equal to that of the Am. Soc. C. E. Divisions of the principal society could be established whenever the differentiation in the profession required them. It may not be possible to accomplish this at once, but it is certainly possible to make a start in the right direction. Is the Am. Soc. C. E. ready to accept the responsibility of thwarting such a movement? The attitude taken by a number of our members in this matter is narrow, contrary to the trend of the times and un-American, and if it prevails, cannot help but reflect with discredit upon our society and the profession of engineering generally.

Doubtless there are many difficulties to be overcome in the carrying out of the proposed plan, but these are only matters of detail. Are the engineers who have solved the great problems of civilization going to balk at such puny obstacles? Our profession in its broadest sense should have our first consideration. A great society of engineers would unify the profession. It would do something to counteract the effect of specialized education. It would increase the prestige and influence of the profession of engineering, and assure it that recognition which is its due.

Yours very truly, D. L. Turner,
Assoc. M. Am. Soc. C. E.

New York, February 13.

The Union Engineering Building.

Sir:—The suggestion made by Mr. George B. Francis, in your issue of January 30, concerning the proposed Union Engineering Building, seems to me to be a most happy one. While not wishing to criticize either the Board of Directors [of the Am. Soc. C. E.] or Mr. Francis, I think it is most unfortunate that this idea has not been presented to the Society at a time or in such a way that it could be formally considered. My first thought on this building matter, possibly influenced by a recognition of Mr. Carnegie's generosity as well as by the sentiment that a more intimate brotherhood of all engineers was desirable, was in favor of joining with the other societies in accepting the gift. On a more thoughtful consideration of the matter, however, I must say that I am not in favor of voting "Aye" on the proposition as submitted. We are all governed sometimes, or partly, by motives of sentiment; sometimes, or partly, by motives of self-interest. We should, I think, here allow both set of motives their fair influence.

The objection has been raised that the other, or some of the other, societies which would be associated with us in control of the building through the proposed " executive corporation," might not be able to meet the financial obligations which they would have to bear; thus throwing an undue and unexpected (in a measure) burden on the other societies, or, as we are considering ourselves mainly, on our society. To this the reply has been made that if such an occurrence took place, the property might be sold under the mortgage created through the bond issue and that we could buy it in and become the sole possessor. If we may suppose that the members of our society were to be sufficiently of one mind to do this, would it not destroy the intent and purpose of the gift? Most certainly, at least, it would destroy any sentiment of the universal brotherhood of engineers. As contrasted, however, with this sentiment of brotherhood may we not fairly set our feeling of proper pride in our own society, its membership and its history? The argument presented against the proposed action as set forth in paragraph (6), page 8, of the report of the Board of Directors, is, I believe, most worthy of consideration. Our society is broad enough, in the definition of the title, "Civil Engineers," to comprehend all the other societies; and the housing in the same home would have an injurious effect on at least the popular understanding of the title "Civil Engineers." Both these objections, which, to me at least, are the principal ones, would be overcome by such a proposition as Mr. Francis sets forth; because both in law and in fact each society would have its separate home (though adjoining each other), joined only so much as any owners of adjacent property might elect to do for architectural effect. It might be best to have joint ownership and control in the auditorium as suggested in the plan of Mr. Francis; it might be possible to have this overtop or underly the whole of the adjacent buildings and simply under joint control; which I believe could readily be done by joint articles of agreement between the several societies. Even the Engineers Club, to which so much objection has been raised (and principally, I believe, by members of the club who are also members of the Am. Soc. C. E.), might be a welcome addition—as indeed Mr. Francis plans it—but I would suggest that it would be even more acceptable if a provision could be made by the club, that on the occasion of all annual meetings, or such gatherings, conventions, etc., the club house might be open, for the time, for the entertainment of all engineers attending the same—and their families. I should think that a provision of this kind might be made by the club. Of course, I do not mean free entertainment—there might even be a fixed rental from each of the societies so using the house, in addition to the individual expense to be paid by the members.

Another idea which has presented itself, I find, to many, as to a consolidation of the various societies, but which has usually been relegated to the remote future, would seem to me (though I speak of it with some diffidence) to be perhaps worthy of immediate consideration. As has been stated, the term "civil engineer" comprehends all the others; many prominent engineers are members of two or more of the societies. I am not familiar with the requirements for membership in any of the other societies, but I cannot see why it would not be possible, even feasible, to bring all of these societies into our own now (of course it would require some reasonable time), making their members, of whatever grade, associate members, members, junior members or associates of our society, giving to each individual the grade of membership to which he would be entitled, modifying, perhaps, the conditions of membership slightly in some or all of the classes and possibly creating one or more new classes. Then with a large and diversified membership establish as many different sections as might be desirable—mechanical section, mining, hydraulic, etc., etc. Is it not time that we enlarged our ideas a little and all get together. I believe it is best to consider the matter on all sides before casting one's ballot on the present proposition.

I do not believe that Mr. Carnegie wishes to restrict the terms of his gift in any such way as would prevent the consideration of such a proposition as that of Mr. Francis. I can imagine that none would more gladly hail the amalgamation of all the societies. As a Pittsburgher (as by courtesy all Western Pennsylvanians are), I have seen with what patience he has waited on the somewhat deliberate action of the city of Pittsburgh with regard to his great gift of the technical school. Finally, to vote "Aye" now, would not the result of an affirmative vote bring upon us evil rather than good results? May I suggest that any and all who vote "No" on the proposition now before us, but who would favor the acceptance of a building, either such as Mr. Francis suggests, or such a one as would be required through and after the amalgamation of the societies, should enclose with their ballots a short note setting forth their individual views. If such notes were sufficient in number, they would, doubtless, receive the careful consideration of the board and another letter ballot under modified conditions might result favorably; provided the present one does not.

Very truly yours, T. Sidney White.

Beaver Falls, Pa., February 10.

Sir:—I enclose copy of a circular letter which I think explains itself and which I should be pleased to have you insert in the next issue of the Record.

Yours very truly, Dexter Brackett.

To the Members of the American Society of Civil Engineers:—

A second meeting of the corporate members of the American Society of Civil Engineers residing within fifty miles of Boston, was held on February 9, 1904, at the room of the Boston Society of Civil Engineers, for the purpose of discussing the advisability of the American Society of Civil Engineers joining with other national engineering societies in the occupancy and control of the proposed Union Engineering Building, for the construction of which Mr. Andrew Carnegie has offered to contribute $1,000,000.

The meeting was called to order by Mr. Dexter Brackett, who was elected chairman, and Mr. C. W. Sherman was chosen secretary. There were sixty members present at the meeting. Remarks in favor of joining with the other societies in the acceptance of Mr. Carnegie's offer were made by Messrs. John R. Freeman, George F. Swain, Henry Manley, Frederic P. Stearns, C. Frank Allen, and others. Several of the members questioned the wisdom of joining in the project.

The notice of the meeting was sent to 185 members, and in order to obtain an expression of opinion from as many of the members as possible, those who were not able to attend the meeting were requested to express their opinion by letter. A vote was taken upon this proposition: Shall the American Society of Civil Engineers become one of the constituent societies in the occupancy and control of the proposed Union Engineering Building, under the terms outlined by the Joint Conference Committee? The result was as follows:

	Not present at the meeting.	Present.	Total.
In favor	24	46	70
Opposed	16	4	20
Not voting	85	10	95
Total	125	60	185

It was voted that a report of the meeting and of the vote of the members be sent to the corporate members of the Society. Any member who has already sent his vote to the Society can, if he desires, withdraw his ballot and substitute another.

Dexter Brackett, Chairman.
Charles W. Sherman, Secretary.

Boston, February 10.

To the Members of the American Society of Civil Engineers:

I hope that my brother-members will not take amiss this appeal for careful consideration of the "Statement of the Board of Direction in the matter of the Proposed Union Engineering Building" before casting their ballots.

As at first presented, the proposition did not commend itself to the judgment of many of us, possibly because of the inadequate manner in which it was brought to our attention. But since the Board of Direction was authorized to prepare a statement to accompany the resolution for a letter ballot, the suggestion of Mr. Carnegie has taken an ampler and a more definite form. It is now virtually a project for the establishment of a university in which the application of science and of the useful arts to the uses of civilization by the engineering professions may be worthily demonstrated. If carried through successfully, it will not only be a monument to the liberality and the foresight of the man who has made it possible, but also to the spirit of enterprise which has elevated this country to the first rank of nations.

We cannot hope to vie with the great nations of Europe in picture galleries and museums whose claims to our admiration rest upon deeds of the past, but we may justly be proud of what American engineers have done in controlling the forces of Nature for the future welfare of mankind. Their masterpieces can not be contained within four walls. They are spread over the whole earth. But the records of their glory can be housed within a single building, on the scale that is here proposed. Under the same roof that shelters them may be collected and systematized the growing mass of information on engineering subjects published in many languages and places, which would be otherwise unavailable to the members of any one of the societies. It would also be, in a certain sense, a professional arena in which the latest ideas in the several branches of engineering would be discussed and where the wheat would be winnowed from the chaff by men recognized as leaders in their specialties.

Let us keep one fact clearly in mind; that this is not a question of amalgamating the American Society of Civil Engineers with other engineering societies, but of closer association for their mutual welfare. Our society is what its members have made it and so it will continue. We have nothing to fear as to its prosperity or as to the estimation in which it is held, either at home or abroad, from propinquity to the other societies.

The possibilities that this project offers for securing the best results with the least expenditure of time and labor ought not to be lightly set aside. Think of its value to the younger members of the engineering professions in this country and think, too, of the impression which such a structure would make upon foreign visitors! To them it would seem a fitting symbol of the place which these professions hold in the estimation of the American people. Nor should the advantages be underestimated that are to be derived from the proximity of The Engineers Club. The opportunities for social amenities between members of the several branches of the profession must work toward a closer affiliation among those who by separate avenues approach a common goal.

The arguments for and against the proposition are so fairly stated by the Board of Direction that nothing more is needed to enable us to vote intelligently upon it; nothing except to approach it with an open mind. Those of us who in the course of years have passed beyond the active practice of our profession, and who have gained about all that we might expect to derive from such a project, should consider what it offers to our younger brethren, and, in casting our ballots, should keep their interests foremost in our minds. Nor should we forget that narrow views on important questions rarely prove to be correct.

If in your opinion this project be a worthy one, do not fail to do all in your power to make it a success; for, if this opportunity be lost, another like it may never occur again.

Very truly yours, H. S. Haines,
M. Am. Soc. C. E.

New York, February 10.

Estimating Weights of Rails and Connections.

Sir:—During the several years that I was in railroad service, I found it of great advantage to reduce the long and old-fashioned ways of getting up estimates of weights of rails and fish plates, and send you here some of my formulae, hoping that they may be of use to the readers of The Engineering Record. We will call "L" the length of track in feet, and a ton will be of 2,240 pounds to conform to the United States usage. Should 56-pound rails be used on "L" length of track $(L\times 1/60)$ would give you the total number of long tons; likewise $(L\times 1/56)$ for 60-pound rails; $(L\times 3/140)$ for 72-pound rails; $(L\times 1/42)$ for 80-pound rails, and $(L\times 1/33)$ for 100-pound rails. Should fishplates be used with 56-pound rails $(L\times 6/5)$ would give the total number of pounds; or, should angle bars be employed with 60-pound rails $(L\times 12/5)$ would give also the total number of pounds, as $(L\times 28/5)$ with 72-pound rails and over; this on basis of 30-foot rails.

Yours very truly, E. G. du Mazuel.

New York, February 2.

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The Maintenance of Asphalt Pavements.

The problem of properly and economically taking care of its asphalt pavements is presenting itself for solution to every municipality which has used asphalt to any extent as a paving material during the last few years. It is becoming more important every year, as the amount out of guarantee is being augmented largely every season. When asphalt pavements were first laid, no one knew how long they would last nor how much it would cost to keep them in repair, so that in order to introduce them it was necessary for the promoting corporations to guarantee their work for a period of five years. This period, however, soon expired, and then the repairs had to be provided for by the municipal authorities. Many cases of this kind occurred between 1885 and 1890, when the guarantees of the early pavements began to expire. Omaha, Nebraska, was a case in point. After much deliberation and many conferences with the contractors, an agreement was entered into under which all asphalt streets, as their original guarantee expired, were to be kept in repair for an additional term of ten years for eight cents per annum per yard of entire pavement, no matter how much was actually repaired. At that time no asphalt had been laid fifteen years and the contractors had to guess as to the actual cost of repairs during that period, but the city knew positively what the cost to it would be.

Other cities have pursued the same course, although it must be admitted that it is faulty, as all calculations must be based upon the contractor's guess as to what the cost will be. Then, too, a good pavement under this system will cost as much for repairs as a bad one, and records of repair costs will be of no value as indicating the character of the pavement. Many cities have attempted to dodge this question by extending the guarantee period to ten, and sometimes to fifteen years, but this only postpones the issue, as it eventually must be taken up.

The city of Buffalo has made its repair contracts with a unit price for each square yard of pavement actually laid, with a five-year guarantee on all patches. This system is very much better than the Omaha method, but it involves a large amount of labor in keeping records. Another objection is that the contractor bases his price upon laying a pavement of the same thickness as the original, when as a matter of fact it may be worn down one-half. As the patch cannot be made any thicker than the adjacent pavement, the contractor benefits by this decrease in thickness.

Some time ago, in Washington, it was decided to base the prices upon the amount of material actually used, that is, the contractor submitted figures for the number of cubic feet of material laid on the street. As the material forms a large amount of the cost of asphalt repairs, this seems a logical arrangement. It means, however, keeping a close watch over all repair work by intelligent and honest inspectors. It leaves labor only to be estimated, and while that must vary considerably on different streets, the contractors can average it up very closely. As an example of the operation of these different systems, it can be said that in Brooklyn the cost of repairs under the blanket method was 15.93 cents per square yard, and under the cubic foot system in 1902 it was 5.79 cents, and in 1903, 7.32 cents.

What the municipal engineer wants to know is the actual cost of the work. Without this knowledge, he cannot decide when the pavement should be entirely relaid. An asphalt pavement can be patched from year to year, kept in good condition, and its life thus prolonged indefinitely, but the cost may be more than that of a new pavement at certain periods. Then, too, these records of cost must extend over a number of years, for a certain pavement may cost a large sum for repair one season, but by being put in good condition may require very little attention for some time afterwards. This will probably be the case if the foundation be good. But many of the early pavements were laid on rough and some even on wood foundations, in which case the large repair cost will likely be continued from year to year.

Very few cities have kept their repair records so that they are of any value. Buffalo, Washington and Rochester are notable exceptions. In these cities, it is possible to learn just what each asphalt street has cost since its original guarantee expired. An interesting fact learned from these records is that the old streets do not necessarily cost the most; on the contrary, their low costs are often surprising. For instance, the asphalt pavement on Alexander Street, Rochester, laid in 1885, with a five-year guarantee, had cost to January 1, 1903, but 2.17 cents per yard per year since 1890, and its cost in 1902 was only 0.062 cent.

This illustrates the uncertainties of asphalt. The early pavements were experimental. The paving companies kept exact records of how each was laid. The good ones were reproduced as far as physical and chemical science would permit, yet the results were rarely the same. If, however, the different cities would accurately keep the cost of repairing asphalt pavements out of guarantee, together with the method of repairing and the unit contract price, these costs would be comparable, and the different municipal engineers would soon be able to determine what the normal cost of maintaining an asphalt pavement should be. And when these records have been kept for a term of years, the average life of the pavement would be learned, and so the cost of a perpetual asphalt pavement could be very closely ascertained.

It will probably be some years before the best methods of providing for asphalt repairs will be ascertained, and then different plans must be used in different cities, but it would seem that the problem can best be solved by the establishment of a municipal repair plant in some city that has enough pavement out of guarantee to warrant the attempt. That the asphalt itself can be easily procured is evidenced by the many proposals to furnish it received by the city of Detroit on February 1 of this year. Expert asphalt men who have been employed by the different asphalt companies can easily be obtained, and it is to be hoped that some city will soon make an energetic attempt to solve this problem.

The Freezing Method for Sub-Aqueous Work.

There is probably no more attractive method considered in connection with some classes of sub-aqueous shaft, tunnel and foundation work, than that involving the freezing of the water-bearing material to be penetrated or removed, at least, the first impressions are highly favorable. Yet as a matter of fact it may be stated that no successful application of a freezing process has been made in this country, except, possibly, the Chapin mine shaft in Michigan. The first application of a new method to accomplish anything so difficult as the sinking of a shaft through water-bearing material is seldom, if ever, completely successful, and it may be reasonably contended that the sinking of the Chapin shaft was only an illustration of this common chapter of human experience. Be that as it may, however, it is certain that the freezing method has not been successfully employed for similar work since that time in this country, and the two or three attempts which have been made have not resulted in sufficient promise to be materially encouraging. Indeed, if The Engineering Record is not mistaken there have been but two actual attempts made to use the freezing process since the Chapin mine shaft was sunk in 1888-89. One of these attempts was unsuccessfully made to sink a coal shaft in Pennsylvania, while the other was an application of the method to the foundation work of a masonry bulkhead wall on the Harlem River Driveway in New York City immediately south of High Bridge. In the case of the Pennsylvania coal shaft the excavation was finally completed by the pneumatic process, while the foundation of the bulkhead wall near High Bridge required resort to the ordinary open coffer dam methods. It is not improbable that in both these unsuccessful cases the difficulty of freezing running water caused the failure of the process.

These results are the more remarkable from the fact that the freezing method has been repeatedly applied with at least a satisfactory degree of success for a considerable number of shafts in Europe and in one tunnel at Stockholm. Success in these cases has been sufficiently complete to justify repeated subsequent applications of the method in which the excavation has been carried down in at least one case to a depth of nearly 800 feet. The best statement of engineering experiences in this field which has yet appeared and, indeed, the only statement that can be considered historically or even approximately complete, is the extremely interesting and valuable paper which appeared in the Proceedings of the American Society of Civil Engineers for January, 1904, prepared by Mr. James H. Brace, with the assistance of Messrs. H. F. Dose and Paul A. Seurot. Mr. Brace has rendered a service of substantial value to the engineering profession in placing in such a convenient form the results of experience gained in this particular field of construction, which has of late attracted renewed attention by the proposed application of the Poetsch-Sooysmith freezing method to the construction of the Pennsylvania tunnels under the North River. The successful application of the freezing method in Europe has so far been made in shafts only, with the exception of the Stockholm tunnel, which can scarcely be considered sub-aqueous construction. This may not be significant, but it is a fact which arrests attention in reading Mr. Brace's paper. There appears to be no substantial reason why the method should not be applied as successfully to the construction of tunnels as to the construction of shafts. Of course the pneumatic method cannot be employed in shaft sinking with a head of water sufficient to make the air pressure too great for human endurance. In deep shafts, the freezing method or its equivalent becomes not a matter of choice but imperative.

It is obviously a matter of little or no consequence what freezing method is used so far as congelation of the water-bearing material is concerned; the main point is to freeze that material. There have been encountered, however, serious, if not unsurmountable, difficulties in some cases resulting from the leaking of the pipes through which the freezing liquid circulates, for if the liquid escapes and saturates the material congelation will be prevented at any point. The pipes are necessarily strained to some extent in getting them into place, and in a deep shaft if the congelation is not done by evaporation of the freezing liquid in the pipes the head becomes great enough to make escape through leaks comparatively rapid. There has been sufficient experience, however, with the practical difficulties of this nature to enable them to be reasonably controlled, at least in those successful European cases described by Mr. Brace, and there seems to be no reason why control should not be effected as a uniform procedure in all cases.

The great difficulty in inducing contractors to undertake the application of a new process of this nature arises from the facts that his experiments are made on a large scale and are costly, and that the owners of enterprises usually endeavor to shift all such responsibility to the contractors themselves.

The successful application of the freezing method to such a great sub-aqueous construction as the proposed Pennsylvania tunnels under the North and East Rivers would have some practical advantages over the pneumatic method or any method in which there is liable to be a movement of the water-bearing material around the structure during the progress of construction. The escape of compressed air from a working chamber keeps the material around it in a constantly loosened and moving condition prejudicing the safety of the work to some extent and destroying the advantages arising from a completely undisturbed environment. Water-bearing material is of course frozen absolutely in place under any freezing method and remains undisturbed not only during the progress of construction but after completion also. So far as experience has extended laborers seem to experience no injury in working in the low temperatures accompanying the excavation of frozen material. The congealed sides of the excavation make it necessary to excavate only to the neat lines of the structure and this requires a minimum amount of both excavation and construction.

The circulation of the freezing liquid can certainly be maintained as well in a horizontal excavation, like that required for a tunnel, as in a vertical excavation, and so far as estimates of cost are concerned it would appear to be an economic plan of procedure, although it is to be observed in this connection with some emphasis that preliminary estimates of cost and final costs of work completed are very likely to be separated by a wide gap, especially when new processes are employed. It would be a matter of great interest to engineers to observe the results of the application of the freezing method to some large work like the Pennsylvania tunnels or any other large subaqueous construction. Conservative administration, however, has so much to commend it in tunnel construction at depths easily attainable by the old and tried pneumatic method, either in the ordinary manner or in the manner successfully employed for the rapid transit subway tunnel under the Harlem River, that that method is likely to prove a bar to the immediate application of a procedure so markedly novel as the freezing method in at least some of its features. Doubtless its trial in actual application is destined to come at an early date, and in the interests of the extension of valuable engineering experience it is to be hoped the trial will not be long delayed.

The Thermal Efficiency of a Rotary Cement Kiln.

It has long been recognized that in some respects the scientific side of Portland cement manufacture has not developed so rapidly as the practical. This is not at all surprising when it is recalled that the demand for this material was so great for a number of years that makers were forced to strain every resource to fill orders. Under such circumstances the tendency is always to improve existing methods and plant, rather than to engage in prolonged and painstaking investigations of the scientific aspects of manufacturing processes. It speaks well for the energy and the enthusiasm of American technical chemists that so much good work has been done by them, and it is to be regretted that so little of their work has been recorded publicly. It is apparent, however, that the industry is about to receive in greater measure than before the attention of independent investigators, and it is by no means unlikely that the publication of the results of their studies will call forth some notes of the experience of others whose regular duties have been so heavy that no time was available for the preparation of papers outlining their experiments. This journal deplores the occasional assertion that American chemists have done little or no good work in cement, for it is not only an unjust reflection on able men who are making a life work of the technology of the industry, but likewise neglects the important investigations of independent students.

These thoughts are suggested by the very interesting paper on the thermal efficiency of a rotary cement kiln read by Dr. Joseph W. Richards before the American Chemical Society and printed in its "Journal" for last month. It is based on tests made with a 60-foot rotary kiln 6 feet in diameter in the Dexter works at Nazareth, Pa. The kiln produces an average of 3,600 pounds of cement clinker per hour from 5,980 pounds of raw materials, and about 200 pounds of flue dust are given off in this time. About 110 pounds of pulverized bituminous slack coal are burned for each barrel of cement produced. The object of the tests and the calculations based on their results was to strike a balance sheet of the heat generated within the kiln and its distribution, and to ascertain the temperature of the hot gases which furnish heat to the clinker and the proportion of air admitted in excess of that theoretically needed for perfect combustion. The details of the investigation need not be mentioned here; the results were as follows: Total heat generated per barrel of cement made, 466,400 calories, of which 395,000 calories were from the fuel and 71,400 from the heat of combination of the ingredients forming the clinker. Of this amount of heat, 10.7 per cent. remained in the hot clinker, 36 per cent. was carried off by the excess air in the chimney gases, 36.1 per cent. was carried off by the necessary products of combustion in these gases, 0.2 per cent. was lost in the flue dust, 1.3 per cent. was lost by imperfect combustion, 0.2 per cent. was used in evaporating the moisture in the raw materials, 2.3 per cent. was used in expelling carbon dioxide from the carbonates, and 12.8 per cent. was lost by radiation and conduction.

An important fact shown by these figures is the leading part played by the heat of combination of the ingredients, which amounts to 18 per cent. of the total amount furnished. If it were left out of consideration, Dr. Richards states, there would not be enough heat for the process, exclusive of the losses by radiation and conduction.

The greatest loss of heat is found to be in the gases. The amount of air in excess of that theoretically required for combustion is 132 per cent.; could this be reduced to 10 per cent. the heat lost in the gases would be reduced by an amount equivalent to 40 per cent. of the calorific value of the fuel. If the temperature of the gases could also be reduced one-half, the saving would be equivalent to about 60 per cent. of the fuel used.

The publication of the figures of which the above data are merely the general totals explains why the rotary kiln is so wasteful in comparison with the continuous vertical kiln. This great difference in fuel consumption has been frequently mentioned in this journal, and it has been generally recognized that the first great improvement in rotary kiln practice would take the form of some design which would reduce the cost of fuel. This type of apparatus is useful because of the saving of labor attained by employing it, which more than balances the extra fuel charges. With the growth of competition between plants attention has naturally been drawn to the coal pile, which represents about one-fourth of the cost of the cement in the stockhouse bins. Already some important departures from current practice have been made, and it is interesting to examine them in the light of Dr. Richards' investigations.

One of these innovations consists in enlarging the diameter of the kilns and using double burners. More heat is thus produced, which will drive off the carbonic acid from a greater amount of raw material. In this way the clinker output of a 60-foot kiln is said to be increased about one-third for the same consumption of fuel per barrel. The gases are sent through a boiler and economizer, and a very large amount of waste heat is utilized in this manner; it has been claimed that nearly half the fuel has been saved by such a steam plant.

The second innovation is entirely different and aims to utilize the heat in the gases by exposing the clinker to them for a longer time. It has its leading exponent in the 150-foot kilns of the Edison plant, recently described in The Engineering Record. Double burners are employed to give plenty of heat in the front of the kilns and the intention is to have the waste gases leave at about the lowest temperature at which carbon dioxide can be driven from the raw materials.

At the present time the second method of increasing the utilization of the heat is undoubtedly considered the better. The Edison kilns have probably attracted more attention than any other recent novelty in cement machinery, and their undoubted success may be in some measure a reason for the high favor in which 80-foot kilns are now held. These have been in use with marked success for a year or more, and the results attained with them show that Dr. Richards' figures have an immediate practical value. While such heat balances for kilns have been made before, very little information of the sort has been published and his paper ought to bring out a useful discussion.

The Panama Canal.

The readers of The Engineering Record have already learned through the daily press of the successful outcome of the many years of patient technical study and diplomatic negotiation relating to an isthmian canal. It is with pride that this journal points to its uniformly accurate news regarding this great enterprise. While it has not been made the organ of the French canal company nor the mouthpiece of the administration, whatever that term may mean, its readers have been put in possession of the first and in many respects the only complete account of all important steps taken in late years with regard to the work. Even the revolt of the people of Panama was predicted in this journal two years before it occurred. It is believed that nowhere except in the files of this journal will be found an unprejudiced and reliable account of the leading features of the last Commission's work, which laid the foundations for this great enterprise. The first stage of the project is now finished. The early explorations, the crazy work of the French promoters, and the preliminary investigations of American companies and commissions are now a thing of the past. The ratification of the treaty between the United States and the Republic of Panama is practically complete, the money for the purchase of all adverse interests on the Isthmus is available, and the commission which is to carry out the work is pretty well settled. The time of negotiation, investigation and preliminary planning has closed and the period of construction has begun.

This enterprise to which the nation is now committed is a work of such magnitude and world-wide importance that only those who have followed it closely can really appreciate the responsibilities of the seven commissioners who will have it in charge. The technical skill to plan the works, the executive ability to push everything along just as fast as good construction will warrant, and the diplomatic temperament that will be often needed to straighten out tangles leading to possible international complications, are so rarely combined in single individuals that it is no wonder the President is having some trouble in persuading men to accept positions on the Commission. The duties are so numerous and onerous that the Commission will have to work by committees and any individual failure to carry on work properly will be speedily revealed to the public through the very acts of the Commission itself. The last Commission contained one member whose influence was absolutely nil, and although nothing was ever said about his position in the corner out of the way during the deliberations of the Commission, every intelligent reader of its reports has recognized the failure of this man's early work and his entire neglect by his associates in the remaining investigations.

The chairmanship of the new Commission has gone to Rear Admiral John G. Walker, a fact that every one acquainted with his executive ability and thorough knowledge of the Isthmian problem will welcome. Accustomed to command men of all stations in life, thoroughly acquainted with the methods by which the government carries on its work, and respected by all people acquainted with his part in making the country a naval power in the modern sense of that term, his appointment is an ideal one. As the president of the last Isthmian Canal Commission he will simply change one title for another and not assume a new office; it is hardly proper, in fact, to speak of the "last" Commission, for it is still in existence. The other men who have accepted office are excellent appointments. General George W. Davis will bring to the Commission the knowledge of military affairs which is indispensable when construction begins and the management of an army of laborers has to be supervised. Experience at Havana has shown what the strict supervision of construction by army officers will accomplish in suppressing disease, and the same supervision on the Isthmus may be expected to rob that dread country of its fancied terrors. Col. Frank J. Hecker, of Detroit, a third member, is so well known as a shrewd financier that his presence on the Commission will be an assurance that all its financial affairs will be ably managed. Moreover, he is an experienced executive officer and noted throughout the Central States for his tact in handling important enterprises.

Just who will be the engineer members of the Commission cannot be foretold at this writing, but a number of excellent men have been named as probable appointees. Mr. Alfred Noble would be an ideal man for such a place on account of his wide experience and previous acquaintance with the canal problems, but his friends will be sorry to see him give up the great tunnel undertaking of which he is now the chief engineer to accept merely a share of the responsibilities and the fame of the new Commission; his present engagement is as important as any ever entrusted to an engineer, and it is to be hoped the Pennsylvania Railroad Company will succeed in making it worth his time to remain on its staff until the work is done. Mr. William Barclay Parsons' appointment would be highly gratifying to all who are sufficiently acquainted with the details of his work as chief engineer of the New York Rapid Transit Railroad Commission to recognize the great measure of tact and firmness which has been exercised along with engineering ability in this undertaking. The selection of Mr. William H. Burr is to be commended on the same grounds as that of Mr. Noble. He is so well equipped theoretically and practically for technical problems of the greatest magnitude and is so well posted on the work to be done through his previous connection with the Isthmian Canal Commission, that his selection as a member of the new Commission would add materially to its effectiveness. Moreover, his executive ability in pushing engineering works through to completion is too well known among engineers to need comment. Major B. M. Harrod is another ex-president of the American Society of Civil Engineers, who is stated to be a possibility on the Commission, although a New Orleans newspaper is said to be opposing his appointment on account of his very creditable course in allowing a good brand of American Portland cement to be used on work under his charge, although the original specifications called for a foreign cement. This journal has previously pointed out the childish folly of this charge, which condemns Major Harrod for permitting a good grade of material to be substituted for a far inferior one. He has had a long experience with important public works, particularly in warm climates, and his work as a member of the Mississippi River Commission has been so satisfactory that the President would be thoroughly justified in selecting him as a member of the canal commission. Another engineer whose name has been prominently mentioned is Mr. C. E. Grunsky, at present city engineer of San Francisco. With the exception of Mr. Parsons, he is the youngest of the engineers whose names have been considered by the President, being about 48 years of age. Since 1878 he has been engaged in hydraulic and harbor improvement work on the Pacific Coast, where his reputation as an engineer and executive is of the highest character. Just which of these engineers will be finally selected by the President, or whether others will eventually be chosen, remains unknown at this writing. Enough has been said, however, to indicate the deep responsibility the President feels in making his selection and how admirably he has chosen his list of possible appointees. Every engineer on the list would be a good appointment.

THE TYPHOID FEVER OUTBREAK at Watertown, N. Y., affords a particularly good example of the results which may be expected to follow the use of unfiltered water from a water-shed subject to pollution. The supply is drawn from the Black River, whose basin is occupied by a number of villages and hamlets, some of them of considerable size. Prof. Olin H. Landreth, consulting engineer of the State Board of Health, has discovered proof that at least fifteen cases of typhoid occurred on this catchment basin within 35 miles of Watertown during the last three months of 1903. Late in December there was a protracted period of warm weather and rain followed by cold weather which would detain the accumulated polluting matter on the basin until the next thaw set it free in great quantities. It is not at all surprising, therefore, to find that the number of typhoid fever cases in the city jumped from 7 in November and 15 in December to 180 in January and a much larger number in the present month. The lesson is a terrible one, but the pity of it all is the absolute disregard of most people to pay any attention to it. They read about the fever-stricken inhabitants of Butler and Ithaca and Watertown, but never stop to consider that it is only a merciful providence in many cases which prevents their own condition being similar to that which fills them with horror.

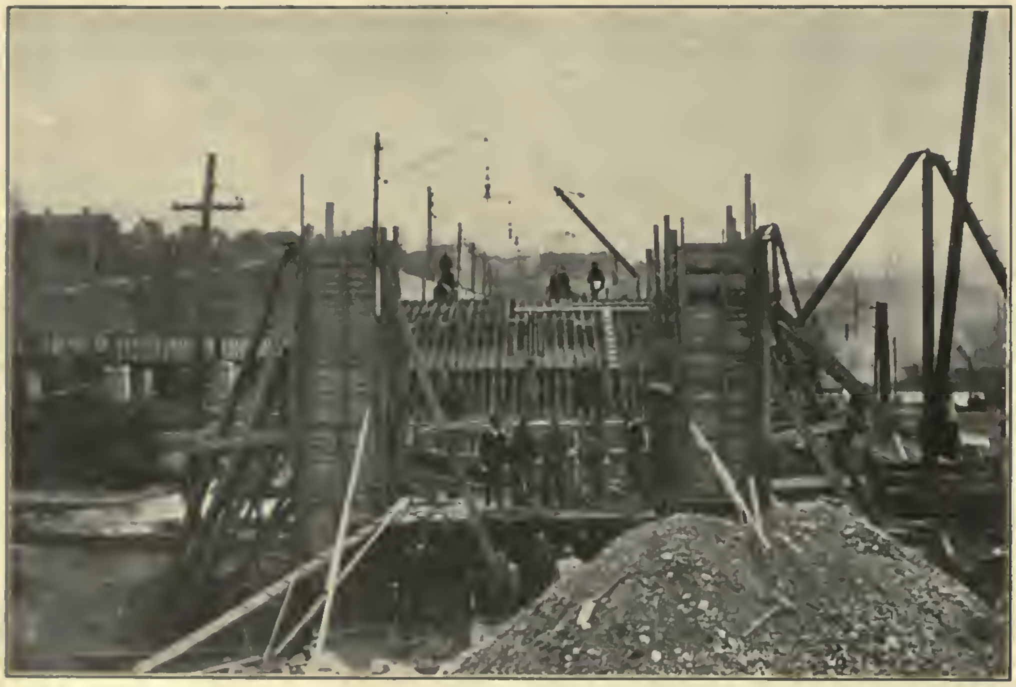
The Herkimer Viaduct for the Utica & Mohawk Valley Railway.

By Wilbur J. Watson, Assoc. M. Am. Soc. C. E.

The Utica & Mohawk Valley Railway is a double-track electric line running from Rome, N. Y., on the west, through Utica, to Little Falls on the east, down the historic Mohawk Valley. The interurban portions of this railway, built in 1901, 1902, and 1903, are of substantial and permanent construction, the bridges being made strong enough to carry any future increase in the weight of the rolling stock which may reasonably be expected. On that portion of the line between the village of Herkimer and the city of Little Falls, and just east of the former, the railway crosses the West Canada Creek and the New York Central & Hudson River Railroad, on a concrete and steel viaduct which is one of the largest structures of its kind. The West Canada Creek is a swift stream having its rise in the Adirondack Mountains and emptying into the Mohawk River a few thousand feet below this viaduct. Its drainage area is not large, but the stream is subject to violent floods. The normal width of the creek bed is about 400 feet at the viaduct, but its flood plain is about 1,600 feet wide. The New York Central & Hudson River Railroad crosses this flood plain a few hundred feet north, up-stream, from the viaduct, providing a clear opening of about 80 feet at the west end of the plain, for use in times of flood only, and a low level structure, about 520 feet in length, crossing the normal bed of the stream. The New York Central structure is composed of concrete piers on pile foundations and a through plate-girder superstructure.

The Utica & Mohawk Valley Railway crosses the flood plain on a structure composed of an earth embankment about 250 feet long and 10 feet high; a through plate-girder span with shallow floor system giving a clear opening of 80 feet, called the "dry channel span," designed for use in times of flood; and an earth embankment from 10 to 22 feet high; and about 600 feet long, extending to the west abutment of the concrete viaduct. The concrete viaduct is 755 feet 6 inches long, double-tracked, and from 24 to 40 feet in height above the general level of the flood plain. The bed of the stream is about 8 feet below the level of the plain. At the east end of the concrete viaduct the railway line crosses the tracks of the New York Central & Hudson River Railroad at an angle of only 22 degrees 23 minutes measured between the center lines of the two railways. The tracks of the New York Central are on a curve of about 3,000 feet radius at this point. There are at present four tracks, but provision is made for a fifth track on the north side, and 12 feet clear space is provided between the center lines of the extreme north and extreme south tracks and the nearest point of the concrete piers. The overhead clearance is 22 feet.

Herkimer Viaduct: General View Showing Relation to Tracks of New York Central Railroad.


Herkimer Viaduct: End View of Forms for Arch and Spandrel Walls, Steel Rods in Place.

In order to reduce the length of trusses required to span these tracks, the piers next to the New York Central tracks were placed with one face parallel to the line of these tracks instead of parallel to the line of the bridge, as is usually done. It was found that a span of 225 feet, center to center of end pins, skewed 67 feet 6 inches, would fulfil these conditions. At the east end of this 225-foot span both the gradient and the alignment of the electric line are changed, the ascending grade of 2 per cent., which has so far been maintained is changed to an ascending grade of 0.9185 per cent., and the alignment is deflected 36 degrees 39 minutes to the right, by means of a 12-degree curve, with 280-foot spirals at each end. The grades are connected by a vertical curve 200 feet in length, and the combination of spiral curve, vertical curve and 4 inches camber in the 225-foot truss span formed an unusual problem in track alignment, which was worked out graphically in the office with very satisfactory results. At the east end of the viaduct, between the 225-foot truss span and the east abutment, are three deck plate girder spans, 55 feet center to center of piers, which are placed at right angles to the line of the spiral curve. The length of the steel structure is 457 feet 6 inches, and the distance from the west end of the parapet wall of the concrete structure to the face of the back wall of the east abutment is 1,210 feet 2 inches.

The bed of the West Canada Creek is composed of gravel, somewhat compacted, water bearing and free from loam, to a depth of about 6 feet below the bed of the stream, and then a hard blue clay of great depth. The bed of gravel increases to a thickness of from 12 to 15 feet at different points on the flood plain. It was originally intended to rest the piers for the arches on this gravel bed, without piling, but a careful study of the conditions, made after the work was begun by the consulting and resident engineers, led to the conclusion that such a course would not be safe owing to the great scouring action of the stream, as evidenced by large pot holes found at various points of the flood plain. All these piers, with the exception of the three east piers supporting the 55-foot deck plate girders, were, therefore, founded upon piling. In the case of the piers for the arches the gravel was entirely removed and the piles driven into the clay; their tops were sawn off from 8 to 10 feet below ordinary low water. The piles are about 15 feet long, of spruce, stripped, and were driven until the penetration under a hammer weighing 1,000 pounds, falling 20 feet, did not exceed about 2 inches.

The concrete for the piers rests directly on, and around, the heads of the piles. All the piers were built by use of ordinary open coffer dams, of sheet piling, kept free of water by pumping. Burlap bags filled with sand were used in connection with the sheet piling in constructing the coffer dams for the creek piers. The piers in the creek bed are provided with concrete cutwaters, the faces of which make an angle of 45 degrees, with the faces of the piers. As these cutwaters are carried up to the springing line of the arches, which is on a 2 per cent. grade corresponding to the grade of the track, their tops are at varying heights above the water surface.

The piers are built of two widths, the second, fifth and seventh from the west end of the viaduct are 12 feet wide under the coping, with sides battered ¾ inch to the foot, and are of sufficient size to withstand the thrust of the adjoining arch, should any one of the arches be destroyed. The other piers are 8 feet wide under the coping, but similar in all other respects to the wider piers. At the wide piers pilasters 9 feet wide projecting 12 inches from the face of the arch rings are carried 2 feet above the coping of the parapet wall. Similar pilasters 5 feet wide at the smaller piers are carried only to the top of the parapet wall. Into these pilasters were set the sockets to receive the iron trolley poles.

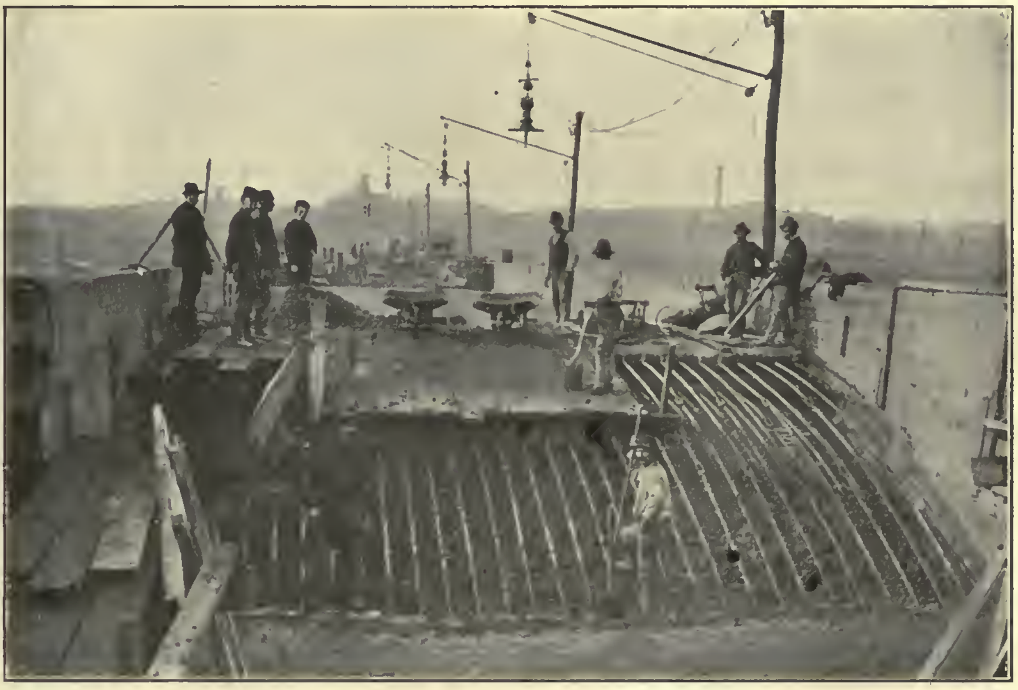
There are ten concrete-steel arches, seven of 62 feet span and three of 66 feet 6 inches. The 62-foot arches have a rise of 12 feet and thicknesses of 21 inches at the crown and about 4½ feet at the springing. They are segmental, the radius of the intrados being 46.04 feet and that of the extrados 57.00 feet. The rise of the 66-foot 6-inch spans is 14 feet; the thickness of the arch ring at the crown 21 inches, and at the springing, about 4 feet 6 inches. The radius of the intrados is 46.48 feet, and of the extrados, 55.5 feet. All arch rings are reinforced with Thacher patent bars, 1¼ inches diameter, spaced 11 inches center to center in both extrados and intrados. The stresses in the arch rings were computed by the graphical method of Prof. W. A. Cain. The maximum compression allowed on concrete was 600 pounds per square inch, and the maximum tension in steel bars 16,000 pounds per square inch, including stresses caused by a variation of 50 degrees in temperature. No attention was paid to tensile stresses in concrete. Stresses were computed for two loadings; first, full dead and live load, the latter assumed at 10,000 pounds per linear foot; second, live load on one-half of the arch only.

Herkimer Viaduct: Concrete Arch Spans over West Canada Creek.

No waterproofing was used on these arches; the valleys between the arches were sloped toward the center, and 4 inch drain tiles inserted through the arch rings to carry off the water. The filling used was gravel.

In constructing the arch rings the section at the crown was first laid, and then the concrete was placed in transverse sections, beginning at the springing line and working toward the crown. The concrete was laid on 2½-inch spruce sheeting, supported every 4 feet 6 inches by carefully framed and trussed centers, the chords of which were built up of three pieces of 3x12-inch spruce held together by hardwood pins. The web bracing of the centers was composed of 6x6-inch pieces supporting the arch ring at seven points. These centers rested on wedges placed on 12x12-inch caps supported by hemlock piles, two at each end and two near the middle of each center. There was no appreciable settlement of these centers during construction. The centering was designed by Mr. C. H. Clark, M. Am. Soc. C. E., chief engineer of the railway company.

Expansion joints were provided in the spandrel walls over each pier, at the junction of the spandrel wall and pilaster. This was done by nailing a narrow strip of timber to the sides of the forms for the arch pilasters, thus forming a groove into which the spandrel wall is tongued. These joints all show evidence of motion, and also allow considerable water to leak through. Two-inch matched sheeting, planed on one side, was used throughout in the forms. Studs were 2x6 inches for spandrel walls, and 3x12 and 2x6 inches spaced 2 feet apart for the pier forms, and braced about every 4 feet.


Herkimer Viaduct: Method of Placing Concrete and Splicing Rods in Arch.

The concrete was composed of Portland cement and sand and gravel taken from the river bed. The cement used was the Nazareth brand, manufactured by the Nazareth Cement Company, of Nazareth, Pa., and was supplied by the Charles Warner Company, of Wilmington, Del. It was tested on the ground. The gravel was run through a crusher and screened. There was a large island composed of coarse gravel and sand in the middle of the creek bed, and it was expected that sufficient material could be taken from the creek bed to build the structure, but owing to the unusual high water during the season of 1902, it became necessary to haul gravel from the hills for a considerable portion of the work. In general, the proportions used were 1:3:7 for the piers and foundations, and 1:2½:5 for the arch rings and spandrel walls, on the basis of packed cement and loose sand. These proportions were decided upon after careful determination of the percentage of voids in the sand and gravel used. All concrete was hand mixed and placed wet. For construction purposes a temporary runway and platform was built alongside the viaduct, and, when necessary, derricks were used to hoist the mixed concrete to the work. The concrete for the spandrel walls was mixed on top of the structure. Filling was done by dump cars and an engine running on a temporary track supported on cribbing placed on top of the arches. The maximum number of men employed at any one time was about 400. In depositing concrete, care was taken to place a rich mortar, 1:2½, against the forms, using slip boards. After the forms were removed, the exposed concrete surfaces were brushed with thin mortar wash, the sand being carefully selected, and then rubbed down with sandstone blocks. In this way a very uniform color was secured.

The piers supporting the 225-foot span over the New York Central are isolated rectangular piers 5 feet 6 inches by 7 feet 6 inches under copings with all sides battered ¾ inch to the foot. The pier on the west side of the Central tracks is 46 feet high above the foundations and rests on 143 piles, which carry a load of 23.7 tons each or about 3,000 pounds per foot of pile. This load is exceeded by several of the piers carrying the concrete arches, the maximum load per pile being 32 tons. In computing these loads on the piles, however, no allowance is made for the supporting power of the soil, which is capable of bearing half the total load.

The design of the 225-foot truss span with its 67½-foot squaring-up girders presents some unusual features. Owing to the large deflection at the third panel point (which comes opposite the end of the opposite truss), it was not deemed advisable to put in a rigid floor connection, and therefore the floor-beams are designed to rest on seats built in the posts, the bottom flange of the floor-beam being rigidly connected to the bottom of the end post by a heavy lateral gusset plate and the top of the floor-beam being left free to move on its seat. It was also decided to omit the usual knee-braces at the intermediate posts, and to rely upon the portal bracing and end posts to carry the entire wind pressure on the upper chords to the shoes. In order to obtain a system of wind bracing which would be as efficient as practicable, the end posts were made vertical, although the designers realized that inclined posts would have improved the appearance of the structure. The portal strut for these trusses is about 72 feet in length. The floor system and lower lateral bracing is continuous over the squaring up girders, the continuity of the lateral system being secured by a strut connecting the end pin of the truss span with the girders.

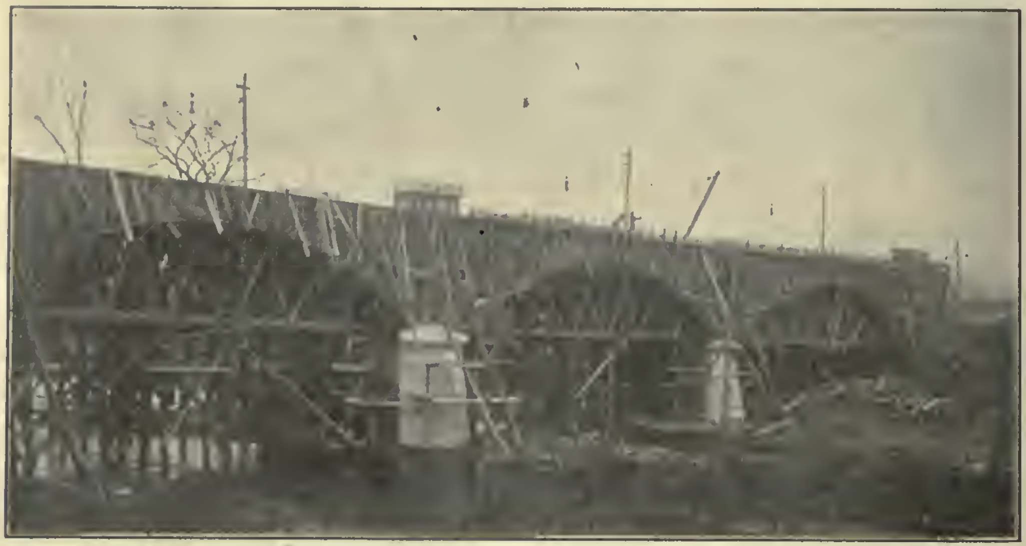
This structure has been found to be very rigid under traffic. The trusses are pin connected, 7½-inch forged pins and 8-inch medium steel eyebars being used throughout the lower chord. Nine-inch segmental rockers give ample provision for the temperature movements of the truss span, which is fixed at the east end and free to move at the west end, the squaring-up girders being considered as part of the truss span. At the east end of the truss span is a cross girder which supports one end of the 55-foot deck plate-girder spans, the other end being supported on concrete piers. These 55-foot deck spans are tilted in such a way as to provide for the superelevation of the outer rail at their west ends, the increasing superelevation due to the spiral curve is provided for by dapping the ties, and, when necessary, using beveled ties. The required notching of all of these ties was computed in the office.

There was used in the construction of this viaduct about 11,500 yards of concrete, 108 tons of steel rods for arches, 584 tons of structural steel, and about 400 M. feet B. M. spruce and 300 M. feet B. M. hemlock lumber.

Preliminary plans were submitted to Mr. Horace Andrews, president of the railway company, on January 27, 1902. Complete general plans were finished on March 10, 1902, and submitted to the State railroad commissioners on May 29, 1902. Work was begun on the concrete on July 1, 1902. It was expected that the structure could be completed during the season, but delays caused by high water, difficulty in getting material on time, etc., made it impossible. Operations were, however, continued up to December 20, 1902, at which date all the arches except the two at the east end, and all the piers, were completed, and then the concrete work was discontinued until April 3, 1903. The concrete work was finally completed, except finishing and removing forms, on April 18, and the first car passed over the structure on April 29, 1903. The contract for the steel work was let on August 15, 1902, and erection began on November 25, 1902; it was completed on April 28, 1903. During the erection an average of about 30 men were employed. The 225-foot span over the New York Central was erected by placing a timber bent between tracks Nos. 2 and 3, which were spaced apart for the purpose, leaving openings of about 28 feet span, measured at right angles to the tracks, which were spanned by 8x16-inch yellow pine timbers, carrying the floor system and erecting traveler.

At the time the work was started the officers of the Utica & Mohawk Valley Railway Company were: President, Mr. Horace Andrews; general manager, Mr. J. J. Stanley; engineer of that portion of line between Herkimer and Little Falls, Mr. C. Loomis Allen; resident engineer, Mr. F. C. Phillips, Assoc. Mem. Am. Soc. C. E. Soon after the work was started, Mr. Stanley retired to take the general managership of the Cleveland Electric Railway Company, and Mr. C. Loomis Allen became general manager. Mr. C. H. Clark was chief engineer and Mr. Phillips, resident engineer. To the resident engineer and his assistants, Mr. E. P. Roundy and Mr. Byron E. Turnbull, inspector, is due the credit for the painstaking care with which the design was carried out. The contractors for the substructure were Messrs. Beckwith & Quackenbush, of Herkimer, N. Y., and the contractors for the superstructure were the Snare & Triest Company, of New York City. The shapes for the superstructure were rolled by the Passaic Rolling Mill Company, of Paterson, N. J., and the plates by the Central Iron & Steel Company, of Harrisburg, Pa. The pins were forged by the Bethlehem Steel Company. The fabrication was all done at the shop of the Passaic Rolling Mill Company, at Paterson, N. J.

The entire structure was designed by the Osborn Engineering Company, of Cleveland, Ohio, for which the writer is bridge engineer. The materials at the mills and the work in the shops and field were inspected by the representatives of the consulting engineers. With the exception of the pins and eyebars, all materials used were basic open hearth soft steel manufactured in accordance with the specifications of the Osborn Engineering Company, which also governed the work in the shop. Medium steel was used for eyebars and pins. All structural steel was given one coat of No-Brac, manufactured by the Patterson-Sargent Company, of Cleveland, in the shop, and two coats of Dixon's silica graphite paint in the field.



Herkimer Viaduct: Side View of Forms and Centering for Concrete Arches.

A 40-Hour Test of a Generating Unit at the Lincoln Wharf Power Station, Boston, was conducted in May, last year, by 108 students of the Massachusetts Institute of Technology. While a number of difficulties arose that prevented best economy being obtained, particularly with the boilers and economizer, the following results were noted in "Technology Quarterly": Horse-power of engine, 3,902; steam pressure, 158.1 pounds, gauge at throttle; superheat, 69.7 degrees Fahr.; vacuum, 11.8 pounds; steam per horse-power per hour, 12.08; British thermal units per horse-power per minute, 223.4; temperature of water entering condenser, 50.5 deg. F.; temperature of water and condensed steam, 93 deg. F.; condensing water per horse-power per hour, 246.2 pounds; dry coal per kilowatt-hour, 2.34 pounds; steam furnished to air pump in per cent. of steam to engine, 5.3 per cent.; equivalent evaporation of boilers per pound of dry coal, 8.72; temperature feed water entering economizers, 134.3 deg. F.; temperature feed water leaving economizer, 211.7 deg.; heat recovered by economizer, 6.9 per cent. of total heat taken up from coal; dry coal per square foot of grate per hour, 17.6 pounds; saving in coal by primary heater, 7.15 per cent.; stoker engine steam, 0.7 per cent. of engine steam. The equipment tested was the Westinghouse unit of the station, described August 17, 1901.

New Cement Works at Portland, Colo.

By James D. Schuyler, C. E.

Part II.—Fuel, Cement Grinding, Power, Buildings, Plaster Works, Analyses.

Before describing the process by which the clinker is converted into merchantable cement an account of the treatment of the fuel used in burning will be of interest. The kilns were originally arranged to burn oil residuum as fuel, using about 15 gallons of oil per barrel of cement manufactured. This is obtained from the adjacent oil refineries at Florence, Colorado, but owing to the uncertainty of the supply of this fuel, arrangements have been made for using pulverized coal. The coal-house is 50x112 feet, 30 feet in height, of concrete and steel, and contains the crushers and grinders. The coal is delivered into a large steel hopper, standing over a set of spike rolls driven by a 40-horse-power motor, which reduces the coal to cubes of ½ to ¾-inch size. It is then elevated into a steel bin over a dryer manufactured by the F. D. Cummer & Son Company, of Cleveland, O., consisting of an enclosed cylinder to which heat is applied at the exterior for the purpose of driving off all moisture from the coal. The cylinder is built in brick, with three furnaces for distributing the heat uniformly. After drying, the coal is discharged into a Williams pulverizer of the same type as those used for pulverizing the limestone. To reduce it to greater fineness it is elevated to steel bins, over a tube mill, 23 feet long, 60 inches diameter, where it is ground with pebbles, and from which it is discharged through the center trunnion into a revolving screen, which separates any broken pebbles that may be in the coal. Thence the powdered coal is delivered by screw conveyors to bins in front of each kiln, having a capacity for twelve hours' run of the kiln. In the bottom of each of these bins is a small screw conveyor, worked by a Reeve's variable-speed countershaft, by means of which the attendant can regulate the amount of coal delivered. From this conveyor the coal drops into an air-pipe, 4 inches in diameter, through which it is blown into the kiln by an air blast working under six ounces of pressure, supplied by a fan, one fan supplying the air for all the kilns, the feed of which can also be regulated by valves. This coal feeding machinery was supplied by the B. F. Sturtevant Company, of Boston.

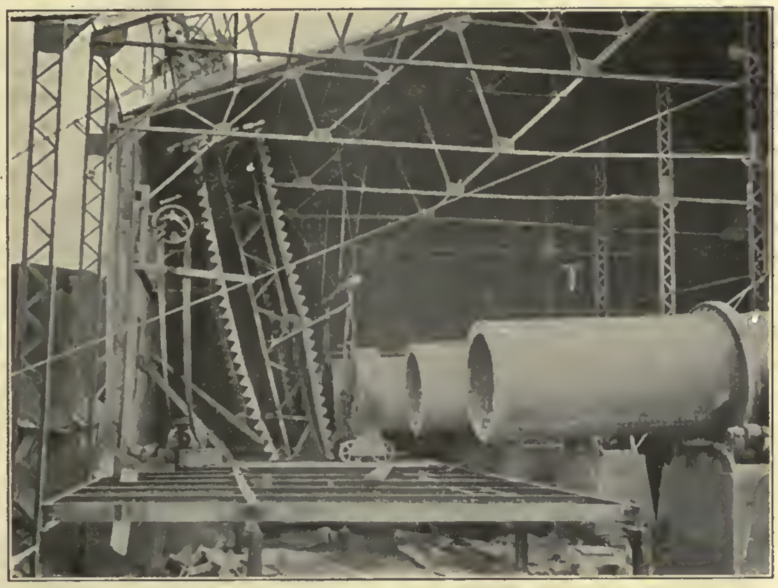
Making the Cement from the Clinker.—Continuing the process of manufacture, the clinker is taken from the huge pile through a tunnel 154 feet long, 5 feet wide, 6 feet high, extending underneath the cement floor. The tunnel contains an 18-inch belt conveyor running its entire length, placed at one side so as to leave a narrow passageway to walk by it. At intervals of 8 feet are cast-iron hoppers in the roof of the tunnel, over the conveyor, at the bottom of each of which is a special valve, called the "12" duplex cut-off valve, made by the C. W. Hunt Company, of New York, for regulating the flow of the clinker through the hopper to the conveyor.

The conveyor delivers the clinker to a continuous bucket elevator, by which it is lifted to a height of 68 feet and delivered to three kominutors on the "cement side" of the factory. These kominutors are of the same size and run at the same speed as those already described on the "raw side" of the works. They grind the clinker to a size that will pass a sieve of 24 meshes per linear inch, the screen being a sheet steel needle slot, which is preferred to the usual gauze screen. From the kominutors the material drops to a screw-conveyor carrying it to an elevator, by which it is lifted to steel bins over the three Smidth tube mills, from which it is fed to the mills by an automatic screw feed. Attached to each of the bins is a smaller bin containing pulverized gypsum, of which 2 per cent. is fed into the tube mills automatically, the purpose of the gypsum being to reduce the time of the initial set of the cement.

After being ground in the tube mills in the same manner as that already described for the raw material, the cement is now finally finished, and drops into a conveyor to which is attached a revolving screen, over a hopper, and from which it falls into an elevator and is again lifted to a height of 48 feet and delivered on to a belt conveyor, 250 feet in length, which distributes it into any one of four large bins in the stock-house, by means of a self-propelling tripper. The stock-house is 100x175 feet, built of concrete, with corrugated iron roof lined with asbestos. Its capacity is 65,000 barrels.

The cement is here stored in bulk until it is shipped. As it is packed for shipment in sacks it is drawn out from the bottom of each storage bin through a 6x6-foot tunnel underneath the cement floor. In this tunnel is a conveyor which carries the cement to an elevator that dumps it into the packing bins, which are provided with four spouts. Here all packing is done. The packing bins will contain about 1,200 barrels of cement. The tubes leading from these bins each have a double butterfly valve which controls the run of the cement down the tube and prevents "landslides." Each sack of cement is weighed, and contains 95 pounds net. Side-tracks from the Denver & Rio Grande Railroad and the Atchison, Topeka & Santa Fe Railway, which cross at this point, are laid on each side of the stockhouse, and the cement has to be trucked but 40 feet to reach a car. The tracks are laid on such a grade that loaded cars can be dropped away from the house by gravity.

Power Plant.—The steam plant providing power for the works consists of five Heine safety water-tube boilers, of 400 horsepower capacity each, with a brick chimney 128 feet high, 8x8 feet inside, 14 feet 2 inches square at base outside and 9 feet 6 inches square at top. The main engine is a Filer & Stowell, 30x60-inch single cylinder condensing engine, running at 65 revolutions per minute and having a capacity of 1,200-horse-power at 150 pounds boiler pressure. It is connected to a 1,200-horse-power Wheeler condenser. The flywheel of the engine is 24 feet in diameter, with 53-inch face, made in two pieces; it weighs 36 tons, and is said to be the largest and heaviest flywheel in the state. It is mounted on a 15-inch solid steel shaft. Power is transmitted to the main line shaft by a four-ply leather belt, 52 inches wide, 1 inch thick, 46 feet 3 inches long, center to center.



Kiln Room; Two New Kilns in Process of Erection.

The main or head shaft in the engine room is 8 15/16 inches in diameter, 33 feet 10½ inches long. On the mill-room side this is reduced to 7 15/16 inches, and passes through the center of the mill, past all the heavy drives, for a distance of 88 feet, where it reduces to 5 15/16 inches and passes into the kiln building, 41 feet farther. On the rock-room side of the main shaft it extends a further distance of 53 feet, to drive the crusher, dryer, rolls, etc., its diameter being 5 15/16 inches. Thus the total length of shafting in one straight line is 216 feet 9 inches. From the main shaft in the engine room a belt is taken to drive a 150-kilowatt Crocker-Wheeler direct-current 240-volt generator. On the same foundation is a duplicate generator, driven by a 14x36-inch Filer & Stowell heavy duty Corliss engine, of 225 horse-power, running at 130 revolutions per minute. Both generators can be run either directly by the engines or from the main shaft. Two additional 150-kilowatt generators are driven by a 22x48-inch Allis-Chalmers Corliss engine. There is also one 150-kilowatt generator in the kiln building used as a motor, and another of the same size in the plaster building.

General View of the Cement and Plaster Works at Portland, Colorado.

The two smaller engines mentioned are connected to an 800-horse-power Wheeler condenser. The circulating water for the two surface condensers is pumped by a 12-inch centrifugal pump, placed in a well outside the engine-house, driven by an electric motor, and delivering 4,600 gallons per minute. The condensed steam is returned to the boilers at high temperature.

Buildings.—All buildings composing the plant proper are fireproof, and are either built of concrete with corrugated iron roof, or entirely of iron. The main building is 100x208 feet in size, 30 feet high, the mill-room being 96x100 feet, and the kiln-room 112x100 feet. The engine and boiler house is 100x100 feet, 18 feet high, equally divided into two rooms 50x100 feet. The rock-room, in which the crushing, drying and grinding of the raw materials is performed, is 40x116 feet, 18 feet high. The coal-building is 50x112 feet, the stock-house 100x175 feet and the office 32x40 feet, with laboratory 40x80 feet, two stories, all concrete buildings. There are besides, a boarding house, cottages and rooming houses for the employees, in addition to the plaster-house, which is 60x112 feet and 30 feet high, built of wood and corrugated iron, with concrete foundations, and a plaster stock-house, 40x80 feet, entirely of wood.

Manufacture of Plaster of Paris.—This branch of the industry is quite new, but has such a promising future that the plant being built for the manufacture of plaster of various grades is of the latest design and of the most improved type. The plant is designed to treat either "dirt" or "rock" gypsum. The former is first passed through screens to remove woody substances, and is then dumped into the calcining kettle, of which there are three, each 8 feet in diameter, provided with a furnace beneath, where heat is applied and the gypsum boiled for two hours to drive off all water and chemically combined moisture. These kettles are of the type developed by Messrs. Ehrsam & Sons, of Enterprise, Kansas, for that special purpose. When the kettle is to be discharged after cooking, a gate is raised, and the gypsum flows out like water into a "hot-pit," from which it is drawn off by conveyor and elevator and delivered to a bolting machine, where it is bolted like flour. The tailings which do not pass the bolt, are returned to the kettles to be re-cooked, while the finished product is taken by screw conveyor to the stock-house.

The rock gypsnm is somewhat differently treated. It is first crushed to a 1-inch ring size; elevated to a bin over a rotary cylinder dryer, and fed into the dryer by an automatic feed from the bin. The dryer is 40 feet long by 40 inches in diameter, set on a pitch of ¾ inches per foot. From the dryer, the rock is discharged directly into a Williams pulverizer, operated by a 75-horse-power motor. After passing through this mill it is ground to a fineness of 96 per cent. through a 100-mesh sieve. The mills used for grinding are 40-inch Sturtevant Turkey emery-stone Buhr mills. After being finely ground it is conveyed to bins over the calcining kettles, holding 50 tons each. The kettles hold about 300 cubic feet or 12 tons each. The rock gypsum is boiled for about the same length of time as the dirt gypsum, but requires less heat.

Before the plaster is ready for use, and while it is being packed for market, it is treated with what is called a "retarder," which retards the setting. It consists of anything organic, sweet or sour, either molasses or vinegar, mixed into a paste with lime, and ground to a powder. Fiber is also added at this stage. The charge of plaster, together with the "retarder" and the fiber, in proper proportions, are mixed together in a rotary mixer, and dumped into a hopper, or racking chest, and thence into sacks.

Power in Plaster Plant.—The power in the rock-room of the plaster plant is furnished by a 150-kilowatt generator, used as a motor. The three kettles are each provided with an agitator, stirring and cleaning the bottom to prevent burning. These move at a speed of 17 revolutions per minute. A 90-horse-power electric motor drives a line shaft, from which all these agitators are operated, by belts, with friction clutches. All conveyors and elevators in the calcining department are driven from the main shaft of the plaster room.

Water Supply.—The water system of the cement works is an excellent one, costing $25,000. A reservoir, about 200 feet long, was excavated in coarse gravel, 17 feet deep to bedrock, near the river bed, on the opposite side of the river, and an 18-inch vitrified pipe laid from the bottom of the reservoir under the river, 12 feet below its bed, a distance of 1,940 feet, to a cylindrical well of wrought-iron, at the engine room. The water thus obtained is abundant and comparatively pure, containing but 35 grains of solids per gallon, whereas the ground water around the factory, on the south side of the river, contains over 300 grains per gallon and is unfit for use in making steam.

Economy of fuel and conservation of heat have been so intelligently carried out in this plant that power is generated at the remarkably low figure of $35 per horse-power a year. This result is in large measure due also to the fact that the works are within 6 to 8 miles of the oil fields and coal mines of Florence, enabling them to secure fuel at minimum cost.

Cost of Works.—The original plant cost $150,000. The new plant will have cost $500,000 additional when the improvements under way are completed, including $60,000 for the plaster plant. Sales of the product from the new plant began April 1, 1903, and in the following three months from that date, 75,000 barrels were sold.

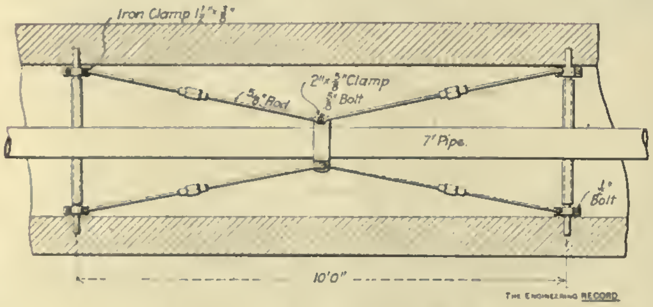
The officers of the company in charge of the works are Mr. Aman Moore, local manager, with sixteen years' experience in the cement business; Mr. F. W. Brown, chemist, with thirteen years' experience; Mr. L. D. Gilbert, mechanical engineer, superintendent of the factory, also experienced in eastern works, and Dr. L. D. Gould, with ten years' experience in the chemistry and manufacturing of gypsum products. The stockholders are principally residents of Pueblo, Denver and Florence.

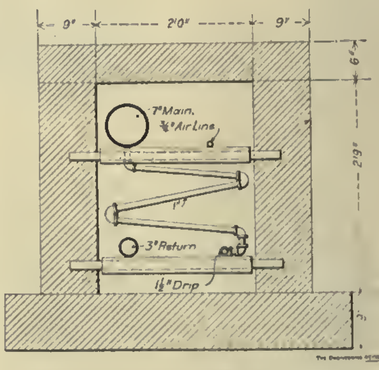
Tests of Cement.—Following is a sample record of tests of the cement as it is taken from the stock-house for shipment:

Fineness: Passing 100-mesh sieve.......96 per cent.
" 200 " ....74 "
Setting: Initial set...........2 hours 05 minutes.
Final " ....4 " 20 "
Tensile strength:
Neat cement, 1 day.........320 pounds.
" " 7 days ....760 "
Mortar, 1 : 3, 7 " ....270 "
" " 28 " ....345 "
" " 3 months......428 "
" " 6 " ......497 "
Raw materials, fineness: 90 per cent. passes 100 mesh sieve. Gypsum added, 2 per cent.

Tests made by Booth, Garrett & Blair, chemists, 407 Locust Street, Philadelphia, April 20th, 1903, gave the following results, as per their report:

Specific gravity 3.05
Fineness: Passing No. 50 sieve....... 100 per cent.
" " 100 " ....93.5 "
" " 200 " ....73.0 "
Setting time:
Neat cement, initial set.1 hour 15 minutes.
" " final set..........5 hours.
Percentage of water..........20 per cent.
Temperature of water....60 degrees Fahr.
" " air.... 70 " "
Normal pat tests: (Am. Soc. C. E.)
Air pats (A), sound and hard.
Cold water pats (B), sound and hard.
Accelerated tests:
Hot air test (C), sound and hard.
Warm air test (D), sound and hard.
Boiling water test (E), sound and hard.
Tensile tests of standard briquettes:
Neat cement, 1 day in air, 6 days in water, with 20 per cent. water, average of 5 tests .... 734 lbs.
One of cement to 2 of sand, with 14 per cent. water, 7 days, average of 5 briquettes .... 421 "
One of cement to 3 of sand, with 10 per cent. water, at 7 days, average of 5 briquettes .... 282 "
Compression tests of neat cement, in 2-inch cubes, average of 5 tests.........5,225 "





Drain Connection and Anchor for Steam Main in Tunnel, Gulfport Central Station System.

The finished cement shows the following chemical analysis:

SiO_2	21.30 per cent.
Al_2O_3 & Fe_2O_3	10.40 "
Ca O	64.20 "
Mg O	0.70 "
SO_3	1.60 "
Alkali	.50 "
Volatile	1.30 "
	100.00 per cent.

The stratum of shale in the quarry about 30 feet thick, which has been referred to as containing the proper proportions of lime, silica and alumina to be converted into cement directly, without admixture of other ingredients shows the following analysis:

Lime, $CaCo_3$	75.10 per cent.
Silica, SiO_2	14.20 "
Alumina, Al_2O_3	5.20 "
Iron, Fe_2O_3	1.73 "
Magnesia, MgO. Co_2	1.10 "
Alkalies	.32 "
Volatile	2.35 "
	100.00 per cent.

[Since the first part of this article was printed, The F. D. Cummer & Son Company has written that there is a Cummer style F dryer in the coal house of the cement plant, which has a capacity for drying 350 tons of slack bituminous coal per day of twenty-four hours.—Ed.]

New Railroads in Germany opened to traffic during 1903, aggregated 508 miles in length; during the year 1902 the total length of new lines was 601 miles.

A Central Heating, Lighting and Ice-Making Station, Gulfport, Miss.

A central station for supplying heat, light and ice to an adjacent hotel and neighboring buildings was built last year at Gulfport, Miss. Owing to its location in open view, an unusual degree of attention has been paid to the architectural features of the building, especially for a structure of its character, and there are a number of interesting details in connection with the plant equipment and the distribution system. It is the property of the Gulfport Development Company, which is closely associated with the Gulf & Ship Island Railroad, the president of both organizations being Mr. J. T. Jones, of Buffalo, N. Y. It serves the Great Southern Hotel, the office building of the railroad and a group of business buildings. It was built from the plans of Mr. Thomas Sully, of New Orleans, while the engineering work was executed by Mr. James C. Kennedy, of Congress Junction, Arizona, as superintendent of the company.

The station comprises a main portion, 52 feet wide and 185 feet long, in which are the boiler, engine and freezing rooms, and two smaller, less lofty parts, at opposite ends, one for a laundry and the other for offices. As shown in the accompanying engraving, the roof is provided with ventilators of the monitor type, three in all, 5x22 feet in plan. Near the entrance to the engine room, this indicated in the photograph where the continuity of the overhanging eaves is broken, rises a water tower, 65 feet high, square for two-thirds of its height and surmounted by a hexagonal top. Besides adding to the beauty of the building, the tower is useful as a water reservoir. In it are located two tanks for the general water supply. The walls of the station are of an interesting construction, consisting of double sheeting wire lathed to hold cement outside. The roof framing, which is supported by vertical timbers on a foundation of brick and concrete, is made up of trusses consisting of laminations of 2x12-inch planks, held together by bolts and rods. The cement faced walls are blocked off to represent stone, and the roof is of terra cotta tiles.

The boiler room contains space for four Scotch marine-type boilers, of which two of 150 horse-power each have already been installed, built by the Walsh & Weidner Boiler Company, of Chattanooga, Tenn. The remaining pair are to have a rating of 200 horse-power, so that the total steam generating capacity of the plant is 700 horse-power. The boiler room is approximately 52 x 56 feet in plan, and besides the boilers, which are arranged in a row through the center of the room, coal storage is provided in front of the stoking space, the smoke stack rises through the back of the room and there are two boiler feed pumps and a feed-water heater, this of the Cochrane type, of 600 horse-power rated capacity. There are thus 4 square feet of floor area per horse-power of boiler capacity, including auxiliaries.

The chimney is a self-supporting steel stack, 72 inches in diameter and 100 feet high, but lined to within 15 feet of the top with firebrick, leaving a flue about 64 inches in diameter. The boilers feed by means of 5-inch U-shaped bends into the top of a 12-inch header, which is carried overhead across the boilers to a cross header suspended in the boiler room parallel with the partition wall between the engine and the boiler rooms. This arrangement was made primarily for convenience in making connections to the units in the engine room. Throughout the piping work long bends are employed to take up expansion and vibration, and metallic gaskets are used in joints. The main steam header is drained through an Emergency steam trap.

The engine room, which is 52x60 feet in plan, contains at present one 100-kilowatt electric-generating unit, in operation, one 225-kilowatt unit, of the same type, in process of erection, a 25-ton ammonia compressor for the ice and refrigeration system, and electrical apparatus for a series alternating-current arc lighting system that is being installed. The electric unit comprises a three-phase generator of the General Electric revolving-field type and a Harrisburg standard four-valve 16x16 inch automatic cut-off engine. The generator leads are carried underneath the floor to the switchboard, which is of Vermont marble. The primary voltage is 2,300 volts and the switches are all of the oil-break pattern.

Central Heating, Lighting and Ice-Making Station, Gulfport, Miss.

The refrigerating plant was built by the York Manufacturing Company, of York, Pa., and is of 25 tons capacity. It is of the ammonia compression system, and the compressor is of the type having a horizontal steam engine and vertical compressing cylinders. There is the usual adjunct of condensers, coolers, filters and brine pumps, and steam condensers, reboiler and distilling apparatus. The plant includes an ice-making tank, two cold storage rooms, 13x19 feet in size, and an ice store, 18x35 feet, as well as three refrigerating rooms in the hotel. The ice is lifted from the freezing tank by means of a crane, as usual, and is carried to a melting apparatus where it is released from the can and automatically dumped into the ice store. From ante-rooms of this room, opening on a platform, the ice can be loaded on cars or wagons.

The aggregate heating requirements of the buildings served by the station are placed at 185 horse-power. The exhaust from the electric-lighting and compressor engines and from the pumps is all collected into an exhaust main which is carried into a so-called heater pit immediately outside the station building, where distribution is made. The exhaust main in passage through the boiler room has a connection to the Cochrane feed-water heater and also to the atmospheric exhaust line, this fitted, as usual, with a back-pressure valve. The usual live-steam supply, as an auxiliary to the exhaust supply, is arranged for, a reducing valve in the connection providing for decreasing the pressure. The heater pit is about 11x16½ feet in plan, and is roofed over with brick arches between I-beams, leaving 6 feet head room. It contains an automatic pump and tank, placed low so as to receive the return water from the heating system by gravity, so far as possible, and delivers it to the feed heater and thence by means of the feed pumps into the boilers.

There are two main steam heating lines, each 7 inches in diameter, one going to the hotel, 55 to 60 feet from the heater pit, and the other to the rest of the buildings connected to the system. Allowing 34½ pounds of steam per hour per horse-power of heating, 2,125 cubic feet of steam are delivered per minute, corresponding to a maximum velocity of 4,000 feet per minute with the two 7-inch pipes considered. The pipes, which include besides the heating main, the return pipe, an air line and a drip line, are carried in a trench tunnel, the proportions of which are indicated in an accompanying illustration. The general 7-inch supply main is carried straight for 240 feet, has a right-angle bend offsetting the line of the tunnel 45 feet, continues straight again for 200 feet, has another offset 30 feet long and another straight run 250 feet long, from which the final taps are made to the different buildings. Anchors are placed about the middle of the long runs, so that the piping extends each way from them, the offsets being depended on for taking care of the changes in length. The construction of the anchors is indicated in an accompanying engraving and in the cross-section sketch of the pipe tunnel is shown the method of connecting a drip pipe from the heating main into the drip main. The piping throughout is wrapped in 85 per cent. magnesia covering manufactured by the H. W. Johns-Manville Company.

A Rapid Filter Plant for the New Chester Water Company.

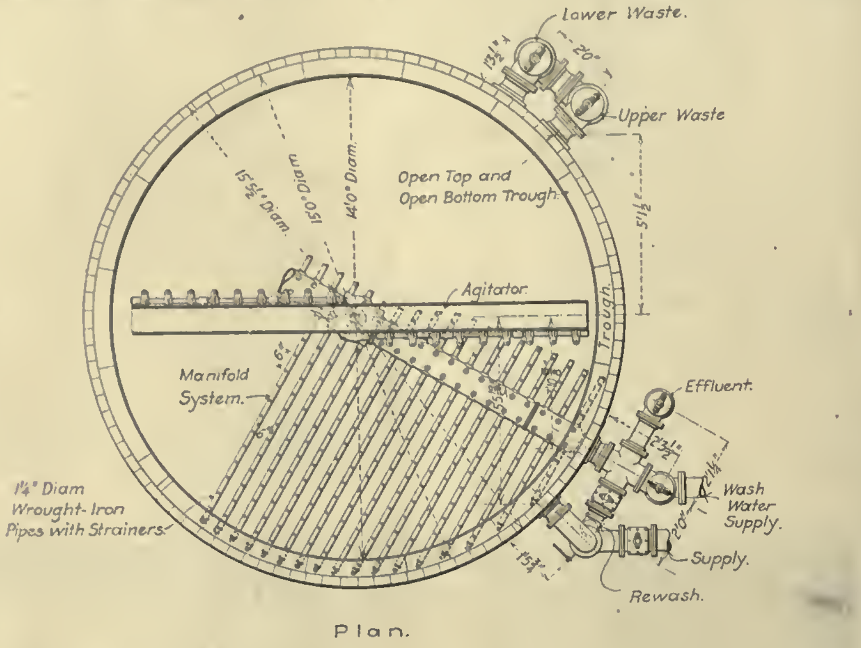
Chester, Pennsylvania, is a city of about 38,000 inhabitants, 14 miles from Philadelphia, on the Philadelphia, Baltimore & Washington branch of the Pennsylvania Railroad. The water supply is taken from the Delaware River. The present water works system was designed by Messrs. S. R. Bullock & Company, and, as completed in the year 1888, consisted of two 5,000,000-gallon pumping engines, about seventy miles of mains and two reservoirs of 8,000,000 gallons capacity each, located about 3½ miles from, and 204 feet above, the pumping-station. A 24-inch and a 20-inch cast-iron force main lead directly from the pump house to, and terminate in, a gate house at the reservoirs, where water is delivered into one or the other as desired. For some years it was the custom to settle the water in one reservoir while supplying the city from the other, but to improve the quality of the supply the company, in the year 1897, constructed a third reservoir of 3,000,000 gallons capacity, in close proximity to the others, but at an elevation 9 feet lower. With the third reservoir completed, water from the pumps was delivered into reservoir No. 1, made to travel the entire length thereof, to promote sedimentation, and when it attained a depth of 16 feet the surface water flowed to reservoir No. 2 through an open spillway. After additional sedimentation in reservoir No. 2, the water flowed to reservoir No. 3, from which it was delivered to the city through a 24-inch cast-iron main.

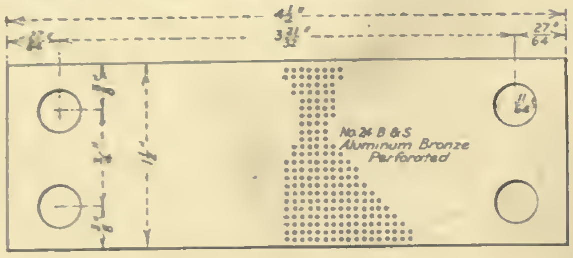
To still further improve the quality of the supply, in the year 1901, the company equipped reservoir No. 1 with wooden baffle-boards, as shown in the general plan, to cause a more complete displacement of its contents and increase its subsidence efficiency, and at the same time installed at the pumping station a coagulant feed plant. A solution of sulphate of alumina of uniform density was prepared and applied in known quantities to the water in the force main by means of a small steam pump. In traveling through the 3½ miles of force main between the pumping station and the reservoirs ample opportunity was given for a thorough mixing of coagulant and water. This method of coagulation and subsidence was continued up to the time of installing the filter plant, and effected material improvement in the quality of the water delivered to the city. The matter precipitated in the reservoirs is periodically removed. Owing to increased consumption the clarifying and purifying methods above described became inadequate, and to maintain a high standard of purity, the company commenced the construction of a rapid filter plant in the fall of 1902. The average daily consumption of water for that year was 2,800,000 gallons, and the maximum 3,500,000 gallons.

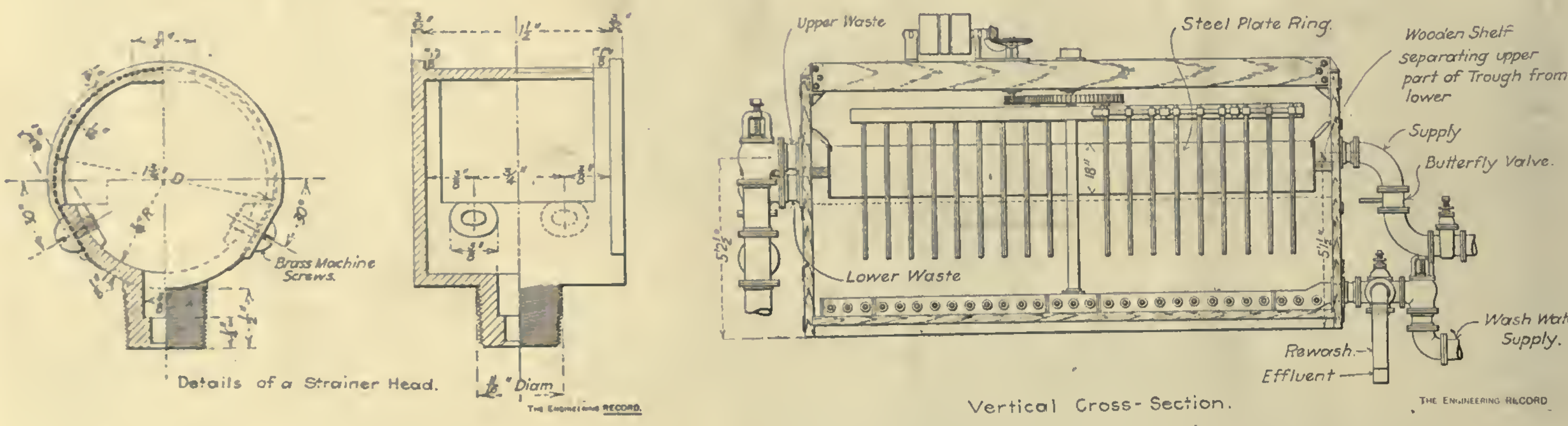
The pumps are operated for about twelve hours each day to deliver into the reservoirs the water consumed by the city during twenty-four hours. While the maximum daily consumption is only 3,500,000 gallons, if a filter plant of this capacity had been located at the pumping station it would have been necessary to operate the pumps at slower speed for longer periods, at a sacrifice of duty and at increased expense. Placing the filter plant at the pumping station would have necessitated double pumping, the construction of large coagulating-subsidence basins, a filtered water basin and the covering of the three large reservoirs. It was therefore decided to locate the filter plant at the reservoirs, where a filtered water basin already existed, where provision had already been made for subjecting the water to natural subsidence for from four to five days and to coagulation and subsidence for from six to twelve hours preparatory to filtration, and where extra pumping would be avoided, since the filters would receive water by gravity from the two upper reservoirs and deliver it into the lower one. As will be seen by reference to the general plan, the water enters the south end of reservoir No. 1, travels around the baffle-boards and enters the north end of reservoir No. 2, passes around the baffle-boards therein and enters the coagulating compartments, from which it flows to the filters. The arrows indicate the direction of flow, and the point at which the coagulant is applied is also designated. The water is subjected to natural subsidence in all of reservoir No. 1 and about three-quarters of reservoir No. 2.

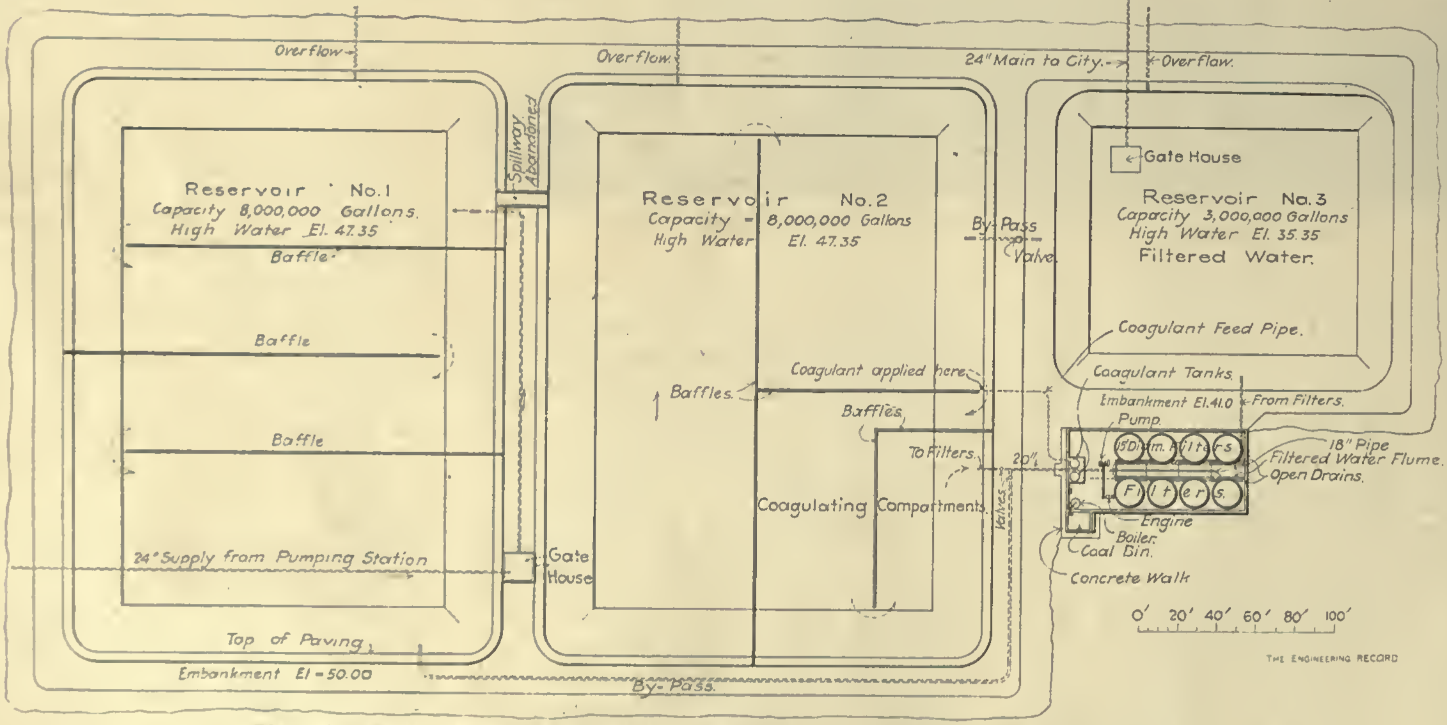
The filters have capacity to deliver 4,000,000 gallons per twenty-four hours when operated at the rate of 123,000,000 gallons per acre. Whenever the consumption exceeds the delivery from the filters, the excess is supplied from the reserve of 3,000,000 gallons of filtered water in reservoir No. 3. Reservoirs Nos. 1 and 2 having been pumped full during the day, water flows from them to the filters over night, and from the filters to the filtered water reservoir supplying the city. The water in reservoirs Nos. 1 and 2 stands at the same level, and may be lowered more than 4 feet (equal to about 1,500,000 gallons) before the filters cease to be operative.

There are eight circular filters. Each tank is 15 feet inside diameter, constructed of 2¾-inch dressed cypress lumber and bound with flat iron hoops. The influent pipe of each filter is provided with a balanced valve and float for maintaining the desired water level within the filter and to prevent its overflowing. The effluent pipe is also provided with a balanced valve and float for controlling the yield from the filters and to close them off when the level of water in the filtered water collecting flume (which is coincident with the level of water in the filtered water reservoir) reaches an established maxi-





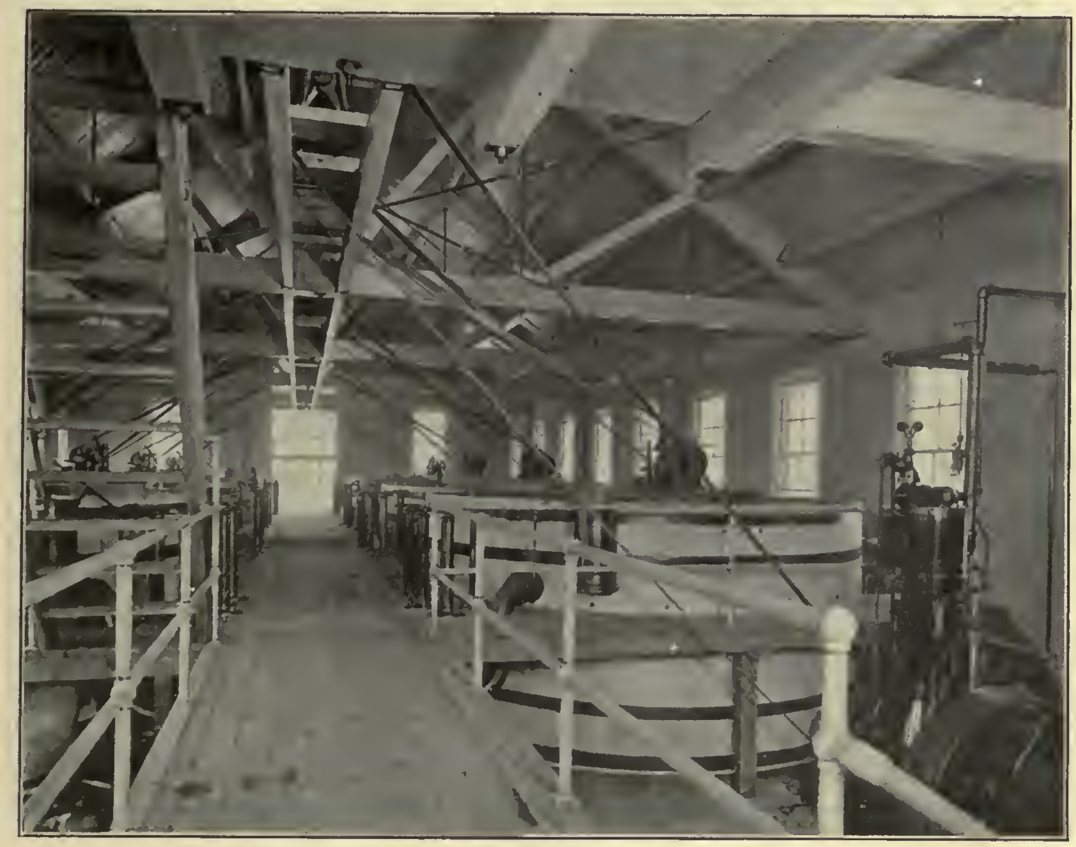




Plan of Reservoir and Filter House at Chester, Pa., and Details of One of the Filters.

mum elevation. Across the center of each filter is laid a cast-iron main collector, and extending laterally from this to within 3 inches of the inside of the tank, on 6-inch centers, are 1¼-inch extra heavy wrought-iron pipes, which receive the 710 strainers constructed as shown in an accompanying detail drawing. The strainers are located 6 inches apart on centers as nearly as possible. The bottom of the tank is filled with concrete to a depth of about 3½ inches, or to the top of the 1¼-inch lateral pipes. Over the strainers is placed 6 inches of gravel varying in size from ⅛ to ½ inch diameter, and on top of the gravel is placed 31 inches of sand having an effective size of about 0.40 millimeter and an average uniformity coefficient of 1.5.

The filter house is a brick structure on stone foundations, having wooden roof trusses on 17-foot centers, and slate covering. It contains the filters, a 40-horse-power Nagle engine, a 75-horse-power Nagle boiler, the concrete filtered-water flume and an R. D. Wood & Company centrifugal pump. The floor of the filter house is concrete throughout, graded to drain freely.



Interior of the New Chester Water Company's Filter House.

An operating platform is located about 3 feet below the top of the filters, and on this is mounted the floor stands of the operating valves of the filters. All pipe work and valves are concealed beneath the operating platform. The plant is arranged so that additional filters may be readily installed to meet future increase in consumption. The filters are cleansed with a reverse or upward current of filtered water supplied by the centrifugal pump, which takes its suction from the filtered-water collecting flume located between the two rows of filters. The filtered-water flume is connected at its farther end with the filtered-water reservoir by a 20-inch cast-iron pipe. A mechanical agitator or rake, for stirring the sand layer to its extreme depth or on the surface only, forms a part of the washing apparatus. This agitator is shown in the illustrations.

The Chester filter installation embraces a method of surface agitation for the removal of intercepted matters from the surface of the sand layer, which, it is claimed, has not been embodied in any filtration plant heretofore constructed. In rapid or mechanical filters it is the custom to cleanse the sand layer with a reverse or upward current of water, assisted, in some instances, by a mechanical rake, air or other means, and to thus carry off by a slow process of dilution the matters retained by the sand layer during filtration. The Chester filters, as stated, are washed with a reverse current, and are equipped with a mechanical agitator or rake, but instead of being provided with only one waste or wash-out, located, as is customary, 12 inches above the sand layer, they have two waste openings, one immediately at the level of the sand layer and the other 12 inches higher, each communicating with a steel trough. About 3 feet from the top the staves of the filter tanks are chined to receive circular wooden segments which form a watertight shelf. A steel ring 3/16 inch thick and 18 inches wide is secured at its center against the wooden segments by bolts running to the outside of the tank staves, provision being made for leveling the upper edge of this ring. A double trough is thus formed of which the upper part is open at the top and the lower part at the bottom. The surface of the sand layer is brought close to the open bottom of the trough, which forms a practically closed tubular mouth extending entirely around the filter, with only a narrow slit provided in the trough along its lower edge, into and through which the water, during surface agitation, with the dislodged film or crust is drawn in all directions outward from the filter bed to the interior of the trough, from which it is led to the drain or sewer through suitably arranged pipes and valves. Before agitating the surface of a filter, the water is drained off through the effluent pipe until only one foot or 9 inches remains over the sand layer. The surface accumulations are then broken up by the agitator and form with the remaining water a thick fluid which is drained off completely to the level of the sand bed through the open bottom trough. With the bulk of the intercepted matters thus removed, washing with a reverse current may be proceeded with, when the reverse wash becomes necessary, but the surface washing feature just described may be repeated two or more times, under favorable conditions, before it becomes necessary to cleanse the sand bed to its entire depth. When the loss of head in rapid or mechanical filters, as usually constructed, reaches a prescribed limit, it becomes at once necessary to cleanse and disturb the entire sand layer with the reverse current, but in the Chester filters the surface accumulations only may be removed, as above described, and filtration resumed, without disturbing the lower strata of the sand or interfering with its filtering functions.

The coagulant apparatus includes two cypress tanks 6 feet in diameter by 6 feet high, bound with seven ¾-inch round iron hoops, located on a platform carried by beams supported at one end by the front wall of the filter building and at the other by one of the trusses. About 18 inches from the top these solution tanks are provided with a diaphragm made of 1½-inch boards perforated with ½-inch holes 6 inches apart on centers. The diaphragm is supported by 2x4-inch pieces, on 12-inch centers, secured to the tank staves by ⅝-inch wooden dowels driven from the outside. The use of nails or metal fastenings in contact with the solution is avoided. The coagulant solution is prepared by placing given quantities of sulphate of alumina on the perforated diaphragm and filling the tanks with filtered water through a 1¼-inch pipe from the boiler feed pump. The solution may also be heated and agitated with steam from the boiler by means of a perforated pipe laid across the bottom of the tank. The solution from the tanks is fed to a small feed box through hard rubber pipes, valves and fittings, and a constant level is maintained in the feed box by means of a float and cock. The feed of the solution from the feed box is regulated by hard rubber valves which receive their supply under a constant head. To prevent the obstruction of the feed valves the feed box is divided by a piece of sheet lead, liberally perforated with small stabbed holes, the rough side of the plate being opposed to the direction of flow. Each solution tank is provided with a gauge glass and scale for measuring the vertical fall of the solution, which is prepared of uniform density, given volumes being fed for given rates of filtration.

The Chester filter plant was constructed from plans of Mr. George F. Hodkinson, consulting engineer, Chicago, and was installed under his supervision. It has been in operation since the middle of November, 1903.

The Pollution of the Water Supplies of cities and towns in Massachusetts is threatened by a proposed amendment to the existing law on the subject, the amendment providing that the board of health shall not prohibit or restrict boating, fishing or ice-cutting on any so-called great pond. At the February meeting of the New England Water-Works Association it was determined to issue a circular to water-works superintendents throughout the State, calling attention to the character of the proposed legislation.

The Heat Treatment of Brittle Steel is a species of "faking," according to a remarkable discussion by Professor Arnold of the recent report of the Alloys Research Committee of the Institution of Mechanical Engineers. Experiments made on 1-inch boiler plate, restored by heat treatment, resulted in splitting the plate from end to end like glass. It was satisfactory according to chemical and mechanical tests, but it nevertheless failed as stated. After eighteen months study he was confident that when once brittleness—not of the ordinary character, but under vibrating or alternate stress—was developed in the steel, it would only be aggravated by heat treatment.

The Philadelphia Filtration System.

Part VII.—The Torresdale Conduit.

The Torresdale filters are some eleven miles in a direct line from the center of Philadelphia, as stated in a previous article, and at such an elevation as to necessitate the pumping of the filtered water. A pumping station for supplying Delaware River water to parts of the city and a wharf with some facilities for handling coal and other supplies had been established by the Water Works Department at Lardner's Point, in the village of Wissinoming, about 3 miles from the filter plant, toward the city, several years before the filtration system was begun. But the existing pumping station has not sufficient capacity to deal with the whole supply from the Torresdale filters and so an additional and larger pumping station is needed, which it was decided to locate at this same place on an adjoining plot of land. The construction of the new station is now well advanced.

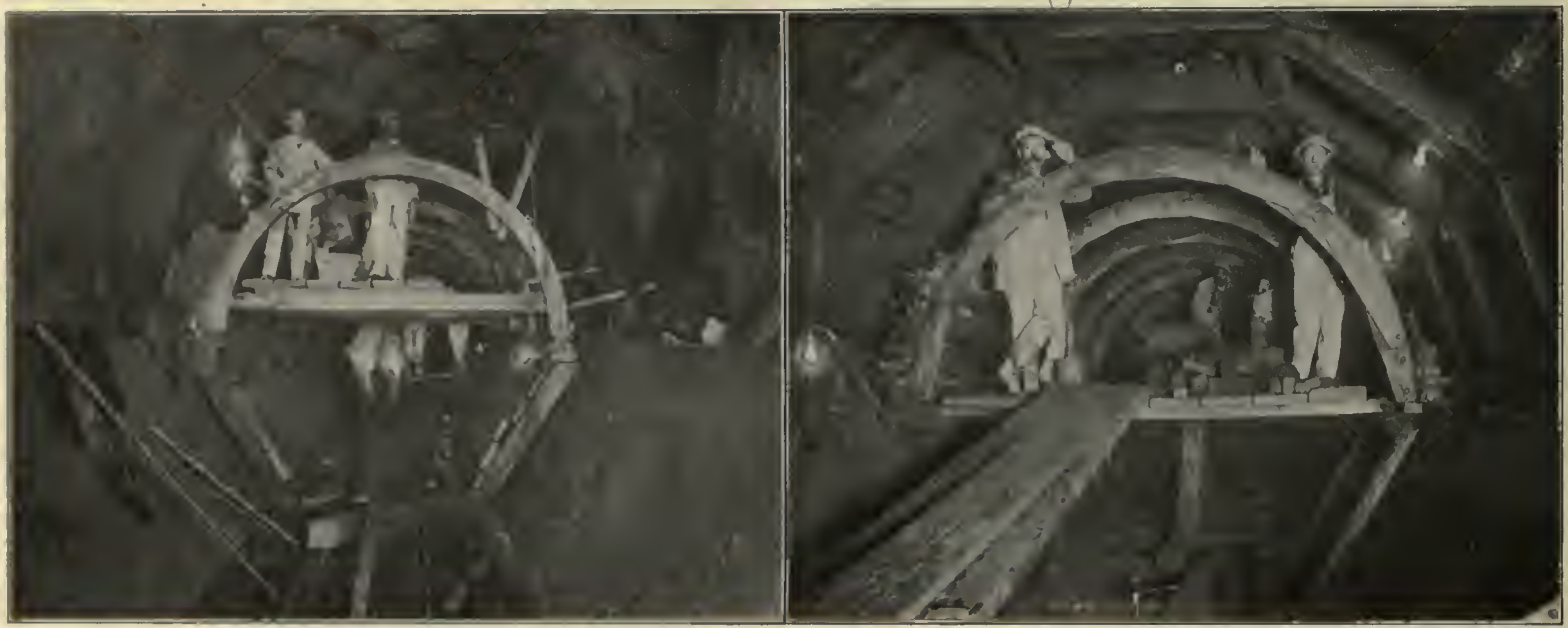
To convey the filtered water from Torresdale to the new pumping station a deep masonry-lined tunnel was chosen in preference to cast-iron or steel pipes on account of its lower first cost, much greater permanence and the avoidance of complications with surface structures and other pipes inseparably connected with the laying of several large pipe lines at the usual depths. The design of this conduit was described in this journal May 18, 1901, and drawings of typical cross-sections of the tunnel and details of the shafts were reproduced. During construction a few modifications were made, as will be more fully mentioned later in this article.

The Torresdale conduit is an inverted siphon 10 feet 7 inches in diameter inside and 13,809 feet long between the two permanent end shafts, constructed substantially in accordance with the drawings shown with the article just mentioned, having a computed capacity under normal conditions of 300,000,000 gallons per day with a loss of head of 8½ feet, which can be raised to 350,000,000 gallons per day by increasing the speed of the pumping machinery, when the installation at Lardner's Point shall have been completed. It is expected, however, that the normal capacity of the conduit as constructed will be at least 320,000,000 gallons per day. Shaft No. 1 is connected to the filtered water basin at Torresdale by a concrete-steel conduit having a cross-section equivalent to a 10-foot circle, described in the previous article, and shaft No. 11, at the Lardner's Point end, is connected to the pump wells by two conduits having cross-sections equivalent respectively to a 14-foot and a 7-foot circle. At Torresdale the bottom of the conduit is 108.68 feet below mean high water, and at Lardner's Point 98.34 below, having a slope of 9 inches per thousand feet toward shaft No. 1, or against the flow, as an aid to draining the conduit when empty and to force any air entrained in the water to escape toward the higher end rather than to collect in pockets. Under like conditions as to discharge and loss of head the conduit is estimated to be equivalent to twelve lines of 48-inch cast-iron pipe. It will cost, including the end shafts, about $91.50 per linear foot, while the pipes, at prices ruling last spring, would have cost about $192 per foot. From the pumping station additional large force mains will be laid to convey filtered water into the city distribution system.

Form for Quarter Bend in End Shafts.

The tunnel line is close to the shore of the Delaware River and has four curves of 1,000-foot radius, the longest of which is 345 feet. Near shaft No. 1, the line crosses beneath Pennypack Creek and, at another place, for a short distance, the tunnel is beneath the river where the line crosses an indentation in the shore. Shaft No. 1 is 129.5 feet deep from the surface to the bottom of a sump 5 feet below the invert grade and has a finished internal diameter of 10 feet 7 inches for its whole depth, being lined with brick masonry to the level of the top of the quarter-bend which connects it with the tunnel. The quarter-bend of 15 feet 9 inches radius of center line at this shaft and the one at shaft No. 11 have been made of concrete masonry with granolithic finish, instead of brick as shown on the contract drawings. The form used for one of these bends is shown in an accompanying illustration. From the ground surface to a depth a few feet into the hard rock the upper part of shaft No. 1 was built inside a steel shell.

Shaft No. 11 is about 120 feet deep; for a depth of 40 feet its finished internal diameter is 21 feet 1 inch, in order to reduce the velocity of the water before its direction is changed 90 degrees to enter the connection conduits to the pump wells; but for the lower 71 feet it is 10 feet 7 inches in diameter. The upper portion is enclosed in a steel shell, the top of which is 10 feet above the surface of the ground and roofed over. The change in diameter is made through a conical intermediate section. Besides these two permanent shafts nine intermediate working shafts were sunk. In all cases riveted steel cylindrical shells 12 feet in diameter, of ¼-inch plates except the top course of ½-inch plates, were sunk from the surface to varying depths into the rock so as to secure a satisfactory seal to prevent the inflow of water following down the outside of the shell. Each shell was seated on a heavy cast-iron shoe, which was footed on a ledge cut in the solid rock. The seals were constructed of concrete and brick masonry, and, in some cases, had to be extended to considerable depths. Each shaft was lined with 9 inches of brickwork, excepting the portions in solid rock, thus making the internal diameter 10½ feet. The total depth of shafts sunk amounted to 1,131.5 linear feet. A single cage was installed in each shaft. The original plans called for timbered shafts with two cages each. The tunnel excavation has now been completed and five of the shafts have been closed by arches at their bottoms and refilled, and at the completion of the work the other shafts kept open for handling the materials for the lining masonry in the tunnel will also be filled.



Torresdale Conduit: Views Showing Hard Rock Formation and Timbering in Soft Rock, also Method of Building Arch.

Much difficulty was experienced in sinking some of the shafts on account of the large quantity of water encountered owing to the proximity of the river. Especially was this true of shaft No. 7, located in the river a few feet out from shore. The cast-iron shoe with two sections of steel plate were first lowered in position on the mud flats at low water. This was followed immediately with the orange peel excavator, the material taken out being dumped around the outside of the shell for protection. The first steel shell started down was so deformed by the action of the high tides that its alignment was seriously affected. In order to correct this it was necessary to load the shell with 80 tons of steel rails and ballast so that it might again assume its perpendicular position. In consequence of this loading the shoe parted from the shell in places and several of the plates buckled, necessitating a second or inner lining being placed just inside and just above and below the top of the rock, the space between the new shell and the old brick lining being filled with concrete. So badly did this seal leak that it was finally found necessary to reline the shaft with a 6-inch concrete lining extending from the top of the old seal clear to hard rock, thus reducing the working diameter of the shaft to about 8 feet. So much trouble was experienced with the water in making the first seal that it became necessary to use compressed air until the sealing of the foot of the shoe had been accomplished, and so much time was consumed that the full benefit of this shaft was not realized in excavating the tunnel.

For construction purposes the conduit was divided into four sections. Mr. D. J. McNichol, of Philadelphia, secured the contract for all of them, but subsequently let three sections to the Mason & Hoge Company, of Frankfort, Ky., who further sub-let one section to Messrs. Mason, Rinehart & Company, and Messrs. G. H. Cole & Company. The contract was signed in June, 1901, and work was begun soon after. Previous to advertising for bids some twenty borings were made adjacent to the line of the tunnel by sinking 4-inch pipes by the water jet process and then lowering diamond drills to the rock and driving them down considerable distances into the rock. In this way 2¼-inch cores were obtained. The deepest hole was about 135 feet and the average depth was about 90 feet. Observations were also made to determine approximately the depth at which no water passed through the rock into the drill holes, and the 4-inch casings were capped so that intending bidders could make such further investigations as they chose. The average depth to the rock, as determined by the borings, is about 30 feet, and, on the basis of the information secured, the elevation of the tunnel invert was established as shown on the contract drawings and described in the issue of this journal of May 18, 1901. Conditions revealed by sinking the shafts, however, led to the final adoption of an elevation 10 feet lower.

Torresdale Conduit: One of the Stone Crushing and Concrete Mixing Plants.

The tunnel is in rock for its whole length, but the character and condition of the rock varied greatly from place to place. The rock is generally softer and more micaceous toward the pumping station and harder toward the filtration plant. While most of the rock penetrated is hard biotite and hornblendic gneiss, intersected with quartz veins, some portions have been found soft, yielding and treacherous. It is generally seamy and "blocky" and contains frequently occurring seams of very soft, rotten rock, sand and mud. Some of the rock also deteriorated rapidly on exposure to the atmosphere. The fissures usually yielded water freely, and at the Torresdale end very freely. In some places there was great difference in the nature of the rock in the opposite sides of the tunnel, especially in the portions between shafts Nos. 8 and 9, where the soft rock caved in from one side so as to leave great cavities in the roof.

Of course rock of such nature as that just mentioned made it necessary to timber the excavation wherever it occurred, but by far the greater part of the length of the tunnel, some 86 per cent. or about 11,875 feet, required no timbering. The timber ordinarily used consisted of octagonal frames of five pieces of 10x10-inch sticks, although some 12x12-inch sets were used, with 12x12-inch or 10x10-inch hard pine wall plates. More or less lagging and blocking was used, depending upon the nature of the rock from place to place. In some places near shaft No. 9 the rock was so soft that it was necessary to place five-piece frames of 7x14-inch timbers, laid flat, solidly side by side, or with but very small spaces between them. In other places the rotten rock and soft materials tended to run in so freely that it became necessary to use hay to stop up all the crevices. Between shafts Nos. 8 and 9 some unusual forms of timbering were required, on account of the caving from the roof, as is indicated by a few drawings reproduced herewith. One of the accompanying views shows the usual form of timbering.

The presence of large quantities of water encountered at the Torresdale end of the line necessarily rendered the progress of the work slow and tedious. From two to three pumps, mostly of the Cameron, Reilly and Worthington types, were installed in each shaft, and pumping was maintained day and night continuously. The water entering through the roof of the tunnel was especially troublesome during the building of the arch of the lining. It was sometimes carried beyond the place where the bricklayers were working by means of troughs of tarred paper held against the rock by scantlings and props, as shown in one of the views. Two headings were driven from each shaft, excepting shafts Nos. 1 and 11, from each of which but one heading was driven. The lower part of the cross-section was taken out as one bench. The spoil was loaded into 1-cubic-yard cars on narrow-gauge tracks and drawn by hand to the shafts. The cages were operated by Mundy, Lidgerwood and Exeter double-drum steam hoisting engines. The drilling was done with Sullivan, Rand and Ingersoll-Sergeant drills, and 60 per cent. dynamite was used for the blasting. The drills were operated by compressed air and, to supply the air, four compressor plants were installed, two being equipped with Rand compressors and one each with Ingersoll-Sergeant and Sullivan machinery. Steam for various purposes was supplied from some thirty locomotive and vertical boilers of Erie, Mundy, Lidgerwood, Exeter and Stroudsburg makes.

The line for driving the tunnel was taken down into the shafts by means of heavy plumb bobs hung on wires and immersed in water, the line being prolonged by means of transits, as usual. Attempts were also made to project the line down the shafts by plunging the telescope of an inclined standard transit, but generally with indifferent success on account of the mist and falling water which obscured the vision. Notwithstanding the difficult and uncomfortable conditions amid which much of the line work had to be done, the lines from adjacent shafts met with errors ranging only from ½ inch to 3 inches, results for which credit is due to the engineering parties. During construction the tunnel has been lighted mostly with incandescent lamps.

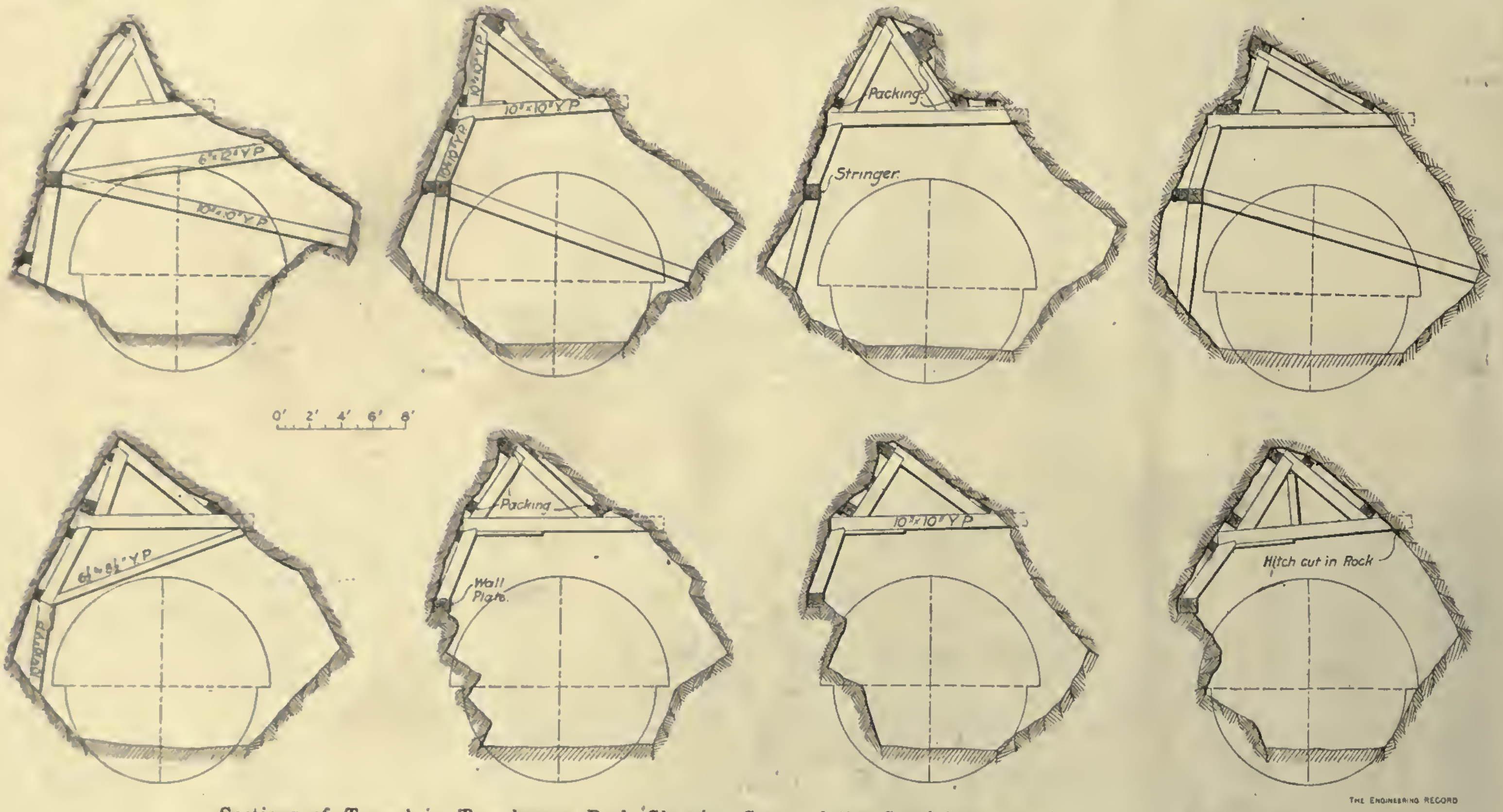
The tunnel is lined throughout with brickwork and Portland cement concrete. The invert up to the springing line has two rings of brick in Portland cement mortar, laid in a cradle of Portland cement concrete plastered with ½ inch of mortar just before the laying of the brick. The arch was built ordinarily of three rings of brick in Portland cement mortar, but through the disintegrated rock its thickness was increased to four and five rings, there being in all some 2,000 feet of this heavier construction. The arch was backed with Portland cement concrete, carried up along with the brickwork wherever the spaces between the arch and the rock were very small, but in large pockets the packing was completed after turning the arch. The larger cavities in the roof, however, were filled with concrete and rubble masonry laid in mortar, the timber packing being removed wherever possible; but if the timbers could not be removed the spaces about them were thoroughly filled with Portland cement grout. As far as possible, the middle portions of the cap timbers over the arch were cut away, after the arch had been keyed, and their ends supported by the concrete backing. The lining was ordinarily begun midway between two shafts, so that closures between two portions of the work were made at a shaft. This allowed the bricklayers to fill the last key space from above. The bottom of the shaft was sealed by a 7-ring brick arch covered with 2 to 3 feet of Delaware clay puddle in order to prevent percolation into the tunnel. Only three closures were made at other places than at shafts, and these were so chosen as to have a minimum space between the crown of the arch and the rock roof of the tunnel. At these places it was possible for the bricklayers to fill the small space with mortar introduced through the key space. In the wetter portions of the tunnel it was found necessary to use two layers of three-ply tar paper over the whole arch. Weepers were also employed to convey the water through the lining to the inside of the tunnel while the masonry work was in progress.

A sufficient quantity of the harder rock excavated from the tunnel was selected for concrete material, and sections 1, 2 and 3 each established a crushing, screening and mixing plant near shafts Nos. 2, 5, 6 and 8. From these places 3-foot gauge tracks were laid along the tunnel line in each direction and over them 1-cubic-yard steel cars were hauled by mules to the various shafts, as required, and taken down into the tunnel on the cages. The accompanying view shows one of these plants in operation on section 2, at shaft No. 8. On the ground floor of the building there was installed a No. 4 Champion rock-crusher driven by a 20-horse-power engine. This crusher had a capacity of about 75 yards per day of 10 hours. Above the crusher were three storage bins for broken stone, with inclined bottoms, and over them a rotary cylindrical screen, to which the broken stone was raised from the crusher by means of belt and bucket conveyors. Three spouts led from the bins to a horizontal belt conveyor just outside of the building, and through openings in their bottoms controlled by sliding gates, crushed stone was fed to the belt, which delivered its burden into the buckets of a belt and bucket conveyor, as shown. This third conveyor discharged the stone on to a measuring platform on top of a trestle tower adjoining one corner of the building.

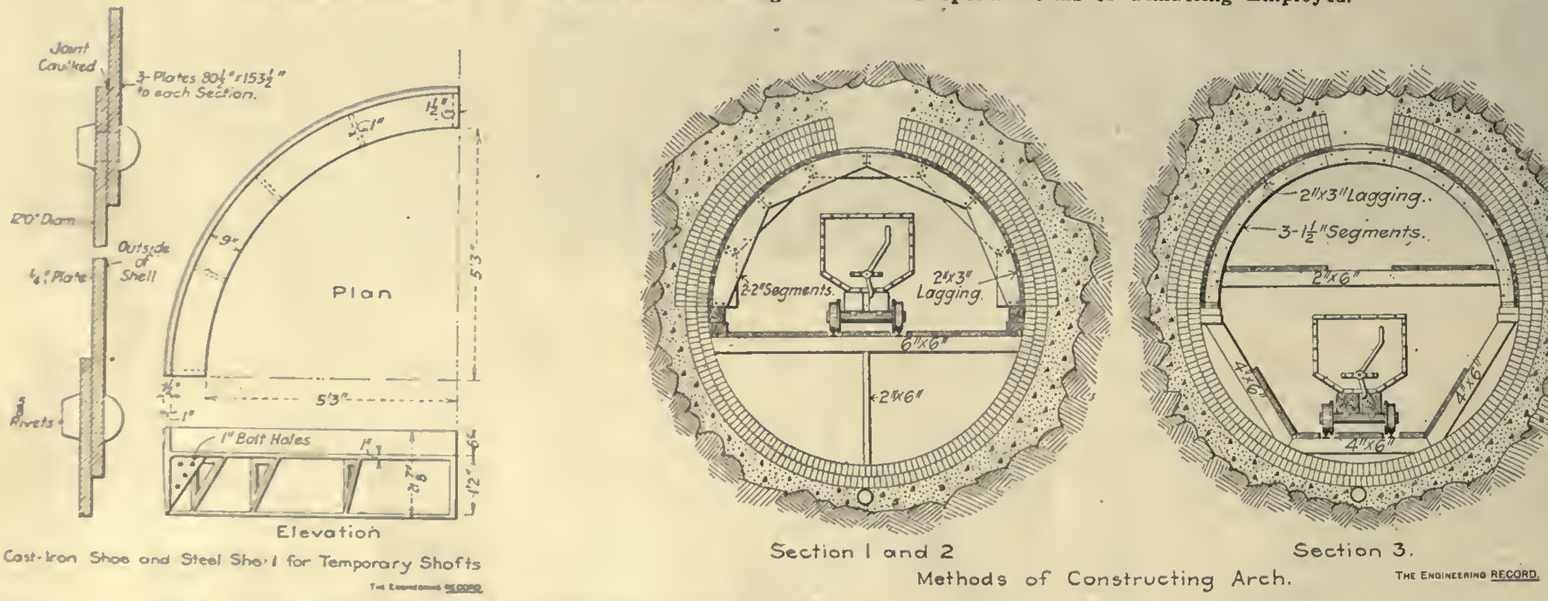
At the corner where the building and tower met, a tall guyed mast was erected, from the top of which a cableway led to the wharf where the sand was received by boat. The cableway buckets delivered the sand also to the measuring platform. The hauling rope was wound on to a drum, on the corner of the platform near the mast, driven by a belt from the sprocket-driven jack shaft, which also actuated the belt and bucket convéyor. Lehigh, Star Bonneville and a little Giant Portland cement were used and were brought by railroad to the different storehouses located near the shafts on each section. From these storehouses the cement was taken to the measuring platform, as needed, by means of the tramways. Just beneath the measuring platform a portable gravity concrete mixer, furnished by the Contractors Plant Company, of Boston, was installed so as to discharge the concrete into the cars which ran through the lower part of the trestle tower. Water for the concrete was pumped to a tank and fed through a pipe to the lower part of the mixer. The maximum output of this plant herein described, on section 2, was about 70 cubic yards per day of 10 hours, and it was run by 14 men and a chain horse. While the capacity of this mixer was much greater than this, yet the rate of placing the concrete packing rarely exceeded this amount on any one section.

Mortar for the brickwork was mixed by hand, in most instances at the top of the shafts, and was taken into the tunnel in cars and deposited in mortar boxes at the point of lining. Similar plants to this, though varying somewhat in detail of mixing concrete, were employed on the different sections.

About 10,000,000 bricks were used in the lining and were furnished by the Mack Paving Company and the Kelly Brick Company, of Philadelphia, and Sayre & Fisher, of Sayresville, N. J. The average force employed on the excavating of the tunnel was 700 men, and for the work connected with the lining 500 men.



Sections of Tunnel in Treacherous Rock Showing Some of the Special Forms of Timbering Employed.



Cast-Iron Shoe and Steel Shell for Temporary Shafts

Section 1 and 2

Section 3.

Methods of Constructing Arch.

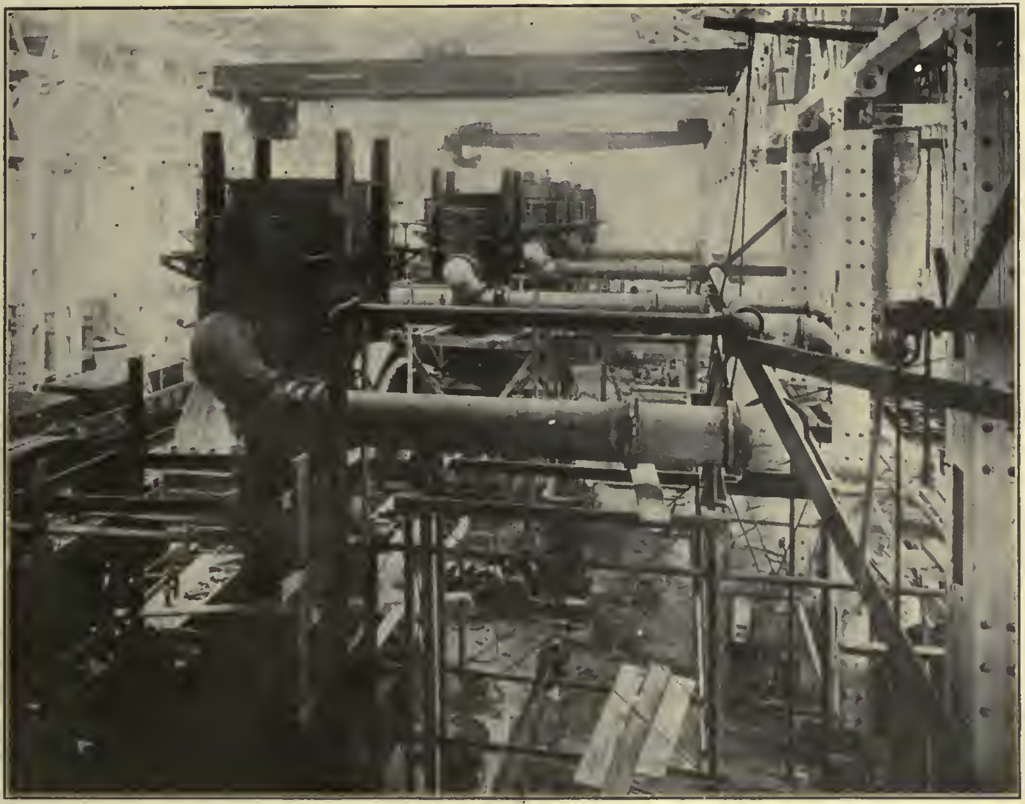
Torresdale Conduit: Steel Lining for Temporary Shafts and Methods of Building the Masonry Lining in the Tunnel.

All these works fell under the executive control of Mr. Peter E. Costello, director of the Department of Public Works. Under the direction of the chief engineer plans and specifications were prepared by Mr. R. I. D. Ashbridge, first assistant engineer, who first assumed charge of the tunnel, later resigning to take up other work. Mr. T. N. Spencer was appointed resident engineer in charge of construction; associated with him in the engineering department were Messrs. Charles P. Bower, Samuel M. Purdy and Moriz Bernstein, second assistant engineers, and Messrs. William H. Thorpe, Frank McHugh and John D. Quinn, third assistant engineers. Much credit is due to Mr. George Hein, mining inspector, whose thorough knowledge of the character of the ground encountered and methods to be adopted was of great practical advantage. The lining of the tunnel was under the direct supervision of Mr. John E. Peters, chief masonry inspector.

Besides the engineers mentioned above and in the preceding article, it is appropriate at this time to give a more complete statement of the men employed on the various parts of the filtration system than has been given in any of the foregoing descriptions of the different plants. The conduct of this work since its inception, in February, 1900, has been in charge of Mr. John W. Hill, first under the title of consulting engineer, and since the approval of the ordinance creating the Bureau of Filtration, as chief engineer. In the preparation of plans important services were rendered by Messrs. Samuel T. Wagner, Henry C. Hill, George T. Prince, La Monte Lloyd, as first assistant engineers in general charge. The following first assistant engineers have at times been in charge of important details of the work: Mr. S. M. Swaab, Lardner's Point pumping station No. 2; Mr. Frank R. Fisher, Lower Roxborough filters and later Upper Roxborough filters; Mr. D. Jones Lucas, Oak Lane Reservoir; Mr. Charles H. Paul, Belmont filters; Mr. Seth M. Van Loan, Lardner's Point pipe distribution system; Mr. John H. Gregory, draughting room. Valuable assistance was rendered also by the following second assistant engineers: Mr. Fred Schaffhauser, in charge of contracts Nos. 17 and 19 of the pipe distribution system; Mr. Stephen Harris, in charge of contract No. 12 at the Upper Roxborough filters; and Messrs. William I. Klein, Glenn D. Holmes, Frederick E. Field, J. Lee Allen, George R. Mackenzie, and Chester F. Drake. Not the least important of the duties connected with a great enterprise like this, involving an expenditure of over $25,000,000, is the clerical work, in charge of which are: Messrs. J. William Lee, chief clerk; William J. Logan, in charge of estimates, and Cheston M. Stuart, in charge of accounts. In conducting the experimental work at the testing stations, upon which many of the details of the filters are based, valuable assistance was rendered by Messrs. Morris Knowles, Charles G. Hyde, W. W. De Berard, and William R. Copeland.

Some Details of the Louisiana Purchase Exposition Service Power Plant.

The service power plant for the general arc and incandescent lighting of the grounds and buildings of the Louisiana Purchase Exposition, for the electric pumping plant and for some exhibit work has already been described in more or less general terms in these columns. It is now the intention to discuss by the aid of the accompanying illustrations some of the more interesting details. The plant has been laid out with a special effort to reduce complication and provide reliability and ease of operation, standard apparatus, for example, having been employed throughout and the equipment of vital points being duplicated to obviate interruptions of service. While many of the special features are the result of the temporary character of the work, and of the comparatively light construction of the buildings in which it is housed, they have the value of suggestion or of direct adaptability in the design of a permanent central station. The plant, therefore, while an exhibit plant, may be regarded as representative of modern practice.



Engines in Service Power Plant, Louisiana Purchase Exposition.

The design and construction of the service plant has been carried out by Messrs. Westinghouse, Church, Kerr & Company, and the general contract was awarded to the Westinghouse Electric & Manufacturing Company, which furnished the entire electrical equipment, with the exception of two generators and their controlling apparatus. The entire engine equipment was furnished by the Westinghouse Machine Company. It will thus be seen that the execution of the work was entrusted almost entirely to establishments closely related, a point of value, with the necessity of conforming to a rigid time limit.

The space reserved for the service plant is located in the western end of the Machinery Building and in the adjoining Steam and Fuels Building; the former containing the electric generating plant, and the latter the steam generating plant. The Steam and Fuels Building also contains miscellaneous exhibits of steam boilers, briquette-making and gas-producing apparatus. The electric plant is conspicuous, as it occupies 230 feet of the central aisle of the Machinery Building. It lies midway between the exhibits of the two largest American electrical manufacturing companies, the Westinghouse Electric & Manufacturing Company's exhibit occupying the southern wing and the General Electric Company's the northern wing. Each company is represented in the generating and switchboard equipment. The electric generating part of the plant is served by a 40-ton three-motor Niles traveling crane.

In the erection of the plant many difficulties were experienced on account of the treacherous nature of the soil, which is made-ground on river bottom. All ground had to be piled not only under the building and machinery foundations, but also under boiler and flue walls, pipe tunnels and overflow conduits. The buildings, being of temporary character, are naturally of light construction, which introduced further difficulties in providing proper supports for piping. It was found necessary to support the large piping directly from the floor upon steel towers. The general arrangement of the steam and electric plant is shown in the accompanying plan.

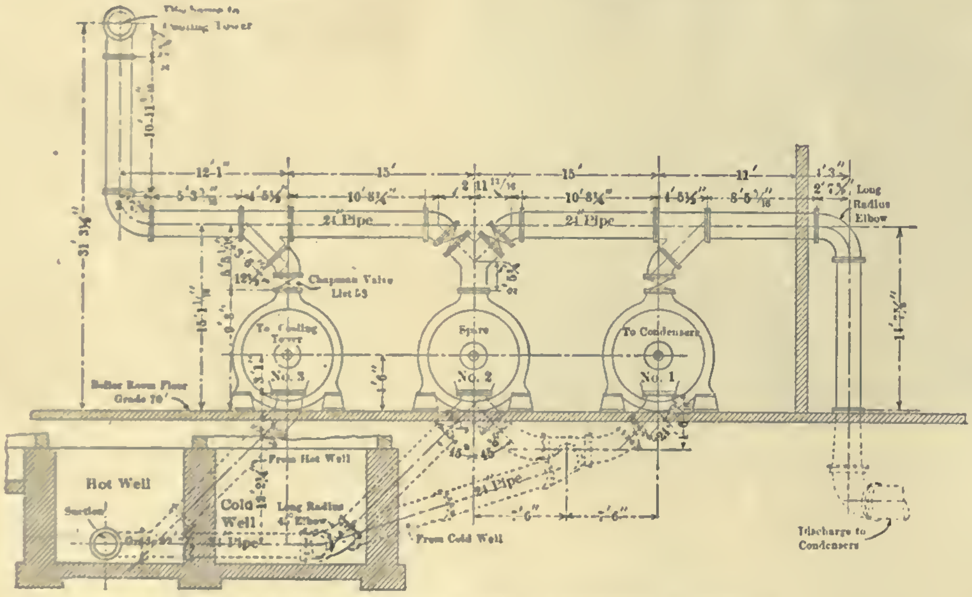
The main generating plant is of 8,000 kilowatts capacity, in four units of equal size. The plant is served by three 80-kilowatt exciter units, two of which are sufficient to operate the entire plant, together with such auxiliary machinery as may be required in the adjacent exhibits, leaving the third unit as a reserve. Each pair of generating units receives steam from a separate steam line, in turn supplied by a separate battery of boilers, and exhausts into a separate condenser. The entire plant thus consists of two sections practically in duplicate, which may be operated independently or together.

Each generating unit consists of a Westinghouse Corliss vertical cross-compound engine direct-connected to a 2,000-kilowatt revolving field alternating-current generator, the unit operating at 83 revolutions per minute. The engine is 38 and 76 by 54 inches in cylinder dimensions, indicating 2,883 horse-power at full-load with 27½ pounds mean effective pressure referred to the low-pressure cylinder. The engine has a maximum overload capacity of 5,244 horse-power under normal conditions of 150 pounds steam and 26 inches vacuum. The overall dimensions of the unit are approximately 32½ feet high, 35 feet length and 15 feet width for the engine alone; the fly-wheel being 23 feet in diameter. The shaft, of steel forged hollow by hydraulic pressure, is 31 inches in diameter at the generator and 28 inches at the bearings, which are of the ball and socket self-aligning type. The guaranteed economy of the engines is 13½ pounds per indicated horse-power at the point of best efficiency.

The generators are rated at 2,000 kilowatts at the usual temperature rise. They deliver three-phase current at 6,600 volts directly to a distributing system, without the introduction of intermediate transformers. Fifty per cent. overload may be carried for one hour without injurious heating. The guaranteed efficiencies of the Westinghouse unit, based upon measured iron and copper losses, and on 100 per cent. power factor, are as follows: Full load, 96 per cent.; three-quarter load, 95 per cent.; one-half load, 93 per cent. Each engine, complete with bed-plate, weighs 196,000 pounds, the rotating member having a flywheel capacity, at 5¼-foot radius, of 70,000 pounds. The exciter units are standard Westinghouse engine-type machines, driven by 12 and 20 by 12-inch compound engines operating at regular boiler pressure and exhausting into the main condensing system.

The switchboard for the entire generating equipment will be located at the western end of the main aisle upon a raised platform. It will consist of 35 panels, four of which will be devoted to the main generators; three to the exciters; two to incoming feeders from the Union Electric Light & Power Company's plant; two are used for load panels and 24 for outgoing feeders. A duplicate set of bus-bars is employed, each having an individual load panel for totalizing the output. The main current will be controlled entirely by automatic electrically operated oil switches, operated from the main board. A high-tension underground conduit system connects the service plant with distributing sub-stations located in the various buildings, where current will be stepped down to alternating-current voltages suitable for general distribution, and converted to direct current for motor work. Miscellaneous voltages and frequencies will be supplied entirely by exhibit apparatus.

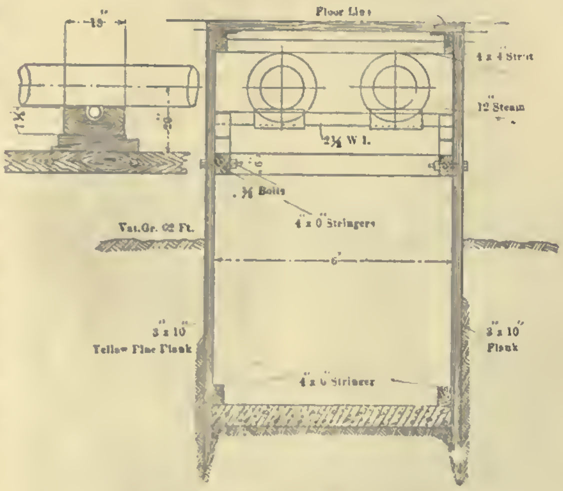
Boilers.—Conforming with the duplicate construction employed in other parts of the plant, two complete steam generating outfits have been installed, each with independent flues, mechanical draft, steam and feed-water system. The capacity of the plant is 6,400 horse-power at the standard rating, uniformly distributed between eight batteries of boilers.



Pumping Equipment for Condensers and Cooling Towers.

Each battery contains two 400-horse-power Babcock & Wilcox, inclined header, water-tube boilers built into a single setting. The boilers have 42-inch drums hung from a structural steel framework so as to be independent of the setting, thus relieving the brickwork from the stresses due to dead weight and differential expansion. The products of combustion discharge horizontally through the upper part of the setting into a single flue common to each section of the boiler equipment. The boilers are all fitted with Roney mechanical stokers, driven by Westinghouse Standard engines, through worm gearing, each stoker engine operating two complete batteries of stokers by means of a shaft extending along the stoker fronts. The boiler plant furnishes steam at 150 pounds pressure without superheat.

Two spur tracks entering the Coal and Fuels Building along the western wall, will be utilized for handling coal and ashes. A complete conveying system, furnished by the Link-Belt Engineering Company, receives the coal from the hoppers located between the track rails, elevates and distributes it among individual bins, each serving one stoker through steel chutes. The system also conveys coal to a storage bunker of about 500 tons capacity, from which the coal may also be drawn for miscellaneous boiler and gas producer exhibits located in the same building. The individual bins in front of the plant boilers are supported by structural steel frames independent of the boiler columns. They each hold about five tons of coal and are circular in form with conical buttons, the discharge being controlled by wing valves. The chutes conveying the coal to the stoker hoppers are arranged to swing about a horizontal axis in order that they may be swung back into a vertical position to clear the stokers and boiler doors.



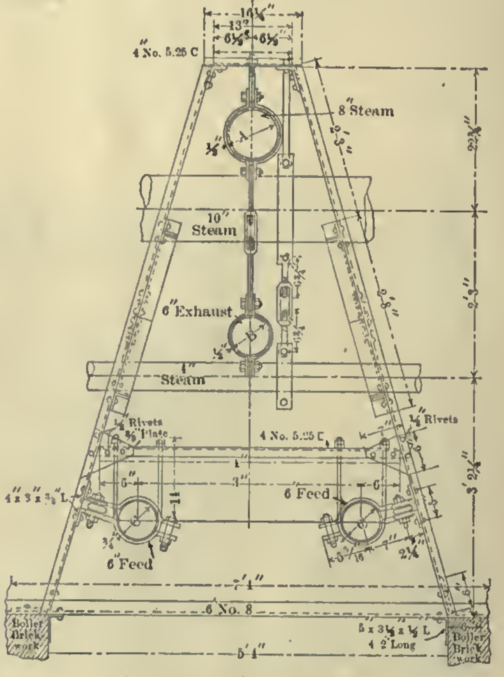
Cross-Section of Pipe Tunnel.

Ashes from the stoker grates gravitate into concrete-lined pits, from which they are moved into ash cars running through tunnels beneath the floor. These tunnels connect with the cross tunnel outside the building, which rises to the surface.

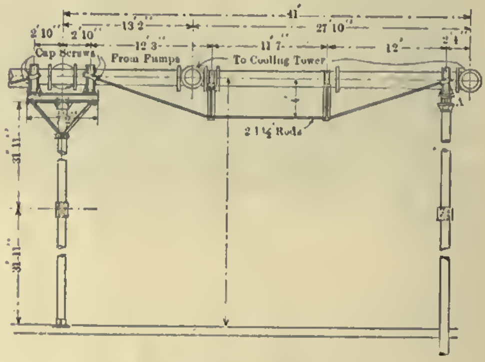
The boiler plant is supplied with feed-water from the city mains, after passing through a duplicate set of 4,000-horse-power Cochrane feed-water heaters using exhaust steam from the boiler house auxiliaries. This heater is mounted 3½ feet from the floor upon a hollow concrete pier reinforced with expanded metal.

The battery of pumps located near the heater supplies the entire plant with feed-water. Two types are represented: duplex out-side-packed double-plunger, and the Admiralty type, both of Worthington make. Two of the former type are used, each 9x16x7½x15, and one of the latter, 14x10x18 inches. These pumps discharge into a ring main in order that they may be operated singly or together, as desired.

Mechanical Draft Plant.—Two complete mechanical draft plants have been installed, each serving eight boilers aggregating 3,200 horsepower, and a duplicate fan is provided for relay purposes. The flue construction consists of concrete floors and brick ceilings supported by 2¼x2¼-inch tees which span the space between the rear walls of the boiler settings. As this space is about 10 feet in width, a row of 4-inch pipe struts with I-beam stringers supports these T-beams at their center. The ceiling is finished with two courses of common brick laid flat and flushed with cement. This flue leads directly to the fan housings, the joint being sealed with a sleeve formed by angles riveted to the housings.



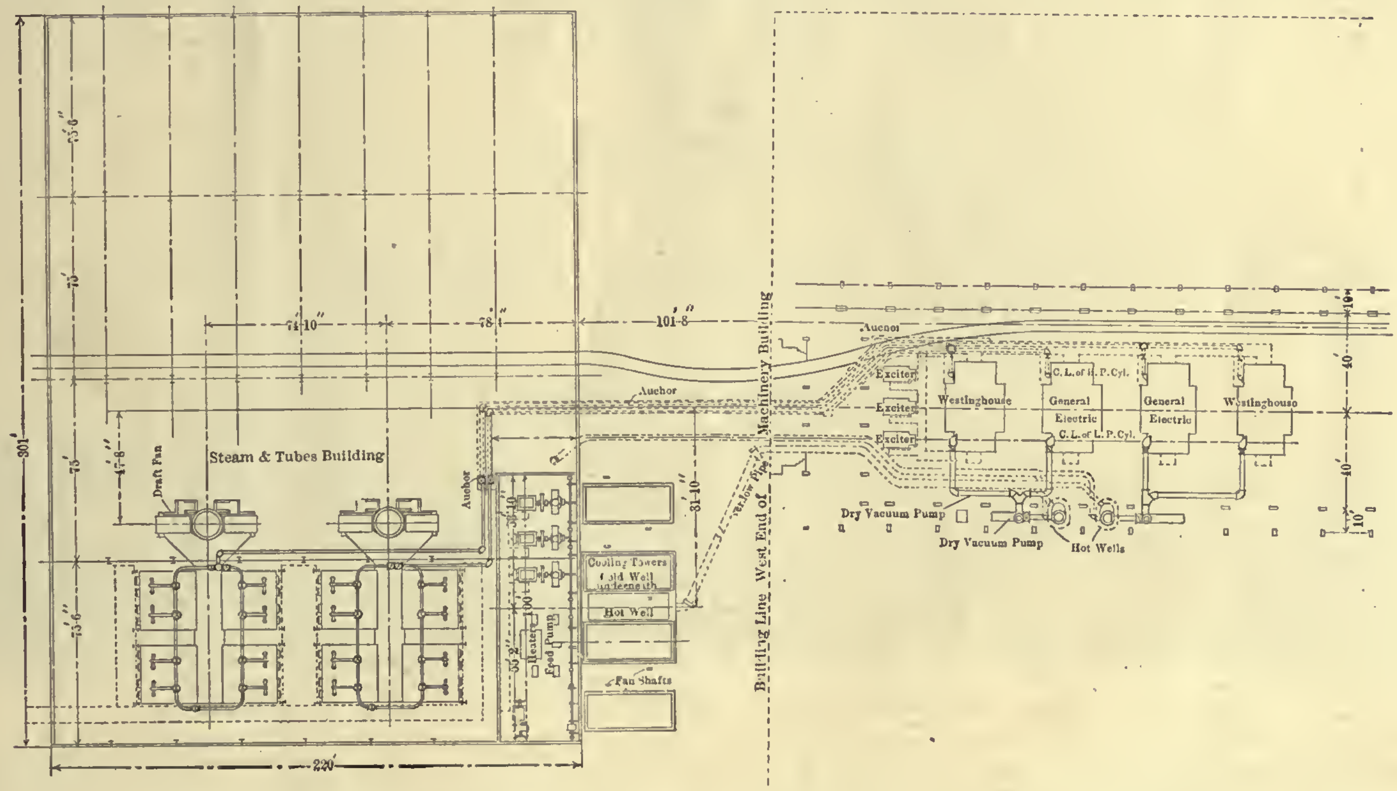
A-Frame Pipe Hanger.



Pipe Truss in Pump Room.

The fan equipment consists of two 14-feet 12-blade steel plate fans. These are of three-quarter-housed overhung pattern built from special designs of Westinghouse, Church, Kerr & Co. by the New York Blower Company. The central part of the housing supports the steel plate stack, which is 11 feet in diameter, the whole resting on a concrete pier. The two fans operate in opposite directions, receiving the flue gases at their center and discharging the periphery into the central compartment leading to the stack. A deflecting damper hinged at the center of this compartment, provides means for isolating the idle fan as well as for insuring a continuous surface for the ascending gases from the fan in motion. The intake of each fan is closed when idle, by a steel plate damper 10½ feet square, which is hung from rollers and may be shifted from one intake to another by means of a chain and hand-wheel. With the two dampers mentioned, each fan may be operated independently of the other, or if unusual capacity is required, the dampers may be placed in mid-position and both fans operated simultaneously.

Each fan is direct driven by a Chandler & Taylor 13x14-inch simple automatic high-speed engine controlled by a throttle governor. The fan bearing is supported by a cantilever I-beam grillage, and is of the ring-oiling type protected from the heat of the flue gases by a water-jacket.



Louisiana Purchase Exposition Service Power Plant, in Steam and Fuels and Machinery Buildings.

Condensing Plant.—The two condensing plants are practically duplicates, although each is intended to serve one-half of the engine plant. The condensers, which are 40 inches in diameter at the entrance, are of the Worthington elevated jet or barometric type. They are located in the space between building and crane columns in order to clear the crane. At the junction of the horizontal and vertical lines of exhaust piping is located a cast-iron entrainer which forms a water pocket draining the horizontal line and so directing the passing exhaust steam as to pick up any water collected in quantity in the pipe and carry it over to the condenser in the form of spray. At the top of each exhaust riser is an automatic relief valve which in event of loss of vacuum provides a vent to the atmosphere through a line of vertical spiral riveted pipe extending through the roof. A gate valve at each engine and at the condensers gives complete control of this part of the system. The weight of the condenser is borne by two 15-inch I-beams spanning the concrete hot-well, lugs having been fitted on the tail pipe for furnishing the required bearing.

Injection water is supplied through a 30-inch cast-iron main from the pump room, two 20-inch risers leading to the two condenser cones. At this point is located on each condenser a tubular air cooler, around which the injection water circulates on its way to the condenser. Three dry-vacuum pumps are furnished for the two condensers, one of which may be held as a reserve. Two of these are 10x22x18 inches of the horizontal rotative pattern, and the third an 8x16x12-inch vertical marine type high-speed pump, all of Worthington build. They are supplied with steam from the engine auxiliary piping system and exhaust into the main condensing system. The air discharge is led through spiral riveted piping to the roof.

The overflow water from the two condenser hot-wells is conducted through a 36-inch tile conduit to a concrete hot-well located about 200 feet distant at the cooling towers. On account of the nature of the soil it was found necessary to support this conduit on piling. For this purpose the entire conduit line was enclosed within a timber trough 2½x3 feet deep, built of 4-inch pine tongued and grooved, this trough resting upon cross sleepers capping the double row of piles. The sides of the trough were reinforced and the structure held together by tie-rods.

Cooling Towers.—An interesting feature of the plant is the equipment of the cooling towers for furnishing cold water to the condensers. The equipment is of sufficient capacity to supply the entire station, aggregating about 14,000 indicated horse-power, including auxiliaries operating upon the main condensing system.

The four towers are identical in size and construction. Each consists of a rectangular brick stack 52 feet in height, containing ten tiers of wooden gratings occupying 20 feet of the height of the tower. These gratings furnish the cooling surface of the tower, and are constructed of 3x6-inch pine timber set on edge four deep, with uniform side spacing. This construction forms a horizontal grating 24 inches in height and filling the entire area of the tower, the ten tiers of grating being at right angles, in order to break up more completely descending streams of water and secure maximum effectiveness of cooling surface. A space of 12½ feet beneath gratings provides for the introduction of the fans and a corresponding space of 20 feet above the gratings conveys the vapor above the adjacent building roof and provides some natural draft in addition to that furnished by the fans.

The distributing system of each tower comprises a 20-inch cast-iron supply pipe extending through the wall of the pump room the full length of the towers. This in turn supplies 30 transverse distributing pipes drilled underneath with numerous holes, the entire pipe system being suspended from steel cross beams anchored in the walls. A 20-inch cast-iron main connects the four branches of the towers with the circulating pumps, each branch being controlled by a gate-valve. Underneath each tower is a settling well connecting with a central cold-well from which the condenser water is drawn.

Draft is supplied to each tower by four 120-inch Seymour fans arranged in two pairs. All sixteen fans are belted to a jack-shaft with Neptune waterproof belt. This jack-shaft is carried by brackets attached to the building wall, and is driven by an 18 and 30x16-inch Westinghouse compound engine, the strain of the main belt being taken up by a structural steel tower built independent of the building wall.

Injection water for condensers and water for cooling towers is handled by a battery of three 24-inch centrifugal pumps of the Worthington turbine pattern, one being normally used for the two condensers and one for the towers, while the third is held in reserve. Either pump may be replaced by the spare when desired. These pumps are direct driven by 18 and 30x16-inch Westinghouse compound engines and operate upon a head of approximately 45 feet including suction. Each pump unit has a capacity of 17,000 gallons per minute under a total head of 50 feet including equivalent friction head. The output of the pumps may be regulated according to the water required by means of handwheels at the end of the engine shafts. These communicate with the respective engine governors, the adjustment of which may be changed while the unit is running, and the speed then proportioned to the load. The 24-inch water main supplying the tower is supported by 10-inch pipe columns with intermediate trusses.

Piping.—Two complete and independent systems of high pressure steam piping have been laid out, one for each of the two main sections of the boiler plant. The four batteries of boilers constituting each section of the boiler plant are interconnected by a 10-inch main and a 4-inch auxiliary line, both in the form of a ring main, the latter underneath the 10-inch ring and not shown. No pipe bends are used except on this ring main, the necessary flexibility of the piping system being secured partly by this means and partly by the method of support. Extra heavy Eaton, Cole & Burnham fittings and Chapman outside screw and yoke gate valves are used on all high pressure piping, and standard fittings on the low pressure piping. At the junction of the ring main and the various risers from the boilers, angle valves are used in the case of both the 10-inch and 4-inch mains. With the location of the valves adopted, in the event of rupture of any section of a ring main, the trouble may be localized by shutting off the disabled section, the remaining half of the main being kept in service. The use of the ring main also largely facilitates the steam distribution.

Each of the 10-inch ring mains connects with a 12-inch supply pipe leading to the engine room in the Machinery Building. The two 4-inch auxiliary ring mains similarly connect with an 8-inch supply main serving the boiler plant auxiliaries, together with the circulating-pump and cooling-tower engines. No connection exists at any point between the 10-inch and 4-inch systems; this separation being still more complete by the fact that the auxiliary ring mains are supplied by 2-inch taps into the boiler headers, thus rendering the operation of the auxiliaries quite independent of any break in the main piping system. As a precautionary measure in case of rupture to the 8-inch auxiliary supply line, a 2½-inch duplicate supply pipe also leads to the auxiliary room, so that sufficient steam may be available for operating the boiler feed pumps, thus keeping this part of the plant under control.

At the northwest corner of the auxiliary room, the two 12-inch engine supply lines drop approximately 28 feet to the level of a pipe tunnel through which they are carried to the Machinery Building, a distance of about 475 feet in the case of the longest run. The average length of run from the respective ring mains to the corresponding pair of engines supplied, is 464 feet in one case and 617 feet in the other. The entire high-pressure piping system in the boiler house is drained by a steam loop and Holly gravity return system, which automatically returns condensation to the boilers. This system not only drains the piping itself, but also the water-pockets in the various valves.

All boiler room auxiliaries, as well as the circulating pump and fan engines, exhaust into two Cochrane feed-water heaters in duplicate, the distribution of the exhaust steam between the two headers being controlled by valves, so that either heater may be replaced by the other one when desired. Both headers are provided with oil extractors at the point where the exhaust enters the heater. These largely prevent the oil carried over in the exhaust steam from contaminating the feed-water. The two heaters are provided in common with an atmospheric relief of spiral riveted pipe leading through the roof.

An unusually symmetrical arrangement of feed-piping is employed. The supply mains are in duplicate and have cross-connections at adjacent batteries through 2½-inch headers. By means of properly located valves, each section may, however, be completely isolated in case of necessity. Ordinarily the feed line to each battery of boilers is controlled by a single valve.

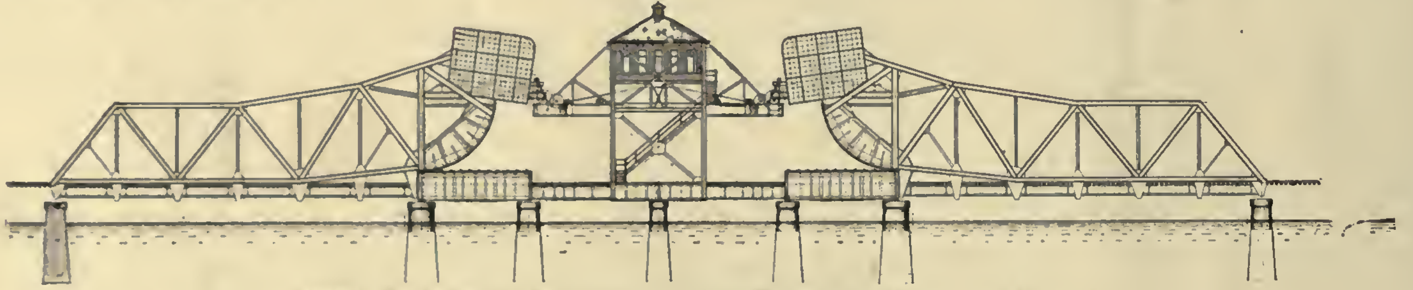
In designing the supports for the various systems of piping, unusual difficulties have been encountered in the absence of facilities for hanging the pipes from the roof trusses, thus making it necessary to support all piping from the ground. In this work wrought-iron pipe columns and trussed pipe-towers have been largely used for carrying the elevated mains where these run clear of the boiler settings. In the case of pipe lines running over the boilers, structural steel A-frames, of which the accompanying illustration is typical, are used. This particular frame spans the space between boiler settings and combines the function of pipe-hanger and anchor.

The problem of expansion in the long run of piping between buildings was solved by providing sufficient swing radius at bends and by anchoring at intermediate points. At the point of entry to the pipe trench, the two 12-inch mains are restrained from horizontal movement by the anchor, and at the corner of the succeeding run, 162 feet in length, both lines are again anchored, as well as at the beginning of the last section of piping at the engines. At each bend in the steam lines double 90-degree elbows are employed, with short nipples, which form hinge joints through which sufficient flexibility is secured to relieve the fittings of undue strain.

At the points intermediate between anchors, roller supports are used. The weight of the pipe line is carried by 2½-inch wrought-iron pipe extending across the trench with ends set into wood blocks. The elevation of the support may be adjusted by wooden wedges. The steam pipes rest directly upon loosely fitting pipe sleeves which accommodate the expansion and contraction of the pipe line.

A Rolling Lift Bridge over Newark Bay, New Jersey.

On February 14 the west leaf or half of two new Scherzer rolling lift bridges under construction for the Central Railroad Company of New Jersey, across Newark Bay, was successfully lowered into position to carry the railway traffic. The bridge had been erected in its upright position and during erection railroad traffic was maintained without changing the alignment or level of the tracks, by operating the trains through the bridge as shown in one of the accompanying illustrations. The new structure is being built across the lower end of Newark Bay to take the place of a center pier swing bridge. At this location the lines of the Central Railroad Company of New Jersey cross the bay on a pile and timber trestle about a mile and one-half in length, with a steel swing bridge spanning a dredged and navigable channel a short distance east of the middle of the trestle. The bridge at this point must be operated frequently to accommodate the passage of a large vessel traffic to and from Newark and other cities along both the Passaic and Hackensack Rivers.



General Elevation of Two Rolling Lift Bridges, Back to Back, over Newark Bay.

The double-track center pier swing bridge was becoming inadequate to carry the increasing engine and train loads and the greatly increased traffic of the company. When it was decided to replace the center pier swing bridge, it was recognized that the new bridge should not only provide for the requirements of the present traffic, but should permit and facilitate the construction of additional tracks and bridges from time to time as the traffic increased. Four tracks are already maintained on both sides of Newark Bay and the eventual construction of four tracks, or more, across the bay was considered.

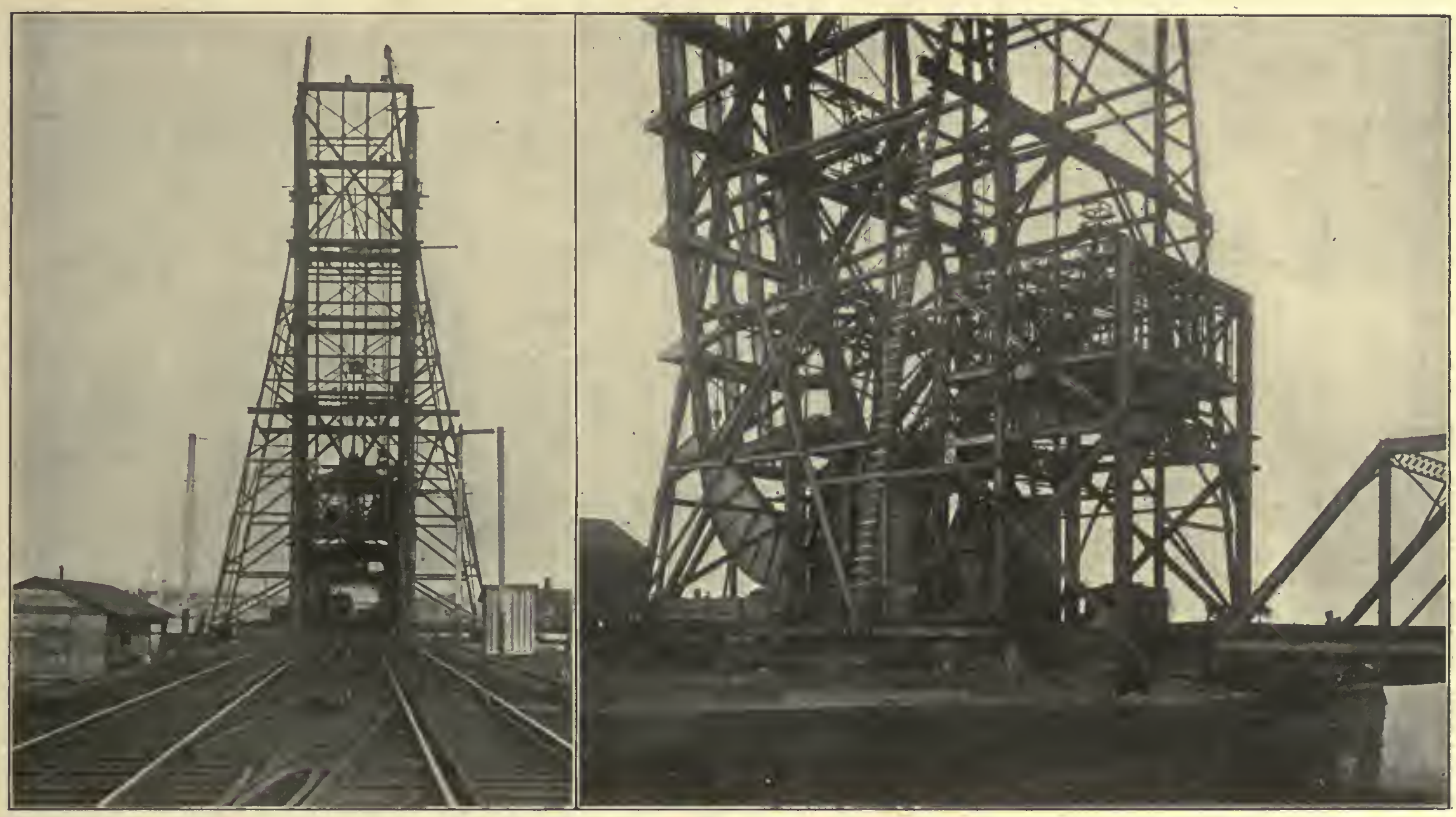
Extensive studies were made of the cost and adaptability of different types of movable bridges to meet the existing conditions and expanding requirements. If a center pier swing bridge were built, it would be necessary to build a temporary trestle with a temporary movable bridge across the navigable channel and divert the traffic of the railroad over the temporary structure. It would be necessary to construct the new swing bridge as a four-track structure, although only two tracks are to be maintained across Newark Bay during the early future; for if only a double-track swing bridge were constructed it would have to be discarded and removed as soon as it was decided to increase the width of the bridge across the bay to accommodate four tracks. The tracks across the bay would also have to be elevated several feet, introducing undesirable grades, if a four-track swing bridge were constructed because of the increased height required for the drum and rollers under a four-track swing bridge.

All of these difficulties will be obviated by the use of a Scherzer rolling lift bridge which also saves time to the very frequent and important train service crossing the bridge by providing unobstructed channels for expediting passage of vessels. Railroad traffic will also be facilitated, as fully eighty per cent. of the traffic through the bridge is composed of barges and tugs, for the passage of which it will only be necessary to open the bridge slightly, while the center pier swing bridge would have to make a complete opening.

A provision of the charter of the railroad company required that two channels should be maintained for navigation at this crossing. It was therefore decided to build two double-track, single-leaf Scherzer rolling lift bridges, placed back to back, each bridge being independent of the other in its operation; the west leaf or bridge to be constructed first while navigation was accommodated through the old swing bridge. Upon the completion of the west leaf or bridge and its opening for the accommodation of vessel traffic, the construction of the east bridge would proceed. Whenever it was decided to increase the number of tracks across Newark Bay, one or more single or double track rolling lift bridges could be added alongside of the existing double-track rolling lift bridge.

The general elevation of the new bridge is shown in one of the illustrations. The base of rail is only 4½ feet above extreme high water, yet all metal parts of the bridge are kept above extreme high water, both when the bridge is closed and opened. When in a closed position, to carry the railroad traffic, each leaf or bridge span acts as a simple truss on two supports. Special consideration was given to the safety of traffic when operating trains across the bridge at high speed. The rails are firmly spiked to the ties at all points, avoiding the loose and shifting rail lifts and end lifts of the swing bridge. The rail joints between the fixed and movable spans make close connection, and form a continuous and perfect alignment. The superstructure was designed in accordance with Cooper's 1901 specifications for railroad bridges to carry on each track two 187½-ton engines, followed by a uniform load of 5,000 pounds per linear foot of each track. Two 75-horse-power gasoline engines, manufactured by Fairbanks, Morse & Company, are provided. Each engine is so arranged and connected with the machinery that it can operate both bridges either jointly or separately, as desired. The operator's house is constructed entirely of steel and fireproof material, wood being eliminated.

The bridge is constructed for the Central Railroad Company of New Jersey, Mr. W. G. Besler, vice-president and general manager, but is also used by the trains of the Philadelphia & Reading and the Baltimore & Ohio Railroads. The Scherzer Rolling Lift Bridge Company furnished the designs, plans and specifications for the superstructure, operating machinery and operating equipment of the bridge and also maintained a consulting engineering supervision over its construction. Mr. Joseph O. Osgood, chief engineer of the Central Railroad Company of New Jersey, assisted by Mr. Austin Lord Bowman, bridge engineer, prepared the general plans of the substructure and maintained a supervision over the entire work of construction. The Pennsylvania Steel Company manufactured and erected the superstructure of the bridge, the Bethlehem Steel Company furnishing the machinery. The Sandford & Harris Company, of Hoboken, were the contractors for the substructure of the bridge.



Rolling Lift Bridge over Newark Bay: Showing Erection in Vertical Position Permitting Trains to Pass.

The Manchester Street Power Station of the Rhode Island Company, Providence.—II.

Condensers.—The condensing plant consists of four jet condensers, one for each unit, with vertical twin pumps drawing from one and discharging into a second of two concrete conduits extending lengthwise of the building under the basement floor. The pumps, which are of the Blake pattern, are 16x40x24 inches in size for the horizontal engines and 16x48x24 inches for the vertical unit. Relief valves are furnished near each condenser unit and the exhaust piping is of cast-iron except beyond the relief valves where it is of spiral riveted pipe. There are two 36-inch free exhaust risers, one at each end of the building, the run of pipes being shown in the plan. The two straight horizontal lines leading to the risers are each provided with a Wainwright corrugated copper expansion joint. The risers, which are capped with exhaust heads, are some 100 feet high and the braces used to hold the pipe and at the same time allow for expansion are shown herewith. The rods have a fork at each end, making a hinge joint, one at a bracket fixed to the building wall and the other to a plate bolted to the flange of the exhaust riser. There are three sets of these braces for each pipe. The length of the supports are adjustable, as indicated.

Salt water from the Providence River is used for condensing. It is admitted into a flume 7½ feet wide and 8 feet high, lined with 6-inch sheet piling and having a floor of 4 feet of concrete. The bottom of the suction flume is 16½ feet below mean high water and leads to a screen chamber beyond which the flume takes the form of a flattened ellipsoidal concrete conduit with axes 7½ and 4 feet. The discharge conduit within the building is similar to the suction passage, except that it is 7 feet high. Outside the building it is also of the timber wall and concrete floor construction, with its bottom 7 feet below mean high water or about 2 feet below low water, and it is 4x7.5 feet in cross-section. The concrete discharge conduit is vertically over the suction passage, but a short distance outside the building line it diverges from the line of direction of the suction flume, emptying at the wharf line 46 feet from the intake. Under each condenser the suction conduit can be reached by a well in which is placed the pump suction pipe with strainer foot valve. The screen chamber at the end of the suction flume contains two 5x8-foot screens, of brass wire, one of 1½-inch mesh and the other of 1-inch mesh through which the water passes in succession. This chamber is at the foot of a timber-lined shaft through which the screens may be removed. Hinged covers of heavy planking at grade level give entrance to the shaft and immediately above the screen chamber proper is a 6-inch splined plank roof through which the screens may be lifted in wooden guide posts extending from the bottom of the shaft to the ground surface.

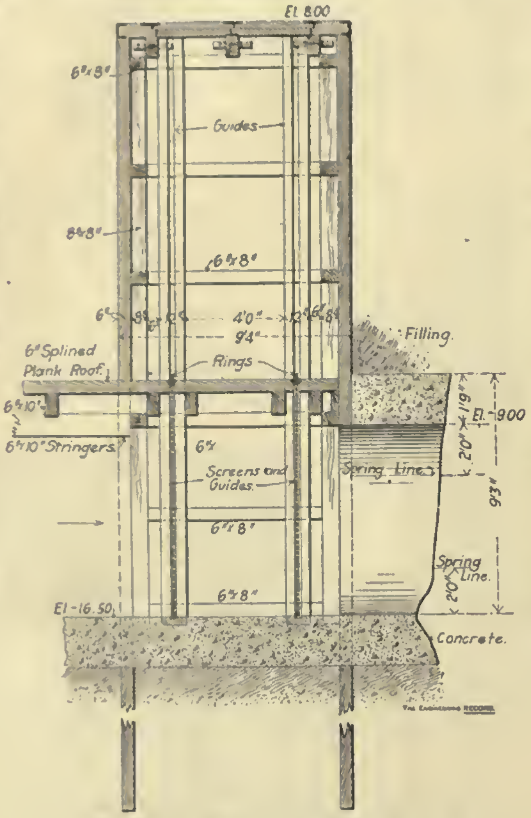
Boiler-Feed System.—The boiler-feed system is one of the specially interesting features of the plant. Owing to the use of jet condensers operated with salt water, fresh water for the boilers is constantly required, taken from the city mains. Normally, the water is passed through feed-water heaters, to which is brought the exhaust steam from the feed and condenser pumps and the marine-type exciter set, and is then taken by the feed pumps, at a temperature of about 170 degrees Fahrenheit, so that the pumps thus handle hot water, and is delivered through the economizers into the boilers at a temperature of 220 to 230 degrees. The heaters, pumps and economizers are all provided with by-passes, and there are also duplicate feed mains to the boilers.

The scheme of piping and connections is indicated in the accompanying diagram. Water is admitted from the public service through either one or both of two 6-inch pipes, and is passed through a meter, provided with the usual by-pass. The city pressure is sufficient to force the water through the feed heaters and to the pumps, which are located on the lower boiler floor while the heaters are in the basement directly underneath. The delivery pipes from the heaters feed into opposite ends of a suction header, into which also two 6-inch heater by-passes connect as shown. Each heater is the Gleaner type made by Messrs. I. B. Davis & Sons, of Hartford, consisting of groups of U-tubes through which the exhaust steam is led successively from steam inlet to drain outlet. Each heater has some 375 square feet of heating surface, and is 4¾ feet in diameter and 12½ feet long. An interesting point is that all oil-laden drips are discharged into the lower row of tubes, and it is stated, that the condensed steam is discharged at a temperature only 4 degrees higher than the inflowing cold water.

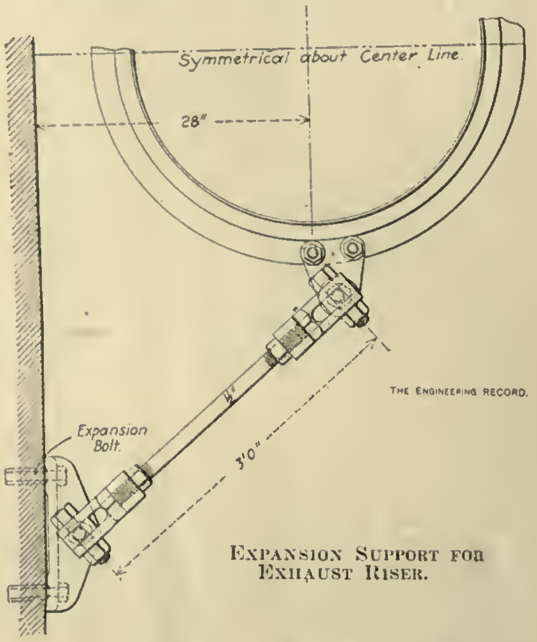
There are four feed pumps, of the Worthington 14x8½x15-inch duplex double-acting plunger pattern, all delivering to the same discharge header, but ordinarily connected, two to the feed system of the lower deck of boilers and two to that of the upper deck. There are two steam mains run across the pumps, with a branch from each to each pump, and the steam valve to the pumps for the upper deck have extended stems rising through the second boiler floor so that they can be controlled from that point.

Opposite each pump discharge into the pressure header is a large air chamber, and in addition each pump carries a relief valve discharging into the suction. The header is formed into a loop in a vertical plane with the lower run in the cellar. From it are carried two 7-inch connections, these being the regularly employed feed mains for the two decks of boilers, and also a 6-inch connection, this leading to an auxiliary feed main to which is also brought a 6-inch pipe direct from the city meter connections. The last pipe provides for filling the boilers with cold water; the other 6-inch main for forcing water in the boilers either hot or cold. A study of the diagram will show that any of the pumps can draw from either heater or direct from the cold supply; and that any pump can be used to supply either deck of boilers, by means of the delivery loop and the arrangement of valves.

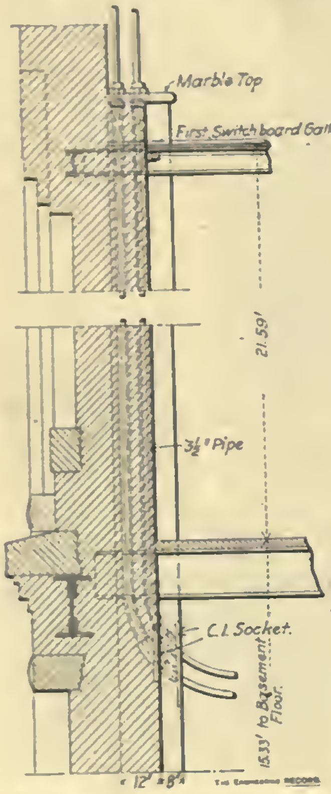
The diagram also shows the distribution of the feed piping for one deck of boilers, the arrangement for the other being similar. The main starting 7 inches in diameter is carried overhead behind the boilers, suspended from I-beams; and the branches to each battery, for the length C to D, are taken vertically upward from it, with a connection for the economizer, as well as direct to the boilers. The auxiliary main,



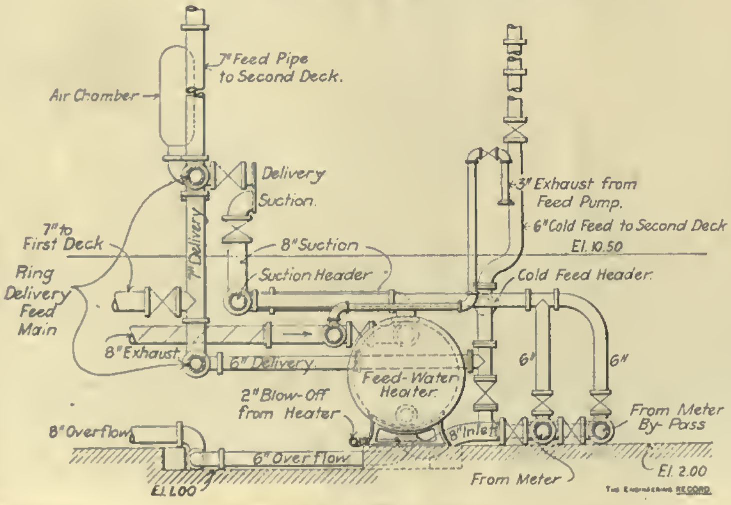
Condensing Water Screen Chamber.



Expansion Support for Exhaust Riser.



Electric Conduits in Building Wall.



Elevation of Feed Piping at Pumps

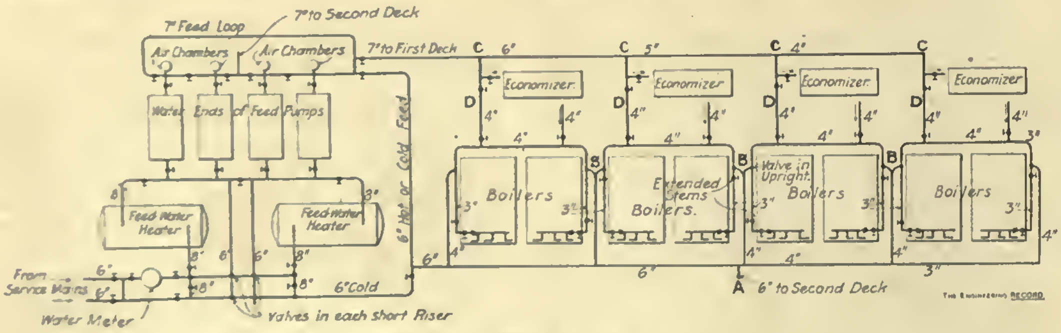
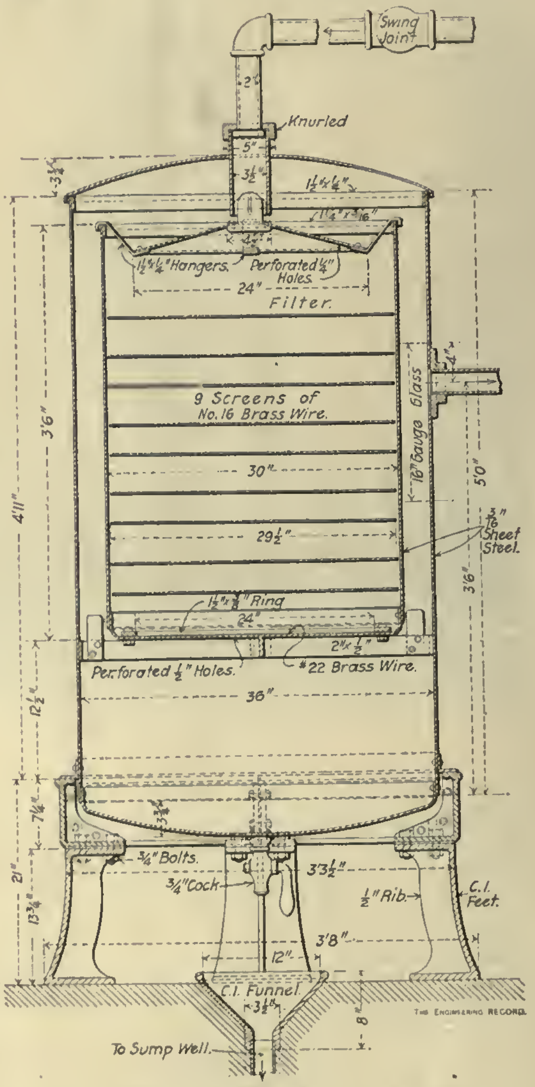


Diagram of Feed-Water Piping.



Filter for Engine Oil System.

Manchester Street Power Station, Providence: Details of Piping Systems, Oil Filter and Electric Conduits.

starting 6 inches in size, is run in the cellar and at the point A supplies a vertical to a similar horizontal main in the upper part of the lower story of boilers for the second-deck installation. The branches from this main at the points B in each deck bifurcate into two vertical pipes for the two adjacent boilers, with a valve in each vertical. At the top the verticals connect into the branches from the main feed system. The valve in the supply pipe to each boiler has an extended stem dropping toward the floor within reach of the firemen.

Electrical Apparatus.—The handling of current at 11,000 volts has resulted in an interesting equipment of electrical apparatus grouped around a two-gallery switchboard, 31 feet above the engine room floor. The various electrical conductors from the generators are carried overhead on the underside of the ceiling in a spacious, well-lighted gangway in the basement. Here the high-tension busbars are located, each enclosed in separate brick housings supported on a slate platform, and connections to and from them are made in oil-break brick-housed switches on the engine-room floor. These are of the pattern operated by relay switches on the switchboard, the switches actuating the main switches through worm and wheel gearing driven by small direct-current motors, one mounted on the brick enclosure of each switch. There are five alternating-current feeders and the conductors pass out of the building opposite the second story of the switchboard where there are cut-out copper bar switches mounted on marble panels, with branches to the lightning arresters, grouped underneath the first gallery.

A feature of the switchboard construction is the provision of 3½ inch pipe conduits built in pilasters against the outside building wall for the passage of the conductors. At the bottoms the pipes are set into special cast-iron sockets giving smooth rounded surfaces into the conduit and at the top they are fitted into the marble cap of the pilaster. The high-tension feeders are carried horizontally through the building wall in the center of an 8x8-inch opening in it, and outside, under the cover of heavy slate hoods, are located the tension insulators, and the beginning of the transmission line.

The alternating-current feeder panels have each a recording wattmeter and three ammeters, the latter showing the state of balance of the load on each phase. The generator panels have only one alternating-current ammeter, but have both an indicating and recording wattmeter, together with an ammeter for field current. For the motors of the electric-driven exciters there are two banks of three delta-connected transformers on the slate platform in the basement. These step down to 460 volts and the motor panel of the switchboard contains the relay switches for cutting in and out the high-tension current of the transformers, the switches being the motor-operated oil-break type.

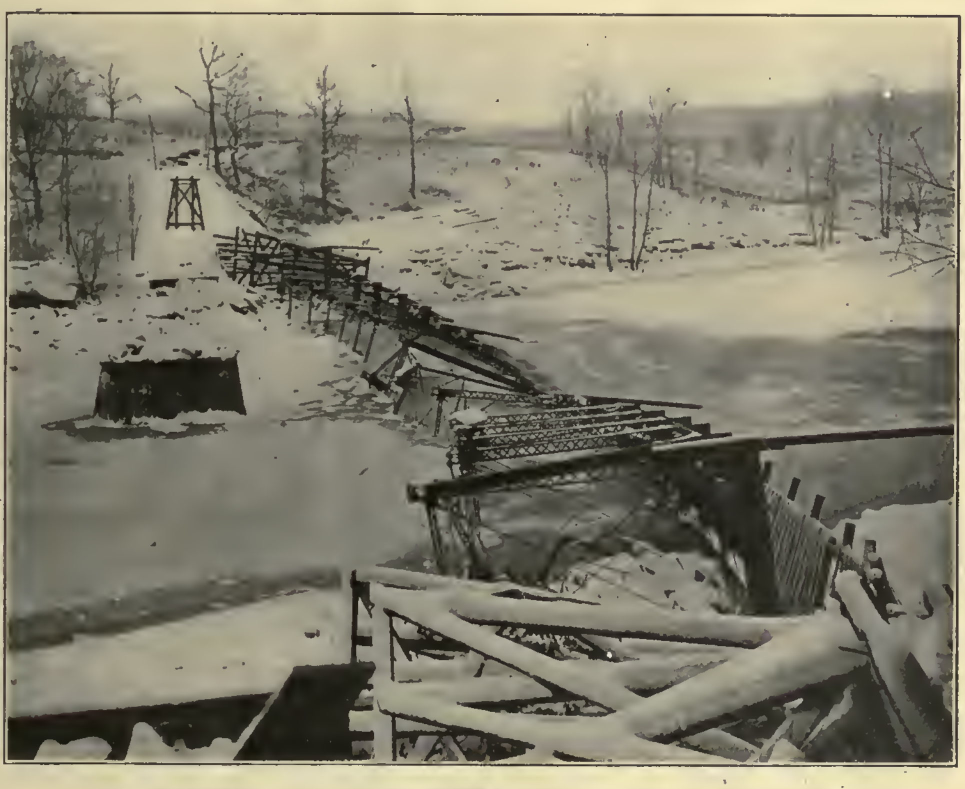
The direct-current board at present provides for 30 feeders in 15 panels. Each panel carries two ammeters for the two feeders, but only one circuit breaker. The generator panels have one switch on the switchboards in the negative side, and one circuit breaker in the negative side, while on a pedestal at each machine there is a positive switch and the equalizing switch. The total direct-current output is measured in a large recording wattmeter on a panel between generator and feeder panels, and this panel also carries a totalizing indicating ammeter. The positive feeders are 500,000 circular mils and the negative returns 1,000,000 circular mils. The switchboards are, generally speaking, equipped with standard General Electric instruments; they are of Vermont marble 2 inches thick, mounted on 3-inch longitudinal timber stringers. The switchboard structure is of steel framing with slate floors.

Operating Details.—The plant is equipped with an interesting oiling system, and is piped for compressed air throughout engine and boiler rooms. A large clock on the partition wall is set to strike a gong every twenty minutes, when the oilers are required to make a circuit of the engine room to ascertain the condition of all bearings, and once a day the machinery is cleaned by compressed air. For the latter there is a Westinghouse locomotive type compressor, automatically controlled to maintain 70 pounds pressure, and the system distributes from an air reservoir about 18 inches in diameter and 7 feet long. For signaling between operating engineer and switchboard attendant, the system in vogue on shipboard is in use, consisting of two dials, one in switchboard gallery and the other on the engine-room floor, these connected together with chains and actuating pointers to stop opposite various legends on the dials to which attention is drawn by the ringing of a gong. The system is patented by Messrs. Charles Cory & Sons, of New York.

The oiling system referred to comprises a duplicate set of storage, separating and filtering tanks, all located in an oil room in the basement of the extension or ell; a 15-barrel reservoir 35 or 40 feet above the engine room floor on the partition wall; two small Mason pumps for lifting the oil from the storage tanks to the reservoir; and a system of brass distributing piping. The separating tanks to which the oil is brought by gravity from the engines are 36 inches in diameter and 7½ feet high above the base. They are partly full of water and the oil is introduced at the bottom through a central pipe, and passes upward through the water and through a circular plate perforated with ⅛-inch holes for catching foreign matter. Near the top is the overflow for the separated oil, which flows to the filters. In these the oil falls on a flat conical plate or shedder, perforated with ¼-inch holes, from which the oil passes by gravity through alternate layers of woolen waste and charcoal. These layers of filtering material are held between brass wire screens, five layers of waste, each about 4 inches thick, and four layers of charcoal, each about 3 inches thick. This filtering material is enclosed in a 30-inch shell, in the bottom of which are ½-inch holes by which the filtered oil reaches the outer chamber of the filter and thence through an outflow pipe to the storage tanks to be used again. This is for the engine oil. For cylinder oil, a good-size vertical tank is located in the engine room, from which distribution to the cylinder oil pumps is to be effected by compressed air.

The station was designed by the Engineering Department of the Rhode Island Suburban Railway Co. The building was erected by Messrs. Horton & Hemenway, and the piping work by the General Fire Extinguisher Company, both of Providence. Plans for the station had been completed for horizontal units and a single floor of boilers when, in August, 1902, it was decided to double the capacity of the plant without an increase in ground area. The pile and concrete foundation work had fortunately been planned heavy and it was necessary only to redesign the superstructure. The steel was rolled and erected, the chimney was built, the brickwork completed and the four engines and the boiler plant installed in a year and four months.

A Trolley Bridge Wrecked by Ice.



Conestoga Creek Trolley Bridge Shoved off Its Piers by Ice in the Stream.

The new bridge of the Conestoga & York Furnace Electric Railroad across the Conestoga Creek, near Lancaster, Pa., was wrecked by ice January 23. The bridge was a light pin-connected through truss structure supported on masonry abutments and a center pier. It was lifted from its supports, carried clear of them and dropped into the river a short distance down-stream, as shown in the accompanying picture. It is reported that the pier sustained little damage and that the superstructure could be removed, straightened and re-erected at a comparatively small expense. A contract to re-construct the bridge within two months has been awarded to the Nelson & Buchanan Bridge Building Company, of Chambersburg, which were the original builders for the Tennis Construction Company, Philadelphia. The height of the substructure will be increased 6 feet above the original level so as to put the superstructure out of danger from future floods. Meantime the trolley company has no bridge at this point.

A Concrete and Steel Covered Reservoir for Hoylake and West Kirby Water Works, England.

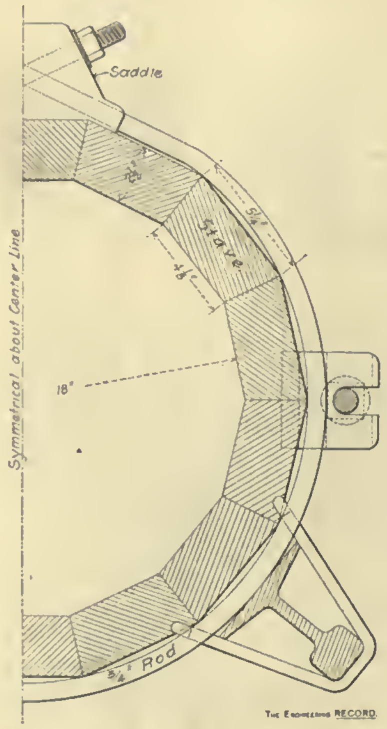
An interesting example of reservoir construction embodying some rather novel features is the new 3,000,000-gallon covered reservoir recently completed for the Hoylake and West Kirby Gas and Water Company. These towns are suburbs of Liverpool and obtain their supply of water from deep wells. The new reservoir has a roof of steel girders, steel and concrete beams and reinforced concrete slabs supported by steel columns, and was described by the engineer who designed and constructed it, Mr. Alfred J. Jenkins, A. M. Inst. C. E., in a paper before the winter meeting of the British Association of Waterworks Engineers. This reservoir is rectangular, almost wholly below the original ground level, and has a depth of 23¼ feet of water when full. The excavation was made in a porous but substantial sandstone in layers of various thickness, dipping at a sharp angle and considerably cross-jointed, some of which were soft, so that the trimming was not easy and the sides were consequently left very uneven in some places. There being no reason to anticipate inward thrust, watertightness was the principle requisite for the walls. Hence the rough rock surfaces were lined with concrete, which was finished to smooth faces and covered with patent bitumen sheeting attached by special ties, one to each square yard, set in the concrete. The sheets of bitumen were hung from top to bottom after the walls were built to their full height and joined by hot ironing, and the holes made by the ties were carefully closed. Inside of this waterproof course were placed 9 inches of brickwork reinforced by large brick pilasters, which also served as supports for the ends of the roof girders. The floor has a minimum thickness of 12 inches, consisting of 8 inches of concrete carefully screeded to a level bed for the bitumen sheeting, 3 inches of concrete above the sheeting and 1 inch of 1½:1 cement mortar trowelled to a perfectly smooth surface.

The type of covering described was adopted chiefly on account of its very considerable economy. The columns are single I-beams and the roof girders are deep I-beams. One-quarter of the number of cross-beams are also I-beams, spaced equally, web-connected to the girders. The intermediate cross-beams are steel channels reinforced with concrete. The bases for the columns are 3 feet 6 inches square, and are of six to one concrete. The bases are of varying height, to allow the columns to be of uniform length and yet permit the roof to be sloped from the middle in each direction. The roof is pyramidal in form, the center being 1 foot higher than the edges, to facilitate drainage. The columns, girders and arched channel ribs are steel, and after being painted were all completely encased in concrete and cement-rendering. The method of enclosing the columns was to surround them, after erection, with expanded metal, and to fill in the spaces between the flanges with fine concrete; the whole of the column was then rendered with cement plaster, for which the netting afforded an excellent key. This rendering was put on in two coats, and gave the finished columns a very neat appearance.

In the cases of the girders and ribs the lower flanges were covered with netting, and the wood centering for the roof so arranged that the remainder of the girder or rib would be completely encased in concrete. After removal of the centering the exposed netting was rendered.

The roof itself consists of one continuous slab of concrete, 5 inches thick, in the underside of which are built sheets of expanded steel of 3-inch mesh, of which the strands have a section of 5/16 by ⅛ inch. The roof is divided up into bays, which measure 16 feet 6 inches by 7 feet 6 inches from center to center of supports. The clear span is slightly under 7 feet, and the slab is calculated to support an evenly distributed load of about 350 pounds per square foot with a factor of safety of 4. It will be understood that with such a thin slab of concrete only the very best materials could be allowed. In this instance one part of cement was used to four of aggregate. The ingredients were mixed twice dry and twice wet, with not too much water. The centering was first covered with oiled paper, and the expanded metal laid upon this with the necessary laps. The concrete was well trodden and spaded down, with the result that the expanded steel was forced slightly up and remained embedded in the bottom ½ inch of the slab, where it was effectually sealed and protected from oxidation.

Instead of using rolled beams throughout, three-fourths of the secondary beams are of concrete built upon cambered steel channels. Whereas in the case of the slab, steel is, as a matter of economy, brought to the assistance of the concrete, so, in the beams, concrete is brought to the assistance of the steelwork in that portion of the beam which is in compression. The concrete in these ribs was gauged three to one; the channels had to be bent to the correct curve, having not less than 1 inch of rise to each foot of span, and the ends were carefully cut to fit the girders upon which they rested. It was also necessary that before any weight was put upon them they should be well strutted from below, and that the strutting should not be removed until the concrete was thoroughly set.



Section of Wood-Stave Outfall Sewer.

Upon the completion of the concrete the roof was covered with bitumen and 18 inches of earth. The outlet pipe from the reservoir is 18 inches in diameter, and upon it is fixed a Venturi meter with a throat ratio of one to twelve, which will record a minimum flow of 9,000 gallons per hour and a maximum of 130,000 gallons per hour. These figures were adopted in order to provide for a greatly increased consumption in the near future, and also to permit of the registration of small flows.

A Small Wood-Stave Outfall Sewer at New London.

About three miles from the center of New London, Conn., on the shore of Long Island Sound and within the city limits, is a small summer resort and park known as Ocean Beach Park, which during three or four months has a population, including excursionists, of about 1,200, crowded upon an area of four or five acres. Up to the present time this resort has been without sewerage facilities and only shallow cesspools used. The healthfulness of the locality being threatened by these conditions, relief was undertaken by the Board of Sewer Commissioners in accordance with a scheme presented by the engineer of the department, Mr. W. H. Richards, in December, 1902.

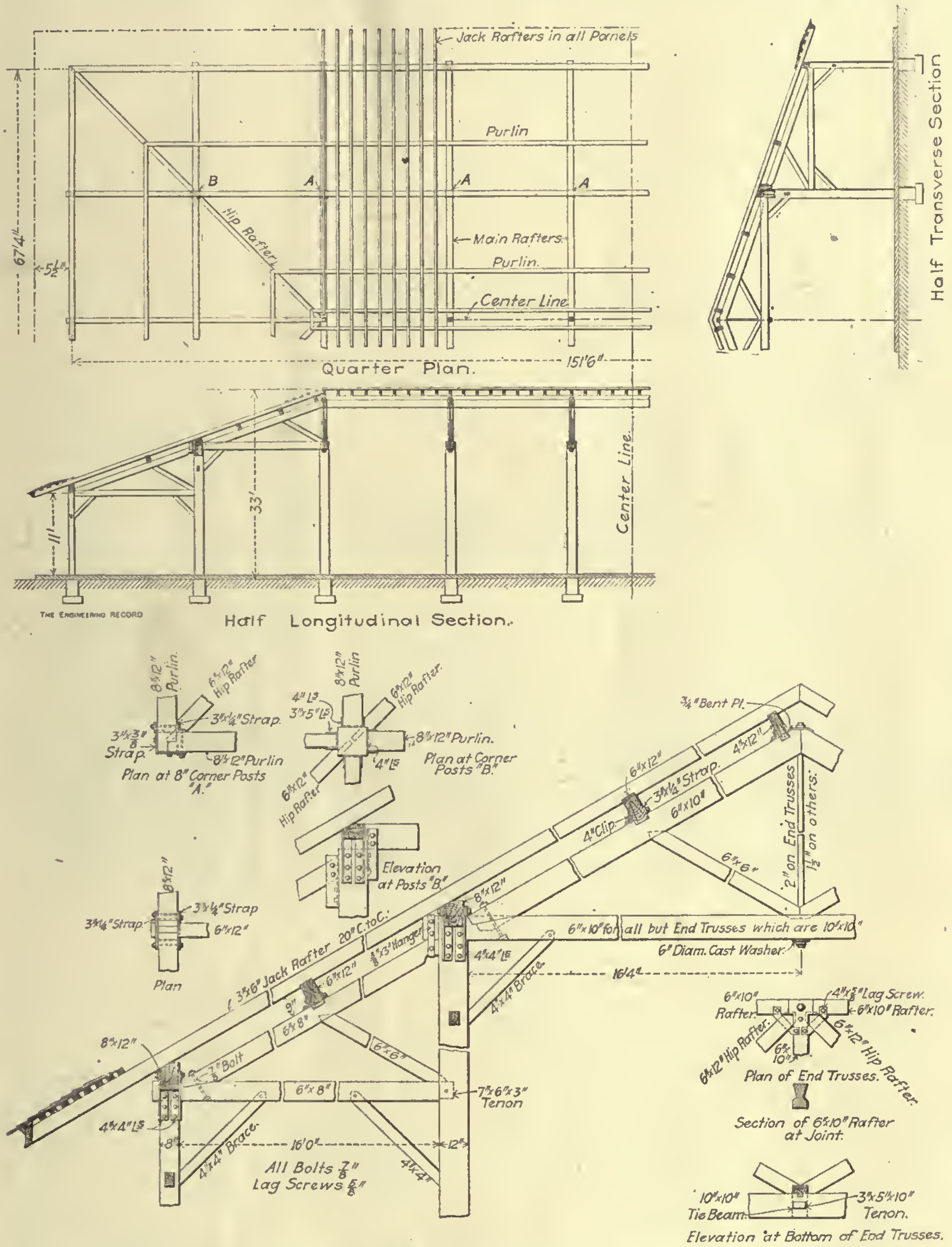
The area in greatest need, and for which sewerage has been provided, is a strip of sand bluff about 1,800 feet long, closely built upon, parts of which are less than 2 feet above high tide; but an additional low-lying tract of 9½ acres, which may soon be built up, must also be drained into these sewers. It was determined to discharge the sewage by gravity into the Sound without treatment, as the expense of a disposal plant or a pumping station could not be borne. Of course, the discharge end of the outfall had to be so placed that the sewage would not give offense to the residents nor the bathers on the beach, and it was necessary to put the main sewer at a sufficient depth to insure its draining all the low-lying territory tributary to it.

Two lines for the outfall sewer were examined, radiating from a point at one extremity of the beach, at the mouth of Alewife Cove, and the one deflecting most from the beach was chosen. The outlet was located about 900 feet from shore, 9 feet below high tide, between two rocky islets, where the bottom of the Sound drops suddenly and the water becomes 12 feet deep. Numerous experiments with floats were made under a variety of conditions of wind and tide, but none of the floats came back upon the beach, although their movements seemed to indicate that the surface currents changed with every combination of wind and tide; the general trend of the undercurrent, however, is offshore. The floats used were quart bottles loaded with sand so as to be wholly submerged, tightly corked and carrying a numbered tin tag attached to a wire inserted in the cork.

It will be perceived that the main sewers will be flooded a portion of the time and must be flushed at frequent intervals, to accomplish which a large flush tank arranged to discharge at low tide is to be located near the upper end of the main sewer. The outfall portion of the sewer is 18 inches in inside diameter and extends in a straight line 1,013 feet from a catchbasin on the shore to the outlet and beneath the water it is covered with from 1 to 4 feet of sand. The cross-section of this sewer is shown in an accompanying drawing. It is made up of fourteen beveled hard-pine staves 2½ inches thick bound with ¾-inch round steel hoops, the ends of which pass through cast-iron saddle blocks on top of the sewer, as shown. The portion of the outfall under water was weighted and reinforced by two old steel rails attached to the sewer as shown. In addition to these, the sewer was bound together longitudinally by 1-inch bolts placed at the extremities of the horizontal diameter through cast-iron lugs, as indicated. The catchbasin mentioned is very small, sufficient only to intercept such stones or sand as may get into the sewers. From the catchbasin the main sewer rises on a grade of 1 in 1,000 for a distance of 1,600 feet. This portion is a pipe 10 inches in diameter, the smallest possible size being selected in order to insure its thorough flushing on the light grade. Whenever higher additional territory is drained a larger pipe laid at less depth will have to be added.

As the entire sewer will be submerged at mean high tide and as at the point where it passes through the catchbasin it is 2½ feet below high tide, it will be entirely emptied only at low water, twice in 24 hours. The work was begun in May, 1903, and is now about completed.

Details of the Large Timber Roof of a Public Shelter in Van Cortlandt Park, New York.



Timber Roof Framing and Main Truss in Public Shelter, Van Cortlandt Park, New York City.

A public shelter in Van Cortlandt Park, New York, which was built for military and other purposes, is a large building that consists substantially of a roof and floor and is open on all sides from the ground to the eaves. It has a total height of about 33 feet and covers an area about 85x162 feet. The double-pitched roof with hipped ends is supported on columns at a height of about 10 feet from the eaves to the ground. There are no wall timbers or beams between the columns, except those which form part of the roof, and the structure is not plastered or ceiled. The roof is pierced with eight dormer windows, one at each end and one in each alternate panel of the long sides, provided with louvres so as to afford ventilation for the space under the peak of the roof. Considerable care was taken to secure a neat and attractive design, to provide simple details which should furnish efficient connection for the timber, and to secure a strong and durable roof.

The columns are 16 feet 10 inches apart in four longitudinal rows which are 16 feet 10 inches and 33 feet 8 inches from the center line of the building. At the ends of the building there are additional columns on the center line, making in all four transverse rows of five columns each. The exterior columns are 8 inches square and 11 feet high. The interior ones are 12 inches square and 21 feet high. All of them have kneebraces at the top and the interior ones have additional kneebraces to the lower horizontal roof timbers. The lower ends of the columns are cut square and are seated on the bluestone caps of masonry piers, through the centers of which there are vertical 1⅛-inch anchor bolts. These bolts have riveted heads engaging horizontal washer plates built into the masonry at the lower end, and nuts engaging shouldered bearings 12 inches from the end of the column, which is bored on the center line to receive the bolts. The pairs of inner columns are connected by transverse trusses, as shown in the cross-sectional elevation, and the outer columns in the same planes are connected to the inner columns by side trusses. The trusses and columns form bents which are braced longitudinally by the purlins and by kneebraces between the purlins and columns.

The regular trusses are omitted in the last two bents at each end of the building, where the roof is carried by diagonal hip rafters supported by inclined struts at their middle points, as indicated in the longitudinal diagram. Four lines of 8x12-inch longitudinal timbers are carried on the tops of the columns and these, together with a double line of 4x12-inch purlins at the ridge and four intermediate lines of 6x12-inch purlins, support the 3x6-inch rafters, which are 20 inches apart on centers and are made in single lengths from the ridge to the eaves. They have a pitch of about 1:2 and support 2x1-inch longitudinal strips 5 inches apart covered with 18-inch sawed cedar shingles laid 5 inches to the weather. The joints in the trusses and at the ends of the kneebraces are made with mortise and tenon, and the former are reinforced by steel bolts and connection plates, as shown in the details. Short vertical angles are bolted to the tops of the columns and project above them to form jaws in which the longitudinal timbers are bolted.

The bottom chords of the middle trusses project beyond the tops of their supporting columns and carry U-shaped hangers of flat steel which support the shouldered ends of the rafters in the side trusses. At the ends of the ridge the tops of the hip rafters are carried in special steel hangers attached to the top chords of the main trusses and to the longitudinal half truss which intersects them there. At the top of the inside corner post B, there are pairs of vertical connection angles on each side which receive the longitudinal and transverse horizontal timbers, and at the outside corner post C, there is a horizontal bent tie-plate connecting the purlins to the post and to an inside vertical corner angle. The purlins are dapped 2 inches over the top chords of the roof trusses and take bearing against angle clips bolted to the latter. The rafters are dapped 1 inch over the inclined tops of the purlins and have flush bearings on the beveled corners of the longitudinal timbers in the planes of the columns.

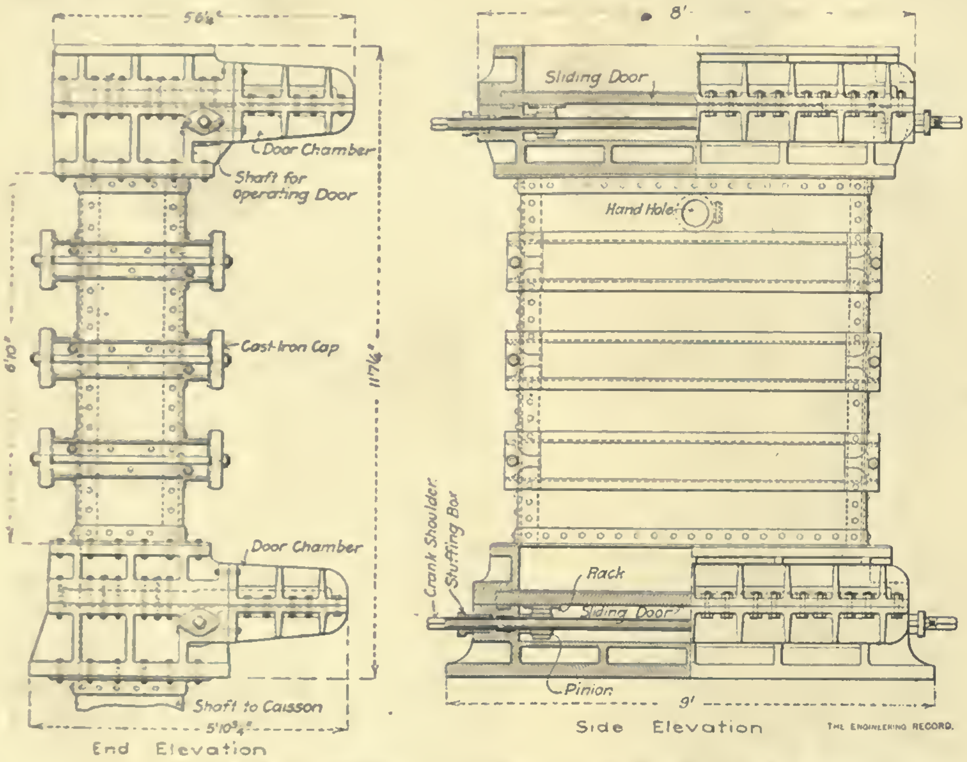
All the woodwork is of the best selected Georgia pine painted three coats of white lead and oil, which was also applied to the steel after the latter had been thoroughly cleaned with acid and sand-paper. The shelter has a monolithic floor with the surface slightly pitched from the center line and raised about 6 inches from grade at the outer edges where it is finished with bluestone curb 12 inches wide and 8 inches deep. The floor consists of 9 inches of concrete made with 2-inch broken stone and filled in with 4 inches of concrete made 1:4:20 with lime, sand and gravel well rolled to a smooth hard surface.

Messrs. Howard and Caldwell were the architects, and Mr. A. R. McKim, M. Am. Soc. C. E., was the consulting engineer.

THE IRON INDUSTRY IN RUSSIA seems to be on the decline, according to a recent consular report. Iron goods of foreign manufacture are handicapped by a heavy duty, but notwithstanding this the total output of cast-iron is decreasing. In 1899 it amounted to 2,632,190 tons; in 1902, to 2,520,916 tons. The Government is the principal consumer. There is reported to be an abundance of superior iron ores in the country, and labor is nowhere cheaper.

Special Pneumatic Lock for the Harlem River Tunnel.

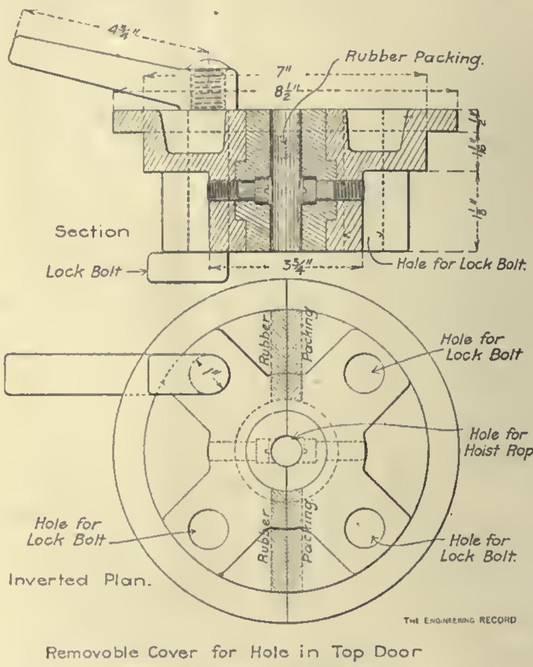
The double-track subway of the New York Rapid Transit Railroad across the Harlem River consists of a pair of 15-foot cast-iron tubes embedded in concrete, as described and illustrated in The Engineering Record of September 5, 1903. The cast-iron shell is in sections about 6 feet square bolted together through inside flanges on all sides. In the west half of the tunnel these sections were assembled under pneumatic pressure inside a special timber caisson, illustrated in the article mentioned. The large sections of the lining were heavy and somewhat awkward to handle through ordinary air locks, therefore a special material lock was constructed. This lock was unusual in its dimensions, of wide and comparatively narrow proportions, for the special type of doors and operating mechanism, for the combination of cast-iron and steel, for the reinforcement of the long flat sides against unbalanced pressures and for the movable disc which permitted the hook of the hoisting tackle to pass in and out of the lock without opening the upper door.



End Elevation

Side Elevation

The Engineering Record.



The Engineering Record

Removable Cover for Hole in Top Door

Details of Pneumatic Lock Used in Constructing the Harlem River Tunnel of the New York Rapid Transit Railroad.

The general appearance and dimensions of the lock are shown in the side and end elevations herewith. It consists essentially of three chambers. The center chamber is of steel plates riveted to inside vertical corner angles and is reinforced by outside yokes. The top and bottom chambers are similar and are each made of four castings flange-bolted together and fitted with horizontally sliding doors operated by racks and pinions commanded by exterior hand cranks.

These outside yokes are made with pairs of 6-inch channels 8 inches apart at the back, riveted horizontally across the wide sides of the chamber. Their ends project sufficiently to engage the flanges of single 8-inch channels riveted across the narrow sides of the chamber. Cast-iron bearing plates are seated on the ends of the 6-inch channels and receive tension rods which, together with those at right angles to them through the ends of the 12-inch channels, are screwed up to considerable initial tension, thus providing very stiff and solid reinforcement in both directions.

The upper and lower chambers have top and bottom pieces which cover the central chamber and are separated by horizontal joints. These pieces are extended on one side beyond the central chamber by the addition of end sections which receive the sliding doors when open. The horizontal flanges of the joints between the top and bottom castings of each chamber are planed to receive the solid rectangular cast-iron doors 3 inches thick, which slide on bearing strips set in the lower castings. The doors are planed to a close fit so that there is little or no leakage around them, and to the lower side of each there is attached a rack extending from end to end. These racks engage pinions on horizontal shafts passing through stuffing boxes in the lower castings of each chamber. The shaft projects sufficiently outside of the chamber to receive the movable cranks at both ends.

In the center of the upper door there is a hole 7 inches in diameter bored to fit a flanged cast-iron plug made in two equal parts with a diametrical joint having rubber gaskets on both sides. The plug is bored through the center to receive a brass bushing tightly fitted to the hoist rope. Each half of the plug is provided with two carefully-fitted hook bolts having lever handles on the upper side. These bolts serve as buttons, lock the plug in position and are easily opened by a quick twist so as to allow the halves of the plug to be separated and removed so as to permit the hook to be lowered through the lock door without opening the latter.

The lock was designed and manufactured by the Cockburn Barrow & Machine Company, Jersey City, Mr. William McIlvrid, general manager, for Messrs. McMullen & McBean, contractors for the Harlem crossing.

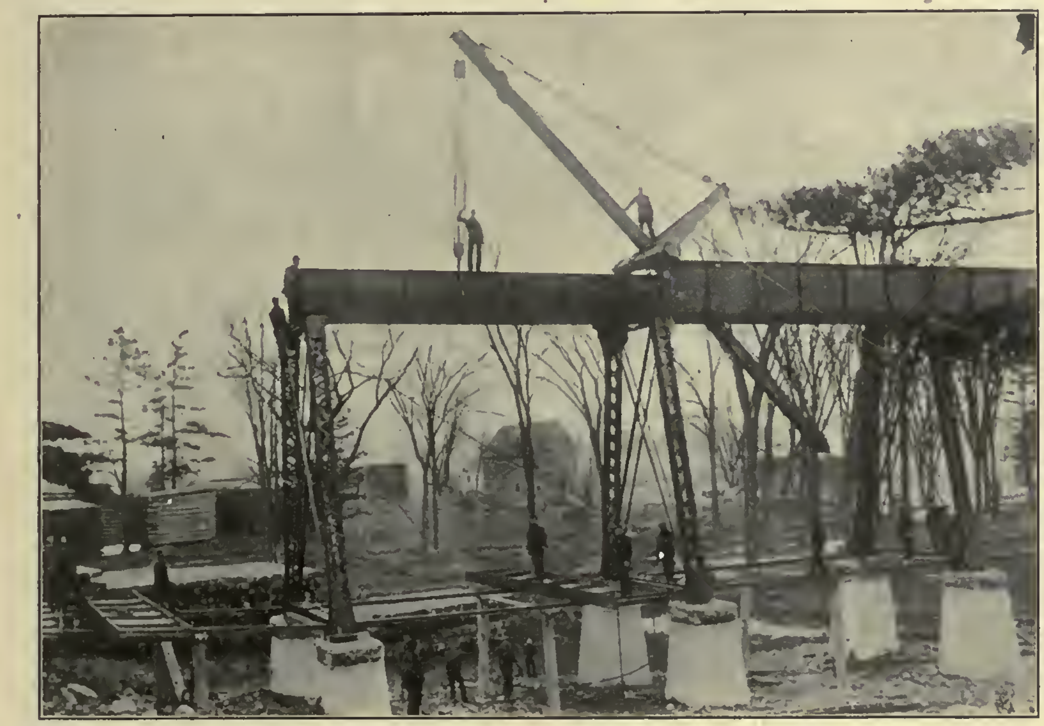
The Effect of Low Temperature on Iron has recently been investigated by Professor Dewar and Mr. Hadfield, using a bar containing 99.89 per cent. of iron, which is practically pure. Tests at ordinary temperatures showed a tensile strength of 21 tons and an elongation of 25 per cent. in 2 inches. At a temperature of — 180 degrees Cent. the tensile strength was increased to 54 tons but the elongation was nil. The part of the bar that had been subjected to extremely low temperature bent double cold after it had returned to the normal temperature.

A Simple Traveler for Erecting a Viaduct.

The main approach of the Interprovincial bridge across the Ottawa River at Nepean Point, between the cities of Ottawa and Hull, contains a number of 30-foot plate-girder single-track deck spans supported on steel transverse bents. Some of these were erected by an overhead four-wheel platform traveler running on the permanent track and having a projecting boom, as described in The Engineering Record of December 14, 1901. The remainder were erected by a very simple and convenient form of trussed balance-beam which proved rapid and efficient in its operation. This consisted, as shown in the accompanying illustrations, of a single 12x12-inch timber about 50 feet long with a horizontal transverse cross-piece 10 or 12 feet long at the center. It was trussed by a short timber post at right angles, to and in the plane of, the transverse piece, and by a pair of light Manila tackles leading from the top of the king post to the ends of the beam and set up to develop positive initial stress. The top of the king post was kneebraced to the ends of the transverse timber and the beam was slid along on the top flange of the girders. The ends of the transverse piece were anchored by small tackles to the tops of the columns and the rear end of the beam was lashed to the completed structure.

When the beam was in a horizontal position, the forward end overhung the center of the next column bent, and being longer and heavier than the rear end, remained in stable equilibrium when unloaded. A six-part tackle was suspended from it and raised and set the transverse bent, which had previously been completely assembled on the surface of the ground. After the bent was guyed in place, the hoisting tackle was released, the anchor tackles at the ends of the transverse beam were slacked a little, and the rear end of the beam was pulled down by tag lines until the beam assumed an inclined position with the upper end approximately over the center of the incompleted viaduct panel. The tag lines were then made fast to the feet of the columns and the main girders were successively hoisted and fleeted to position by hand. Afterwards the cross-frames were put in position, erection bolts were fitted and the balance-beam moved forward another panel in a very short time. This method required no additional expense for constructing the traveler, which was built with the tackles ordinarily used by the erectors and timber borrowed from the falsework. It was light and easily handled, was operated by a hoisting engine, stationary on the ground, and was considered very satisfactory.

Mr. Guy C. Dunn was the acting chief engineer of the Ottawa & Gatineau Railway Company, for whom the bridge was built by the Dominion Bridge Company, Montreal; Mr. Phelps Johnson, manager, and Mr. C. H. Duggan, chief engineer. Mr. H. D. Bush was engineer in charge of erection, and Mr. James Finley was the foreman of erection, who devised and operated the traveler.



Second Position of Traveler in Erecting a Plate-Girder Viaduct near Ottawa.

Massachusetts Institute of Technology Tape Apparatus.

Through several seasons of experimentation and experience at the summer schools of the Massachusetts Institute of Technology means and methods for rapid and very accurate measurement of base lines by the use of steel tapes have been developed successfully. Although this apparatus has been known for some time it seems not to have been adopted for this class of work to the extent it deserves. The apparatus includes an automatic stretching device which makes easy the securing of a uniform tension, the value of which can be determined to a fraction of an ounce, and a thermophone adapted to indicate the expansion of the tape by means of its electrical resistance changes. The following description of tests and comments on them are taken from papers by Prof. Alfred E. Burton and Mr. John F. Hayford published in "Technology Quarterly" volume 14. The thermophone as perfected by some of the students reads directly the mean temperature of the tape to a tenth of a degree Fahrenheit. In 1900, the apparatus was given a test by the United States Coast and Geodetic Survey, in which many of the minor appliances used to further increase the accuracy of the measurements were omitted as needlessly increasing the refinement and thus decreasing the speed of the work. The measurements at the summer school, however, have always shown a smaller probable error than was brought out by the test.

The object of these tests of the Massachusetts Institute of Technology tape apparatus was to determine its adaptability to the measurement of primary bases by the Coast and Geodetic Survey. In considering these tests it should be kept clearly in mind that results of the extremely high degree of accuracy which are stated to have been obtained with this apparatus are unnecessary in connection with primary triangulation. The base measurement is ordinarily the strongest part of the work, and very little accuracy is gained by reducing the probable error of a base further after a probable error of one part in 500,000 has been obtained. In making the tests it was continually kept in mind that what was wanted was a method of measurement which should be as rapid as possible while securing a probable error not exceeding one part in 500,000.

The tests made at Washington consisted of repeated readings on a single tape length between fixed points, the tape being supported at intervals of 25 meters on nails or a wooden arm. One end of the tape was fixed rigidly, and the readings taken at the other end. No glass rollers were used to relieve the friction at the reading end. The conditions differed from those ordinarily encountered in the measurements by students at the Massachusetts Institute of Technology, in that the support interval was changed from 10 to 25 meters; that there was considerably more friction at the fixed nails or other supports than with the swinging hook supports ordinarily used; and that a little extra friction was encountered at the reading end. The conditions as stated were similar to those which are allowed to exist with the 50- and 100-meter tapes actually in use during the season in the Coast and Geodetic Survey base measurement, and it was believed that the desired accuracy, namely, a probable error of one part in a half million, could be obtained under these conditions. On each day the temperature conditions varied greatly, part of the measurements being made in bright sunlight, a part with one portion of the tape in sunlight and another in shade, other measurements being made during daylight but with the sun under a cloud, and the latest measurements on each day being considerably after sunset. The measurements all being reduced to a fixed temperature, using the known coefficient of expansion of the tape, showed a total range of 2.3 millimeters on the first day, and 2.6 millimeters on the second. On taking the sums of the measurements in successive groups of ten, corresponding to measurements of 1 kilometer each, the total range was 8 millimeters on the first day, and 7 millimeters on the second. These ranges are no greater than are obtained in the regular base work of the Survey which serves to give a probable error of one part in a million or less on each base, and therefore indicate that even under these conditions the tape gave sufficiently accurate results for the required purpose.

On December 17 a section of the Alice Base Line nominally ½ kilometer long was measured six times, two or more readings of the tape and thermophone being taken in each position. During these measurements instrument tripods, modified slightly to adapt them to the purpose, were used as marking points for the ends of the tape, and the middle point of the tape was supported on one of the tripods ordinarily used with the base bars. The tape, therefore, hung in two catenaries, each 50 meters long. At the middle support the tape rested across a heavy metallic roller which ordinarily supports one end of a base bar. This roller served to relieve the friction to a small extent, but was, doubtless, less effective for that purpose than the swinging hook. The tension was applied with the Massachusetts Institute of Technology tension apparatus, and was 7.38 kilograms. The residuals from the mean of the six measures were + 2.40 millimeters, — 3.12 millimeters, — .82 millimeter, + .37 millimeter, — .64 millimeter, + 1.84 millimeters. During the first two measurements no friction rollers were used at the reading end of the tape. During the remaining four measurements a small roller was used for that purpose, and the residuals show clearly the increased accuracy gained thereby.

A study of the results, and especially of the readings taken in quick succession with the tape in a given position, indicates that while with the 50-meter interval between supports the required degree of accuracy could probably be obtained during perfectly still weather, the effect of the wind upon the apparent length of the tape is so great that under ordinary conditions this interval is too great for safety. The total time required to make these six measurements of the half-kilometer section was 250 minutes, or 83 minutes per kilometer, in spite of various delays due in part to inexperience with this apparatus, and in part to defects in the apparatus itself which may easily be remedied.

The results of these studies can be most conveniently stated in a readable form as an opinion upon the apparatus as a whole. The three principal advantages of the thermophone method of determining the temperature of the tape are:

1. That the thermophone gives a determination of the actual temperature of the tape, regardless of whether the heat reaches the tape in the radiant form or otherwise; whereas the ordinary mercurial thermometer receives at its bulb less radiant heat than a steel tape exposed under the same conditions, and, therefore, indicates too low a temperature when used in daylight. Attempts to get rid of this error by blackening the bulb of the thermometer or sheathing it with metal have proved unsuccessful, and it has, therefore, been absolutely necessary to use steel tapes at night only when results of a sufficient degree of accuracy for geodetic purposes were required.

2. The thermophone furnishes an instantaneous determination of the temperature of the tape, whereas the mercurial thermometer responds much more slowly to changes of temperature than the tape, and therefore gives indications which are considerably in error at

any instant whenever rapid and irregular fluctuations of temperature are in progress.

3. The thermophone furnishes a measurement of the actual mean temperature of the whole length of the tape, whereas with mercurial thermometers all that can be hoped for under the best possible conditions is a determination of the tape temperature at two, three, or more points at which thermometers are placed.

In regard to the Massachusetts Institute of Technology tape apparatus as a whole, the following statements may be made:

1. That with the thermophone apparatus in its present form, and using all refinements, measurements can be made, even in daylight and when the temperatures are varying rapidly, with a much higher degree of accuracy than is possible with tapes and mercurial thermometers even under good conditions at night.

2. That after the apparatus has been modified and strengthened at certain points with reference to making it proof against comparatively rough usage and capable of quicker manipulation, certain refinements being omitted, much more rapid measurements can be made with it than with any form of bars, and probably more rapid than with the present form of tape apparatus, if the tripod method rather than the stake method is used.

3. That it can be used efficiently with no more previous preparation of the ground than is necessary for bar measurement by substituting tripods for the marking stakes at the tape ends and for the intermediate supports.

If the Massachusetts Institute of Technology tape apparatus is used upon stakes, no time can be saved in the measurement, and the only thing that will be gained by substituting it for the tape apparatus in use in the Survey, using mercurial thermometers, is that the measurements may be made in daylight, instead of at night. If tripods are substituted for stakes, however, the only previous preparation of the ground other than clearing it, is a very rough preliminary measurement made with a tape dragged upon the ground, requiring, say, 45 minutes per kilometer for a party of three men; and this rough measurement is necessary even when bars are used. It is to the Massachusetts Institute of Technology tape apparatus used upon tripods or other temporary supports, rather than upon stakes, that one must look for gain in time over the tape methods in use in this Survey.

Letters to the Editor.

Municipal Water Softening Plants.

Sir:—I note with considerable interest the article in your issue of February 13 on "Municipal Water Softening Plants" and am thoroughly in accord with it, except that the advantages to be gained are hardly as strongly emphasized as they should be. While the desirability of soft water for practically all industrial and domestic purposes is, and always has been, readily acknowledged; and where hard water is the only supply available, the necessity of its use is bewailed by manufacturers and housewives alike; yet there has been a lamentable lack of appreciation of efforts to overcome these troubles.

It is now some seven or eight years since the first installation of a water softening plant (Clark process, used by all manufacturers) as a commercial product in this country, although in Europe there were previous to that date thousands of plants in operation. For the first five years the development of water softening as a business was one continual fight against skepticism and the flood of cheap makeshifts that had for years attracted the attention of engineers in one form or another with guarantees of results by impossible methods, a mere glance at which should have been sufficient to condemn them. Repeated failures apparently detracted not in the least from their attractiveness, provided only a new guarantee or change in name was forthcoming. One line of these, being so-called mechanical purifiers, the long established price of which (applied to industrial works), was on an average about $150 per boiler, had come to be accepted as a standard. On the other hand, the numberless nostrums or compounds, representing only an apparently small supply charge, while acknowledged as of doubtful value, were accepted as better than nothing.

This was the condition of affairs at the time of the writer's first connection with the business. It was not a question of selling an apparatus, but of demonstrating to a man the necessity, and successful operation of the apparatus, and that he would make a profit on his investment by purchasing; and a hard proposition this demonstration was in the start. To the engineer it was a combination of mechanical apparatus and compound; the plant taking considerable space and adding proportionately to his labors with no compensation. To the owner, a large apparatus costing several times as much as any other purifier he had investigated and not making any better guarantees, nor as good in many cases. It was a case of making the market and carrying it for some time, and many plants were installed on a contract to remove and replace all broken connections, in case of failure to give specified results; all rights practically being in the purchasers' hands. In the face of this engineers and even good chemists refused to commend, or even accept, for a long time, water softening as a commercial proposition. During the writer's connection with the water softening business he has been concerned in the selling and designing of probably one hundred and fifty plants, with an aggregate total capacity (daily) of fifteen or twenty million gallons of soft water.

You are wrong in your statement that the railroads have been pioneers in water softening in this country. There were in use in industrial plants millions of gallons daily before a single railroad plant was erected; in fact, it is only in the last three years that the railroads have to any extent taken the matter up and, even now, they are doing so very conservatively. The reason for this is rather unaccountable. Not long ago I was advised by a division engineer on one of our systems that, figuring on a reasonable basis, the saving in motive department on a certain division would pay the cost of establishing water softening plants on the entire division within a year. Yet this was over a year ago and no plants have been built there yet. However, the main thing is that it is now fully acknowledged by engineers, chemists, manufacturers, railroads and others that water softening is not only practicable but that it pays, which is more to the point; and if it pays to soften water for railroad and industrial purposes, so will it pay to do so for municipal purposes.

At this point I must again disagree with you on your assertion regarding consumption of soap. My observation and experience satisfies me that there is a very large difference in the quantity of soap used for domestic purposes by families using hard water and soft water—a difference that would nearly approximate the theoretical difference required. In the matter of soap saving, I have before me letters from two laundries using well waters, who after installation of softening plants show a saving of more than one-half of their soap. This not theoretical, but from bills for supplies extending over several months. In one case the cost of the plant was saved in soap in seven months. This in addition to more satisfactory work and saving in fabrics. Therefore, while the soap saving is undoubtedly large (and in the case of a municipality if only a dollar or two a year to a family, would amount to thousands), it is by no means the greatest item. The economy of a municipality furnishing softened water is divided, of course, between the domestic and industrial consumption, but is very large for either purpose. In domestic uses the saving would be percentage of soap, all compounds of soda, borax, etc.; repairs to hot water pipes, range backs and tanks; fuel, extra wear and tear on wearing apparel and household linens; more satisfactory results and less labor in laundry. In the industries the saving would be felt in almost every line: in the laundries soap, labor and material; in steam plants fuel, repairs, labor and increased life of boilers, hot water pipes and tanks; breweries, in making of beer; paper mills, dyeing and bleaching. Also in ice factories, tanneries, cotton and woolen mills, hotels, etc., it is so absolute that it is possible to figure an amount in dollars and cents, within a reasonable limit, that could be saved by softening the water; and I venture the assertion that there are very few investments that can be made by a municipality that will return as large or sure dividends to the community, individually and collectively, as the installation of a softening plant for a hard water supply.

Many cities are prevented from adding to their wealth and population by reason of their inability to offer manufacturers a suitable water for their purpose; the water supply, both quantity and quality, being one of the first considerations in locating a new industry. Nor is this all: a hard water, if secured from wells, may be free from disease producing bacteria, but it is far from an ideal water for constant use for drinking purposes, or even for bathing (besides being disagreeable to bathe in, the hair and skin become harsh and rough by its use). Taken internally continuously, it is a cause of rheumatism, calculus, stiffness of the joints, disorders of digestive organs and other ills of similar characer.

While it is possible that it will be some time yet before the hard water municipalities awaken to the advantages of softening water for general use, it is gratifying to note the increasing interest manifested in all quarters; and when a more thorough acquaintance with the process has dispelled the somewhat general idea that there is some mystery attached to it, we may look to see these plants as generally used for municipal purposes as sanitary filtration now; the construction and arrangement of a plant for this purpose being very similar to that of the sanitary plant, and the operation comparatively simpler—requiring rather more care and intelligence than technical knowledge.

There is now about completed a small plant for softening the supply of Oberlin, Ohio. This plant, while not ideal in arrangement, is the best that could be made under the circumstances; and the results at this, the initial plant in this country, will undoubtedly be interesting to other municipalities and will, at the proper time, be fully described and illustrated.

While the cost of softening water is not large, it is, of course, sufficient to make strongly advisable the reduction of waste to a minimum; and meters should be used entirely on a supply thus treated. This is, however, in any event, the only true and fair way of selling water; as besides returning to the works proper remuneration for supplies furnished, it means an average reduction to consumers of from twenty-five to fifty per cent. in their water bills—leaving to the few who feel the exertion of closing a faucet after use too laborious, the privilege of continuing their operations if they so desire, the only difference being that they pay the bill instead of their neighbors doing so.

Trusting that your opening of this subject may lead to further discussion and interest, I am,

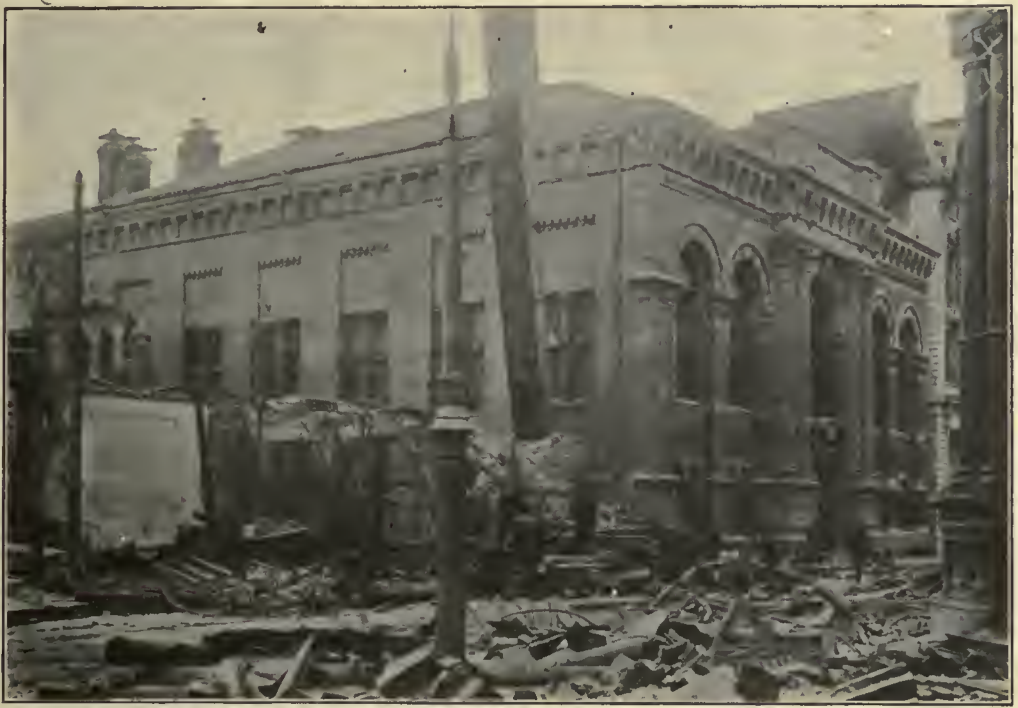
Yours very truly, F. B. Leopold.

New York, February 20.

Further Details of Fireproof Buildings in the Baltimore Fire.

Sir:—In your comment on the writer's article in your February 20 issue, you speak of including in the list of buildings that remained proof against the Baltimore fire, four others, as follows:

First—The Alex. Brown & Sons Bank Building, about 40x60 feet, one story high. This building had a street on the north and east sides and a solid fire wall on the west (windward) side. In the unprotected windows in the east side not a single pane of glass was broken. The fire entered through the rear windows, which had no shutters, and burned out the stationery and mailing departments and consumed the woodwork. The counters in the main banking room are of marble, and there was little in that room to burn. A prominent building firm advertises that it is now manufacturing materials for the restoration of this building. If the wind had been against its east windows there would have been nothing combustible left inside. This building was subjected to very little heat and did not remain proof against it. It was both small and lucky. A very small percentage of its cost would have paid for fireproof shutters.



Safe Deposit and Trust Company's Building, Baltimore, from Northwest, or Windward, Side.

Second—The Mercantile Trust Company's Building. Your picture on page 217 shows the shutters closed in all but one window on one-half of the south front. There was a row of square transom windows across the whole of the west (windward) front and a few on the south front. These small windows were unprotected and the glass was broken in them, giving the fire a chance to sweep through the building, in which practically everything combustible was burned. There was a skylight, in the roof of this building, broken by sash weights dropping from the burning windows of the Continental Trust building. The owners of the Mercantile Trust building say that the fire went down through the skylight. Even so, the draught across the building, through the broken transom windows, must have made the fire more intense. It is also more reasonable to suppose that the fire entered horizontally through these windows on the west side.

Third—The U. S. Warehouse No. 1. This building was sheltered by the new Customs House, directly northwest. It also had a street on the north and west sides. On the west side the paint on the brick walls is not even blistered or discolored. There seems to have been a rather hot fire on the east (leeward) side of this building, about half of the window panes on that side being broken and the outer wall blackened. Your article, page 207, states that fire entered this building through the monitor windows, damaging the building $2,000 and destroying $20,000 worth of contents. This building and the Mercantile Trust building seem to teach the lesson that all windows, no matter how small or hard to get at should have shutters.

Fourth—The new power house of the United Railways. This was certainly not much tested by fire. There is an open space 150 feet wide east and west of this building, the center and more than half the width of each space being waterway for coal boats and bay craft. The fire on the north side of this building was only from the wooden roof sheathing of the adjoining power house. The picture of the wrecked power house, on page 218, is taken from the east (leeward) side. The east wall was evidently pulled down by the roof trusses shown in the picture, still firmly anchored to the west wall of new power house. There was surely very little of an inflammable nature in the wrecked power house to test the one which escaped. It may be fair, however, to admit this building to our Class III., but certainly not the others.

Please note herewith a picture of the exterior of the Safe Deposit and Trust building taken from the northwest (windward) side and showing the outside of the windows on the north of the building, the same windows shown in the interior view on page 219. The building adjacent to these windows, separated by an 8-foot alley, was the "Sun" (daily newspaper) building. This building, all who saw it burn said, furnished one of the hottest fires witnessed. The printing presses were in the basement, the floor of this being 16 feet below the street level. In this basement was a great quantity of news paper. Now this building and contents, and the paper in the basement, burned with an intense heat, driven towards and rising up against the windows of the Safe Deposit and Trust building. It is difficult to conceive of a severer test against the shutters in these windows.

The interior view printed last week shows how slightly they warped. The bricks found on the roof of the Safe Deposit and Trust building counted 5,000 as they were thrown off. Observers who were high enough say the roof of this building, including the wire glass skylight, was covered with blazing coals. The wisdom of the owners of this building in making it really fireproof is more apparent when it is known what a moral effect the safety of this building had. Securities were received here until 10.30 Sunday night, or until within less than two hours of the time when the fire reached this building. The city and county money was deposited here and it is said that two-thirds of the vaulted wealth of Baltimore was in the vaults of this building during the fire. Several of the employes of the trust company begged to be allowed to stay in it, such was their faith in its fire-proofness.

The columns and other ornamental stone work in the front of this building are of blue stone, which is only slightly chipped from the heat. The ease with which granite spalls off under a comparatively slight heat is strikingly shown in the new Customs House. Immense damage was done to the granite in the lower portion of this building by the burning of the board fence, which the contractors had erected, on the curb line, entirely around the building. The wooden stiff leg derricks on top of the masonry, now about 50 feet high, are apparently uninjured, only one of them showing even a discoloration of the paint. If this massive granite wall had had the "Sun" building against it, think what its appearance would be as compared with the brick wall of the Safe Deposit and Trust building, shown in the photograph herewith.

One of the lessons of the fire, previously taught in other fires, is: Use nothing but brick in outer walls; also avoid square windows too small and round topped windows too difficult to be shuttered. Mr. George S. Morison gave a new and large meaning to an old and small word, the word tool. He called a great bridge a tool. A sixteen-story office building which permits its contents to be entirely consumed in thirty fiery minutes is a poor kind of a tool for the transaction of business.

Yours truly, H. D. Bush.

Baltimore, February 22.

The Union Engineering Building.

Sir:—Although it is probably too late to influence any of the voters in the matter of the new Union Building proposition, still, as my name has appeared attached to a circular opposing the proposition, I desire to say one further word explaining why it so appears. I wish to say emphatically that I have no sympathy with any discussion of the admission requirements of the various societies; they are all made up of men as able and as honorable as we believe ourselves to be. I have no sympathy with any questioning of the financial standing of any of the societies, because we all know that each is capable of taking care of its share of this matter, and, being accredited with a proper degree of honor, there should be no question of this kind.

But there are two points that seem to me to be of some consequence; one of very little importance, the outcome either way likely to be about the same; the second is vital. (1) There has been a great deal said about "Breadth," "The broad view," etc. Now if the proposition is to make one great Engineering Society of America with appropriate special chapters geographically arranged, I can see breadth, and shall be more than glad to be one in the movement; but what is there of breadth in becoming tenants in common with a number of allied societies? I am afraid that if there is anything in this, my own breadth of view is very limited. (2) The whole proposition is simply co-operative housekeeping, and co-operative housekeeping has never succeeded since the world began, and never will so long as men are cast in different moulds. And when it fails in this case, who is to suffer? Who but the only member of the co-operative establishment that has a home of its own in the beginning, which it gives up to join the crowd of which it is to be a minority.

These are some of my reasons for opposing this movement: I can see nothing broad, nothing ennobling to any of the professions, nothing for the American Society of Civil Engineers to gain, everything for it to lose.

The idea was the inspiration of a moment; it was born of a good purpose; but to me it seems like many other unconsidered impressions, unwise.

This matter is of such vital importance that if anyone wishes to change a vote already cast either way, he is warranted in using the telegraph.

Yours truly, WM. G. RAYMOND.
M. Am. Soc. C. E.

Troy, N. Y., February 23.

NATIONAL AID FOR GOOD ROADS.

Sir:—I have read with much interest the various contributions on the subject of highway improvements that have appeared in The Engineering Record from time to time, and feel that to have a periodical of such standing as The Record enlisted in this cause means much in attaining the object sought, namely, the elevation and refinement of the masses, and there is no more potent factor that could be employed than to provide means whereby the common classes of the rural districts can be brought in touch with the outside world, thereby giving them the ideas and progress of their fellow man.

Thus far I feel all are agreed and are ready to say Amen; but the great question that we have to confront is: How can this great object be attained, and what are the best means to employ? Shall it be a grand national affair, as is proposed in a measure by the Brownlow bill, or shall it be confined to States and localities? There can in my opinion be but one answer, which is: While the proposed bill is a grand one, and will no doubt do much, as it has already done, to enthuse and enliven the interest in the cause, yet when all is said, from fifteen years' observation and experience in this work, I feel that the success of the scheme must and will depend on the individual efforts of the boroughs or counties of the various States, and while any help received from the coffers of the public treasury of the general government will be received with outstretched hand, I am satisfied that soon the cry of equal rights to all and special privileges to none will be heard, and bickerings and contentions will begin which will break to fragments this grand scheme, and it will fall to pieces on account of its unwieldiness.

There is no more trite saying than this truism: "Nothing succeeds like success;" and this can be asserted without fear of contradiction so far at least as one county in North Carolina is concerned; for literally there is being constructed as magnificent a system of macadam roads in Mecklenburg County as can be found in any part of the Union. The work is being done without State or national aid, and principally by convict labor—and this, by the way, is the best solution of the problem as to what is best to be done with the convict. He is here in spite of himself, forced to build up the interests of his country, as well as meet the ends of justice, and being placed, as he is, directly under the supervision of the County authorities, he is not subject to the brutalities of the over-exacting contractor.

Having been the engineer in charge of the work for many years, I can assert, without a doubt, that ninety per cent. of the convicts leave the work in far better condition than when sentenced, because the enforced habits of diet, etc., lead to improvement. No doubt the question has already entered the minds of some: Is it practicable for other counties to do what the above named county has done, and what will it cost? The answer is in the affirmative: It costs but little more to provide for and work the criminal on the public roads than it does to keep him in the county jail. And under the judicious management of a few skilled men, as guards and foremen, the work will succeed, and you will have accomplished a task that has nothing of paternalism in it, and can feel the true spirit of the independent American that you are. It is no purpose of mine to antagonize the spirit that prompts this movement for better roads, but simply call attention to the fact that with a little well directed effort you can accomplish more than Congressman Brownlow will do, for judging from past history his scheme is not a new one, and in all probability will result as have the other schemes that have been set going by Congress in the past.

Yours truly, C. A. SPRATT.

Charlotte, N. C., January 25.

TESTS OF FIREPROOF BUILDING CONSTRUCTION.

Sir:—The problem of fireproof construction is one which concerns the interests of the engineering world in a large measure, and to-day it is brought into the foreground with great emphasis by the conflagration in Baltimore, where, according to the newspaper accounts, skyscrapers were destroyed by the flames like grass in a prairie fire. Under these circumstances it will surely be of great interest to the architectural and engineering world to know that a fire test will be conducted under the auspices of the University of Cincinnati to determine the relative value of ferro-concrete and fireproof steel-frame construction in the erection of large buildings.

The test will be made on two buildings, one of ferro-concrete to be erected by ferro-concrete contractors, and another of fireproof steel-frame construction to be erected by contractors using this method of construction. The fireproof steel and the ferro-concrete interests are each represented by a distinct committee. Each committee will make recommendations as to size, details and requirements of buildings to be tested. The advisory committee, consisting of two architects, Messrs. Harry Hake, chairman, and Harvey Hannaford, city building inspector, Mr. Charles Tooker, a representative of the National Board of Underwriters, and Professor C. W. Marx, of the University of Cincinnati, as expert engineer, will pass upon these various details and prescribe the size, requirements and other details which each interest must comply with in the erection.

Cincinnati is the very center of the ferro-concrete interests, and it is the intention to make this test as exhaustive and conclusive as possible in order to determine the relative fire-resisting properties of both constructions. In order to have the test as impartial as possible the above committee was elected by the organization, and it was deemed best to have the university take charge of the matter. As a member of said committee I will be pleased to receive suggestions by letter from all persons interested in this effort to determine the relative values of these different types of fireproofing as to their resistance to fire and water.

Very truly yours, C. W. MARX.

Cincinnati, February 11.

MARIETTA BRIDGE ERECTION.

Sir:—I notice an error in your description of the Marietta long span highway bridge. In the second column of page 43, issue of January 9, 1904, the eleventh line from bottom should read: "Wooden struts were used during erection to form an anchorage to this pier laterally," instead of "were provided to brace the pier."

Yours truly, C. L. STROBEL,
Consulting Engineer.

Chicago, February 18.

WHAT IS THE PROPER CURVATURE OF A BUBBLE TUBE?

Sir:—In an ordinary leveling instrument, what should be the relation between the magnifying power of the telescope and the radius of the bubble tube? When the instrument is properly leveled and the cross-hairs focussed on some distinct and distant object, should it not be possible to displace the bubble a perceptible amount before any vertical movement of the cross-hairs can be detected? If not, the observer can never be sure that the line of collimation may not vary from the horizontal by an amount at least as great as his probable maximum error of observation so that any great care in sighting is likely to be wasted. Now the question is, how to ensure the proper conditions. For example, with a magnifying power of, say, thirty diameters, what should be the radius of the bubble tube? I have not been able to find the answer to this question in the catalogue of any instrument maker or in any work on surveying that I have consulted.

Very truly yours, D. O. TELL.

February 22, 1904.

SALT WATER FOR STREET SPRINKLING.

Sir:—The salt water mains, which it is now proposed to lay in Manhattan for fire protection, may also serve another good purpose, that of street sprinkling. Salt water is not only much cheaper, but more effective, as it has a tendency to cake the dust, while its hygroscopic qualities prevent it from drying so rapidly and hence prolong the benefit of each application. I have observed these effects in Cambridge, Mass., where the streets used to be, and perhaps are, sprinkled with salt water from the Charles River. The salt may also have some antiseptic and sanitary value and the surface of a street so sprinkled would not freeze as readily as if fresh water were used. Incidentally, the frequent use of the pumps, which sprinkling would require, would serve to keep them in constant readiness for fire purposes.

I must say, however, in behalf of horses, cyclists and automobilists, to whom wet asphalt is a very serious annoyance and often a positive danger, that asphalted streets should not be sprinkled at all. The money it costs to sprinkle them were far better expended in keeping them cleaner and so free from dust as to render sprinkling unnecessary.

Very truly yours, H. W. BRINCKERHOFF.

February 22, 1904.

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The Rejection of the Union Building Project by the American Society of Civil Engineers.

At the regular meeting of the American Society of Civil Engineers held March 2 the letter ballots on the acceptance of Mr. Carnegie's gift for a union building for the four national engineering societies and the Engineers' Club were opened. There were 1,801 votes entitled to be counted, and of these 1,139 were against and 662 for the project. The large number of affirmative votes were cast because of the feeling that the Society should do nothing to prevent the other organizations from receiving Mr. Carnegie's aid. Had the ballot been taken six months ago the number of negative votes would unquestionably have been much larger. Readers of The Engineering Record have had the facts of this matter, as it appears to the members of the American Society of Civil Engineers, set before them clearly from the inception of the union building project, although for some inexplicable reason no other journal has seen fit to ascertain the truth or to print it if learned.

This paper has consistently refrained from taking sides for or against the acceptance of the proposal by the American Society of Civil Engineers, for the excellent condition of that organization is proof of the ability of the members to manage their affairs with success. It has simply urged a careful consideration of the project before coming to a decision, a course which ordinary business prudence dictates with special force in connection with the affairs of such a cumbersome organization as a national society. For taking this position, The Engineering Record has received all sorts of slander in the columns of esteemed contemporaries which are so childish in this matter as to merit the sarcastic reproof of Job to some of his critics: "Surely ye be the people and wisdom shall die with you."

The lesson that this vote teaches is mainly to the technical press of the country. It is the absolute necessity of reporting facts on a subject of such importance and of recognizing fully the feelings of people to whom an argument is addressed before making an appeal to them. In the early state of this project the American Society of Civil Engineers was asked to subordinate itself in a considerable measure to a local social club and to accept a financial scheme which was entirely impracticable. When the members of the Society hesitated very naturally at such a course, they were told in the columns of various technical journals claiming to represent the members of other national engineering societies that it did not matter whether the civil engineers came into the project or not, for the others could get along without them. In all this unfortunate journalistic floundering there was little regard paid to the distinguished position of the American Society of Civil Engineers in this country and abroad, and its well-tried and successful methods of conducting important affairs were either overlooked or ridiculed. The Engineering Record has been the only technical paper in the country which has told the truth about the opinions held by the members of the Society, but instead of heeding its warnings its esteemed contemporaries adopted a course extremely prejudicial to the cause they claimed to be advocating.

The situation which faces the three younger societies can hardly be serious. They have great resources which have not yet been called upon, and even without Mr. Carnegie's aid are able to put up a joint home creditable to their high position among professional organizations. It would probably be better for them to put up a building without Mr. Carnegie's aid than with it, for the decision of the American Society of Civil Engineers has already added greatly to its standing in the eyes of men of affairs. Surely the other three national organizations are able to accomplish what one similar society has done. If the members of these societies care to accept a building from Mr. Carnegie it is certainly to be hoped he will give it to them; the fact that seems to be overlooked is the practicability of constructing an adequate home without any greater assistance from him than many other men formerly connected with mechanical, electrical and mining engineering will be glad to give. And in this connection The Engineering Record is confident that such a project would have the assistance of many members of the American Society of Civil Engineers who have been unwilling to see that organization do anything which, in their opinion, would cause it to lose any measure of its independence.

Engineers in Contracting Work.

Like all other matters related in any way to engineering, contracting has experienced a remarkable development in many directions during the past twenty years. In the early days of large public works in this country, as well as in such large corporate works as railroads and canals, the contractor was a man necessarily of strong character, of decision and resolution, but who seldom had received other preparation for his work than that which was acquired in actual construction from the contracting side. His part of the performance was eminently important, but it did not involve any technical knowledge of the materials dealt with nor of the principles of design, nor even of conditions requisite for the stability of the completed work. Indeed, even the chief engineers of the older works possessed what would now be regarded as an exceedingly small amount of exact knowledge of engineering science. The operations of design and computations for stability were reduced to about the smallest proportions compatible with any recognition of the fundamental principles of engineering knowledge, as it is now possessed by trained engineers. The business of the contractor was to make his excavations and fills, dispose of surplus or waste where necessary, secure his timber and stone or other materials as best he could without a degree of inspection which gave him any serious difficulty, and complete his contract as quickly as possible. It was not a complicated service to perform, although it involved difficulties that were sometimes exceedingly serious. Whatever else was required, however, the contractor was relieved from the possession of engineering qualifications, and, as a matter of fact, the designing and supervising engineer himself possessed no superfluity of such attainments.

With the growth of communities and the increasing demands of all kinds resulting from it, the performance of contracting work acquired a more diverse and complicated character. While it is, and was, always supposed that the plans and specifications of the chief engineer indicate with sufficient clearness and fullness the requirements of every case, it gradually became apparent that a more technical and adequate appreciation of plans and specifications was necessary even on the part of the contractor. Advancing knowledge as to the qualities of natural materials and the rapidly increasing demand for such manufactured materials as iron and steel required a corresponding increase of technical knowledge not only in the engineering organization of any great work, public or private, but also on the part of the contractor to secure with certainty and facility the desired results.

Even at the beginning of iron bridge building, a field perhaps in which these observations possess most marked significance, a knowledge of mill and shop operations involved so much of a technical nature and was so essential to the construction of satisfactory bridges and other structures, that contractors actually possessed more technical knowledge of the materials involved and methods to be employed than engineers themselves. In general, the great business of contracting in iron and steel has from the very first necessitated on the part of the contractor an amount of professional knowledge and skill rarely possessed by the designing and supervising engineer himself, and this observation has continued to gain force even to the present time until engineers have actually been obliged to go to contractors for much of the technical knowledge required for the best performance of their own work. The relative condition of structural steelwork in Great Britain and the United States clearly proves the good results of the general recognition of this fact by American engineers.

While there are fields of engineering construction which show somewhat less prominent features of this character than iron and steel bridge building, yet the general principles still hold if we pass to such lines of engineering work as great masonry constructions, modern canal works, engine building and the new developments in electric light and power. It is no exaggeration to state that in every such branch of engineering activity the actual advances in the production of materials as well as in their use, and the evolution of economic and rapid methods of construction have generally proceeded from the contracting side of the works. It has been of the utmost importance to contractors to reach with the highest degree of efficiency and economy in labor and materials the ends specified to be accomplished under their contracts, and therein lies the great stimulus for development in their portion of the work. On the other hand, it is equally true that with advances in engineering science and in the professional training of engineers, they have constantly pushed forward their requirements in design and construction just as rapidly as the material gains in mill, shop and field operations of the contractors have been realized, and sometimes even more so. It is obviously a perfectly rational process that the engineer and the contractor should be mutually stimulated to advance, each by the progress made by the other.

It is equally obvious that these increasing demands flowing from the constantly increasing excellence not only in the quality of all materials employed but also of all the processes necessary for the completion of a great engineering work, should induce the engineer gradually to become the contractor, or if it is preferred, should induce the contractor gradually to become also the skilled technical man, and that is precisely what has taken place at the present time. This result was probably found first in the fields of iron and steel construction for reasons that have already been set forth, but precisely the same evolutionary forces have been at work in other fields of engineering activity. Technical knowledge and professional skill have become absolutely essential, not only for the design of work and the elaboration of proper specifications and contracts but also for the production of materials and their proper handling in construction, until at the present time there is no better engineering talent or engineering experience found than that engaged in or connected with the great contracting firms of this country. This is just as true of excavation and construction in great railroad and canal works as in the more obscure and refined operations of the steel mill and the bridge shop, or in the building of ships and engines, or in the great modern electrical works. Probably no higher grade of engineering skill is required than in the development of proper machinery plant and methods of operation in such great works of excavation as that of the Chicago drainage canal and that which will be found in the construction of the Panama ship canal about to be built, or in the design and construction of a great public water supply system. The most refined mathematical, chemical and physical applications known in engineering work are those employed in the electrical and metallurgical operations of great industrial establishments like those at Schenectady and Pittsburg. Yet these are all contracting plants. They are possessed by contractors and are operated for contracting purposes. All such plants necessarily are the product of the highest type of engineering talent developed and trained by the best professional education attainable in the world at the present time.

The result of all this evolution in contracting has been the development of the eminent engineering contracting firms of the present time. The greatest public and private works ever known are constructed and installed by contracting engineers or engineer contractors whose professional attainments, business capacity, and constructive skill have certainly never been excelled even by the professional engineers who design and supervise the completed work. The natural result of this condition of things is not in the slightest degree a reflection upon the professional engineer, because the demand upon his skill and judgment is correspondingly great and constantly increasing, but it simply indicates that the actual construction of great engineering works requires the exercise of just about the same engineering qualities as their design and supervision.

The resulting relations between the contractor and the supervising engineer are necessarily on a higher plane than formerly; they become more nearly like those between professional men, or, at any rate they should become so. They can and ought to be mutually helpful. The time has gone by for either the contractor to attempt to "get the best" of the engineer, or for the latter to "catch" the contractor. The prospective profit of the contractor is no element in the engineer's care or thoroughness of inspection or in the discharge of any other professional duty. They are both engaged in a common purpose, although starting from different points, and their highest interests are best served by reasonable co-operation.

Water Purification at Pittsburg.

The purification of the Pittsburg water supply is so imperatively necessary that the report on the subject made last week by Col. A. M. Miller and Messrs. Rudolph Hering and John W. Hill ought to be followed by the speedy construction of the necessary works. These three engineers were retained to report on the character and size of the plant required to supply the entire city, and on the correctness of the estimates of cost of works prepared by the local officers. In a general way the report approves the designs and estimates of the Department of Public Works. These called for forty-five covered filters of an acre each, while the report states that forty will probably be ample, and there is a corresponding slight reduction in many other features of the plans. The report estimates the cost of the works at $6,750,000, while the Department's estimate was $7,150,000. The three consulting engineers state that the proposed size of works is based on a consumption of 200 and 250 gallons per capita, depending on the part of the city considered. The introduction of meters cannot be safely estimated to reduce these figures below 160 and 200 gallons respectively, the report states, because a material cause of the waste of water in the city is the leakage from street mains, which can be remedied but slowly. These figures all refer to a plant large enough for the requirements of the city in 1907, when it can be finished if construction is begun immediately. With waste curtailed, it may be adequate for the demands until 1918. What it will be desirable to do in the way of extending the works for the greater requirements of succeeding years can be best determined later, when the result of introducing meters has been ascertained and the experience with preliminary filtration at Philadelphia and elsewhere is sufficiently extensive to furnish accurate data as to its efficiency.

This subject of preliminary filtration was introduced at the meeting of the joint councilmanic committee called to receive the report as a sort of supplementary suggestion by Mr. Hill. In his opinion preliminary filtration at the Philadelphia plants under his charge was so successful that it might well be adopted in Pittsburg, thereby reducing the first cost of the works about $720,000, and the annual maintenance charges about $12,000. Colonel Miller and Mr. Hering strongly contradicted these statements, asserting that the Philadelphia roughing filters had not yet been tried with water at all difficult to purify and it would be running altogether too serious chances of failure to introduce them at Pittsburg before more complete information concerning them was obtained. The lack of success with such filters abroad was pointed out, and the majority of the commission emphatically protested against a definite adoption of them until the experience with them at Philadelphia had been sufficiently long to furnish definite data.

This is manifestly sound advice. The city of Philadelphia was forced to adopt preliminary filters or ask the people to authorize a very large sum for purification works in addition to that voted several years ago. A discussion of the causes of this state of affairs is not pertinent to the present subject. The roughing filters have been doing good work, but they have yet to prove their value with turbid water. Every engineer hopes the experiment will be successful and many are confident that such will be the case. If the test is successful it will introduce another valuable aid in water purification, but even if the results at Philadelphia are satisfactory, it by no means follows that the same system will be suitable for the Pittsburg water supply. The purifications works adapted for one water may be useless for another; the magnificent systems of London or Hamburg would fail completely at St. Louis or New Orleans.

The only safe course to be followed at Pittsburg is to build the filters on the plans of the Department of Public Works, as modified by the commission of experts who reported last week. In this way the city will be certain to obtain a plant which will furnish a good supply under proper management. These works will be only large enough to answer the demands for water for a few years after their completion. While they are being constructed the Philadelphia roughing filters will have had a good test, and, if successful, there will still be ample time to run thorough tests at Pittsburg to determine the applicability of such preliminary filtration to the water of that city. If such experimental filters prove successful, the slight additional cost of the roughing filters will be justified. If the preliminary filters were installed as a part of the permanent works at the outset and should prove unsuccessful, as may be the case, the city might as well be without filters altogether until works such as are now recommended are built. Pittsburg surely has sufficient resources to follow the first plan, and cease juggling with the lives of its citizens. It is only good fortune which keeps the city from experiencing on a terribly great scale the recent epidemics at Buffalo, Ithaca and Watertown.

Special Fire Protection Water-Works.

Although it is now a number of years since special systems of high-pressure street mains for fire protection purposes were first installed at Providence and Cleveland, the introduction of such systems elsewhere has been very slow. Perhaps one reason for this is to be found in the fact that the ideal water supply is one in which the street mains are large and a working pressure of 80 to 90 pounds per square inch is kept on them all the time. Such a system, with hydrants so placed that no line of hose need exceed 500 feet in length, gives to each hose line a value almost equal to that of an ordinary steam fire engine as commonly run. Since five to ten thousand feet of hose is not a particularly expensive reserve to maintain, with plenty of volunteers to man the lines in an emergency, a city so equipped has an asset for fire fighting vastly superior to the ability to telegraph for aid to neighboring cities. The experience of Fall River, Syracuse and other cities abundantly demonstrates that this high pressure on mains and plumbing does not cause the extra waste of water which might be expected from a superficial study. One of the most important features of the works recommended recently by the Commission on Additional Water Supply for New York is the magnificent pressure the proposed supply would furnish in all parts of the city. While this is the ideal method of supply, it by no means follows that the alternative plan of independent fire mains is less important. As a matter of fact such mains are possibly better under certain circumstances, and it is not surprising that Chicago, New York, Baltimore, Brooklyn and other large cities are now actively investigating their advantages and drawbacks.

On account of the importance of the subject, the earlier articles in The Engineering Record on the Philadelphia fire-protection water-works are supplemented elsewhere in this issue by a complete description of the pumping station. These works represent the highest type devised up to the present time. Their capacity is best shown by the fact that at one trial twelve standard fire streams of exceptional force were played from one street corner, a concentration of fire-fighting power worthy of careful consideration. The advantages of such special works are two-fold; they enable the nearest source of supply to be utilized, irrespective of the potable character of the water, and the mains can be made heavy enough to withstand a very heavy pressure. These two advantages generally render the works relatively inexpensive when compared with those for regular supply, but they introduce one element which was regarded for a time with much disfavor.

The method of supplying the mains with water was the feature of special fire-protection works which led to unfavorable comment. The gravity supply used in Providence is rarely possible. In other cities it is necessary to use either fire-boats plying along the water-front or construct pumping stations for this purpose alone. In the case of fire-boats, provision is made for connecting the boats to the mains at various places, but it takes considerable time to run a boat to the proper place and make the connection. This is specially true in winter, and in any case the delay occurs at the beginning of the fire when the water is most useful. Small stationary pumping plants have been looked upon with disfavor for several reasons. Their first cost is high, when measured by the time they are actually in service, and although this is an incorrect method of estimating their value, it is commonly followed. A steam plant is expensive in operation, for the fires must be kept up all the time. An electrically operated plant may be rendered inoperative through various injuries to the central power station and the lines. A gas engine plant has rarely been considered desirable on account of the feeling that the gas engine would prove unreliable. As a matter of fact, a pumping plant operated by electric motors or gas engines can be made reasonably safe in any city. It often happens that electric current can be obtained from two independent sources over underground lines, and it is difficult to see any reasonable objection to such a system of operation. It is equally possible in many cases to obtain gas from two holders, and here again reasonable safety is assured.

The Philadelphia plant has proved the practicability and reliability of the gas engine station. The seemingly complicated system of valves and connections in that plant is really very simple, and the actual operation of the plant every day shows that it will furnish ample water under heavy pressure just as soon as the firemen are ready to use it. The various manipulations needed to start the units of the plant are easily and quickly performed, a trained operating force ought to perform them without hesitation or confusion, and it is difficult to foresee any cause of failure. The large number of small units in the station makes it possible to repair any one of them without affecting the efficiency of the plant.

Attention is particularly called to the description of this station because of the very pronounced feeling in several cities that something of the sort should be provided in other danger districts than that of Philadelphia. Mr. George W. Jackson has recently reported in favor of a similar system on a much larger scale for Chicago, and it is interesting to notice that his plans call for a gas engine station. The water supply is to be drawn from one of the tunnels of the city water-works and not independently from the river or lake, although at a later date such an exclusive supply may become desirable. The river is considered unavailable on account of the sediment it contains, which it is feared would cut the cylinders and valves. The large main piping is to be laid in tunnels driven about 70 feet below the river surface, and connected with the 8-inch street pipes by vertical pipes in shafts. In such respects the project is unusual, which may be due to its author's experience in building the telephone subways in the city. Indeed the plan is so novel that considerable study of local conditions would be necessary to pass on its merits compared with other possible arrangements. The general details of the project, however, seem possible now that the Philadelphia plant has proved its effectiveness, and here again the marked educational value of that plant becomes evident. Its installation is a highly creditable piece of engineering on the part of the Bureau of Water and the designers of the machinery and the attention it is now receiving from the officials of many cities is not surprising in view of the facts given in the article elsewhere in this issue.

Notes and Comments.

The Grand Central Terminal Improvements in New York of the New York Central & Hudson River Railroad Company are not yet entirely determined in some respects, and for this reason the article elsewhere in this issue on the work actually in progress contains numerous statements which may require change to make them conform with the final plans for the yard and viaducts over it. This article is printed solely to make clear the methods of conducting work now being followed by the contractor, and it should be clearly understood that it does not present accurately the details of the proposed improvements.

The Effect of Fire in Buildings is sometimes greatly exaggerated by the peculiar construction of the parts reached by the flames. A good instance of this is afforded by the view of a corridor in the Continental Trust Building at Baltimore, printed on page 214 of The Engineering Record of February 20. The tile ceiling of this corridor appears in pretty bad shape, although the ceiling of adjoining rooms is in far better condition. An explanation of this fact is given by the George A. Fuller Company. The corridor was provided with a marble ceiling, and when it was put up the workmen were forced to chip the tile in many places to fasten the marble. This accounts for the appearance of the fireproofing in the corridor, which, it should be added, is in much worse condition than that elsewhere on that floor.

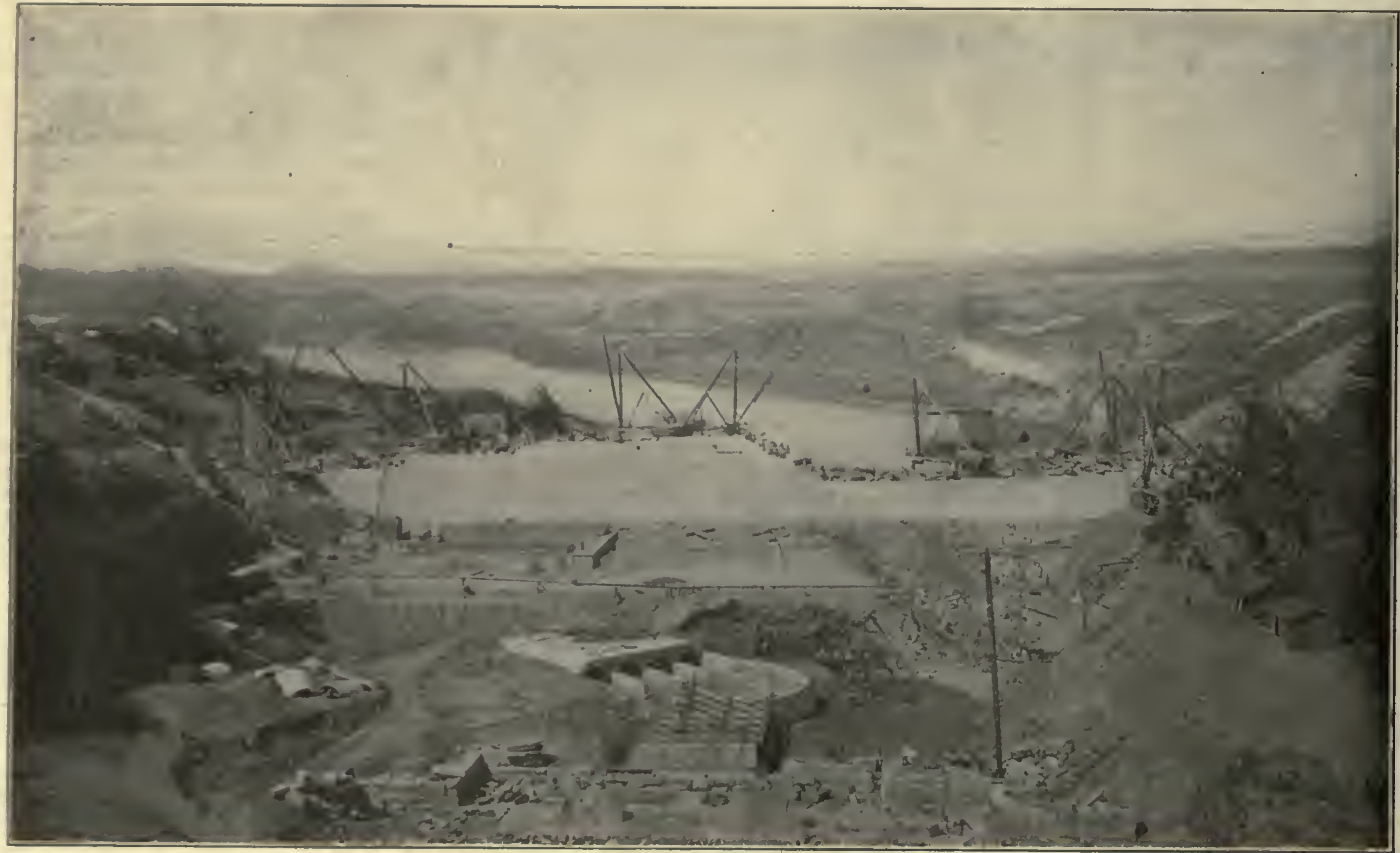
The Rochester Fire last week is mainly important for its duplication of the proof of the value of hollow tile fireproofing which was first thoroughly demonstrated at Baltimore. The Rochester fire was peculiar from the fact that a twelve-story fireproof building acted as a chimney for two others. One of these had been connected with it by removing the division wall between the two structures at the first floor, and the other was joined by a passageway below a narrow street separating the buildings. The other buildings in the neighborhood were ordinary structures, no better or worse than the usual mercantile stores. A fire started between 4 and 5 o'clock in the morning in one of them which speedily reached the structures connected with the high building, known as the Granite Building. The flames soon passed through the openings in its walls and burned out the offices in all the stories, with a few unexplained exceptions. The marble wainscoting in the building was destroyed but the tile and slate withstood the intense heat with trifling injury, completely protecting the cast-iron columns and steel beams. In one of the adjoining structures, where the floors were of brick turned between unprotected steel beams, the latter are warped, the brick fallen and the building a wreck, although it is questionable if the heat was any greater than in the Granite Building. One of the brick walls of the latter structure, which was exposed to the intense heat of the adjacent low building, as well as the flames in the interior, was somewhat cracked and may have to be taken out.

Uniform Building Laws are proposed by the International Society of State and Municipal Building Commissioners, which was organized at Washington last week. Mr. F. W. Fitzpatrick, of that city, the Society's secretary, was the leading spirit in its formation. It goes without saying that the lack of even approximate uniformity in building regulations is an unfortunate condition. There is no peculiarity of climate or of environment which will make a steel beam carry safely a greater load in one locality than another, and it is difficult to understand why the system of fire protection which is adequate in one city is unsafe in another. It is too much to expect complete uniformity in these laws, but there is no reason why the many great differences that now exist should not be reduced. If the new society intelligently and tactfully works to accomplish this end it will be doing most praiseworthy work.

Progress on the Wachusett Dam of the Metropolitan Water Works, Massachusetts.

The large masonry dam, known as the Wachusett dam, across the south fork of the Nashua River at Clinton, Mass., for the Metropolitan Water Works of Boston and its suburbs, has been mentioned so many times in these pages that the readers of this journal are familiar with it, at least in a general way. A complete illustrated general description of the dam and its accessory structures was printed September 8 and 15, 1900, and a detailed account of the contractor's extensive plant and effective methods was given April 5, 1902. The necessary protective works for controlling the river during construction and the progress of the operations have also been described. By way of reminder, however, the following figures relating to the dam may be given: Total length of dam on top 1,500 feet, including the waste weir 450 feet long and a short core wall extending into the hill at one end; maximum height, 228 feet; maximum thickness, about 176 feet; thickness at top, 22.5 feet; earth excavation, approximately 270,000 cubic yards; rock excavation, about 100,000 cubic yards; masonry, all classes, 290,000 cubic yards, 95 per cent. being granite rubble with granite ashlar on the exposed faces. A considerable proportion of the excavated earth and rock has been removed, and most of the materials for the masonry have been placed by the aid of two Lidgerwood cableways with traveling towers, which span the gorge at the dam site.

After the usual winter's interruption, the laying of masonry at the dam was resumed on March 21, 1903, and continued until December 8, when this work was suspended again because of cold weather. Advantage has been taken of the suspension of masonry work the past winter, to lengthen the span of both cableways from 1,150 to 1,250 feet, the head towers being moved back so that the masonry of the dam can be built where these towers were previously located. The excavation of earth and rock has also been in progress whenever the weather permitted, and it is expected that the excavation from the trench for the dam will be completed before the masonry work is resumed in the spring. At the beginning of 1903, the masonry of the dam extended 475 feet across the lower part of the valley, and its top was about 35 feet above the bed of the river. During the year, the masonry has been increased in height about 41 feet and it now extends for about 740 feet across the lower part of the valley. The top of the masonry is about 76 feet above the bed of the river, about 137 feet above the bottom of the foundation (not in the cut-off trench), and about 158 feet above the lowest point in the cut-off trench. The top of the finished dam is to be about 70 feet above the present elevation of the masonry.



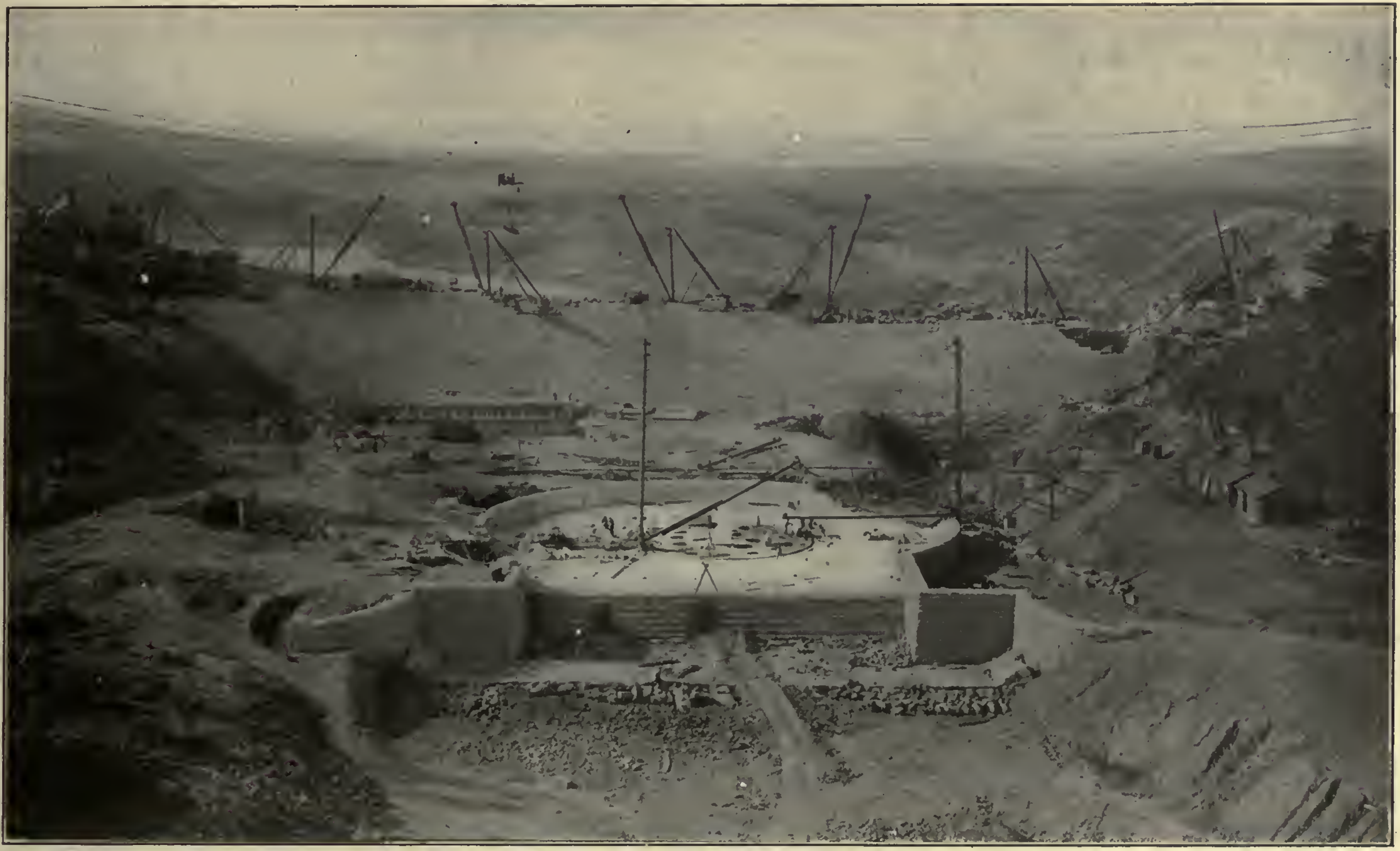
Wachusett Dam, August First: Mortar Mixing Plant at Left, Lower Gate Chamber near Center, and Waste Conduits in Foreground.

The maximum amount of masonry built in any week during 1903 was 2,612 cubic yards. The average amount built per mason per hour has been 1.29 cubic yards, and per derrick 5.56 cubic yards, the average number of masons worked at each derrick being 4.3. The derricks used on the dam during 1903 have been mostly A-frame or self-contained stiff-leg derricks, requiring no guys. The bases on which the masts of these derricks rest are built of timber each in the form of an isosceles triangle, the mast being placed at the junction of the sides of equal length, which are 41 feet long, the third side being 56 feet long. Timber struts run from the top of the mast to weight boxes located at the ends of the third side, which are loaded with stone. The masts are about 38 feet high, and the booms about 55 feet long. Each derrick has a bull, or swinging, wheel 12 feet in diameter attached near the bottom of the mast, and is operated by an engine having three drums, by means of which the engineer is able to swing the derrick and raise and lower the load, also the boom of the derrick. These derricks can lift about 3 cubic yards of stone, or about 7 tons. The derricks are moved from one working position to another by the cableways, the two cableways being used together for moving a derrick. When a derrick is moved, the stone which is piled in the weight boxes is taken off, but the derrick, including the engine and other rigging, is moved at one operation as one piece. The derricks during the past season have been largely located on the masonry. Some of them have, however, been put on cribs alongside of the masonry where possible to do so.

To pass the spring floods of 1903 over the masonry, a gap about 40 feet wide, with its bottom 20 feet lower than the remainder of the masonry, was left through the dam, but at the end of 1903 the masonry was built to practically a uniform height, as no trouble is anticipated from the spring floods of 1904, because of the large storage in the reservoir above the dam, now amounting to over 16,000,000,000 gallons, or one-quarter of the total capacity of the reservoir when completed. Of this storage it is intended to utilize about 9,000,000,000 gallons for the storage of water for consumption, leaving about 7,000,000,000 gallons of storage available for controlling the floods. With the head which will be available, about 1,200,000,000 gallons per 24 hours can be passed through the dam by means of the four 48-inch pipes, built into the masonry 131 feet below the elevation of the top of the dam. The flow of the largest flood in the Nashua River of which there is record, that of February 13, 1900, was 4,130,000,000 gallons per 24 hours.

The 48-inch pipes through the dam and lower gate chamber, as described in preceding articles, are prolonged by flaring riveted steel pipes, which connect them to four 10-foot concrete conduits placed side by side to form one structure. These conduits end beneath a circular concrete pool, and the water to be wasted rises through openings in the tops of the conduits into the pool, from which it overflows into the river channel below the dam. The concrete for the conduits and pool is composed of 1 part of Portland cement to 2½ parts of sand and 4½ parts of screened gravel stone. The conduits were mostly built in 1902, and the concrete was mixed in a cubical mixer, 4 feet on a side, made by Kaltenbach & Griess, of Cleveland, Ohio, the work being done usually in the night time when the mixer was not in use for mixing mortar for the dam.

Much the larger part of the concrete for the pool was put in place during 1903; it was mixed by hand, the mortar mixer not being accessible. The concrete has been mixed quite wet, but not so wet but that some ramming could be done. The floor of the outer pool, which is circular and has a diameter of about 145 feet, was divided on radial lines into blocks 16 feet wide at the outer circumference, and again divided on chord lines 15 feet apart. This was done in order to localize the expansion cracks. The curved wall surrounding the outer pool, which is 7 feet high, has been built of concrete faced with coursed granite masonry, the exposed face of which is fine pointed.


Wachusett Dam, November Second: Showing Cableways and Derricks; Pool over Ends of Waste Conduits in Foreground.

Most of the stone used during the past year for ashlar and dimension stone masonry has been obtained from a quarry situated in West Chelmsford, Mass., but the granite stone for the rubble masonry has been obtained from the quarry situated about 1½ miles from the dam. The two excellent photographs reproduced herewith show the main dam as it appeared near the end of last season and indicate clearly the progress in the laying of masonry made during the three months from August 1, when the earlier view was taken, to November 2, the date of the second picture. In these views may be seen the character of the ashlar masonry in the downstream face of the dam, the pool and conduits in course of construction and the derricks and cableways mentioned above.

Large quantities of the earth and some of the rock excavated from the trench for the dam have been used for filling against and near both the upstream and downstream faces of the masonry. Considerable portions of these materials have been transported by the cableways at times when they were not required for the masonry work, and whenever feasible the skips have been dumped without lowering to the ground by making use of the aerial tripping device with which the cableways were fitted. Against the lower part of the upstream face of the dam a backing of selected boulder clay, free from large stones, was placed. This material was taken from the trench for the easterly end of the dam (left side of picture) and much of it was shoveled into the cableway skips as it was excavated. The skips were then conveyed by the cableways to the derricks on or near the dam, by means of which the clay was dumped in the desired place.

Near the right side of the view of August first can be seen the head-house of the large flume which in the earlier years of construction carried the surplus water of the river across the main excavation. Later in the season this was dismantled and largely removed there being no longer any use for this flume, as explained above. The upper protective dam is now submerged. At the left of the middle of both pictures there appears a small wooden house, at the easterly end of the lower gate chamber. This is a temporary shelter over the controlling gates at the entrance to the Wachusett aqueduct, which pierces the hill in a tunnel and through which the water is sent toward the Metropolitan district. Water for the aqueduct is admitted to the lower gate chamber through side outlets on the 48-inch pipes through the dam, these outlets being governed by 24-inch hydraulic-lift valves. Although considerable quantities of water can be wasted through the 48-inch pipes and the pool, after the completion of the reservoir, the principal outlet for surplus waters of freshets will be over the main waste weir into a large channel excavated in a natural gully around the hill which limits the views at the right side. The waste weir closes the depression between this hill and the higher hill which rises just beyond.

The successive steps in building the waste conduits and pool are suggested by the pictures. The wooden forms for the more difficult portions were gotten out at a planning mill under the supervision of a member of the engineering staff.

The Wachusett dam, as well as the other parts of the extensive Metropolitan Water-Works system, is being constructed under the general direction of Mr. Frederic P. Stearns, chief engineer of the Metropolitan Water & Sewerage Board. Mr. Thomas F. Richardson, as engineer of the Dam and Aqueduct Department, has immediate supervision of the work described, and it is through his courtesy that the materials for this article were obtained. The contract for the dam was awarded to the McArthur Bros. Company, of Chicago, but the work is being executed by Winston & Company and Locher, a partnership of the McArthur Bros. Company, Winston & Company and C. H. Locher. Messrs. J. O. Winston and C. H. Locher have directed operations for the contractors.

Cast-Iron Tools for working metal in lathes were used thirty years ago, according to Mr. J. E. Stead. When a particularly hard material had to be turned an acquaintance had employed a cutting tool of white cast-iron and had succeeded with it where hardened steel failed. Such tools have also been used at the Altoona shops of the Pennsylvania Railroad.

A Concrete-Steel-Construction Filtration Plant for the New Haven Water Company—I.

New Haven, Conn., and two or three adjoining towns are supplied with water by the New Haven Water Company, of which Mr. Eli Whitney is president. The company owns six supplies from streams and lakes, with impounding reservoirs, but one of the sources is held in reserve and not ordinarily used. Two supplies are pumped, but the others are from sources at sufficient elevations to give satisfactory pressures by gravity. The distances, elevations and pumping pressures of the various supplies are such that, with one exception, which is reserved for high-level service, they all are connected with the city distribution system, without the intervention of pressure regulators or other devices for separating different districts. The average daily consumption is about 15,000,000 gallons.

In order to protect the water from harmful pollution the company has for some time been purchasing the lands on its watersheds and now owns a considerable proportion of their areas. A system of sanitary inspection is maintained, fallen leaves are raked up and burned, and the droppings of animals are removed from the roads. But owing to the extent of the manufacturing interests along Mill River from which the Whitneyville supply, averaging 8,000,000 gallons per day, is pumped, it cannot be sufficiently controlled to preclude all danger of contamination; and so it has become necessary to filter this water. Desiring to secure an up-to-date filtration plant, the company decided to obtain the advice of engineers expert in filter design. The works are unusually interesting.

New Haven Filters: Arrangement of Contractor's Plant for Building Floor and Walls of one Filter; the Concrete Mixer.

The filters are located on a tract of land about 1½ miles from the center of the city, near the Lake Whitney dam, and, although topographically it was not so suitable for a filter site as might have been desired, a variety of reasons led to its selection. A slow sand filter plant, having an aggregate area of four acres, of 12,000,000 gallons per day nominal capacity, arranged with the view of having it capable of yielding 18,000,000 gallons per day, the capacity of the pumping stations, or even a little more during short periods if needed, has been designed and is partially constructed. This plant consists of twelve covered filter beds, an operating gallery, a laboratory and a clear-water reservoir. There are no courts for the storage and washing of sand and no regulating houses; the former are dispensed with because of the ingenious method, involving the use of ejectors, for handling the sand, without storage outside the filter beds, and the functions of the latter are performed by the operating gallery (on either side of which the filters are arranged in two rows of six each), which is of the type used in some mechanical filter plants and resembles the operating galleries at the well-known filtration works of the East Jersey Water Company, at Little Falls, N. J.

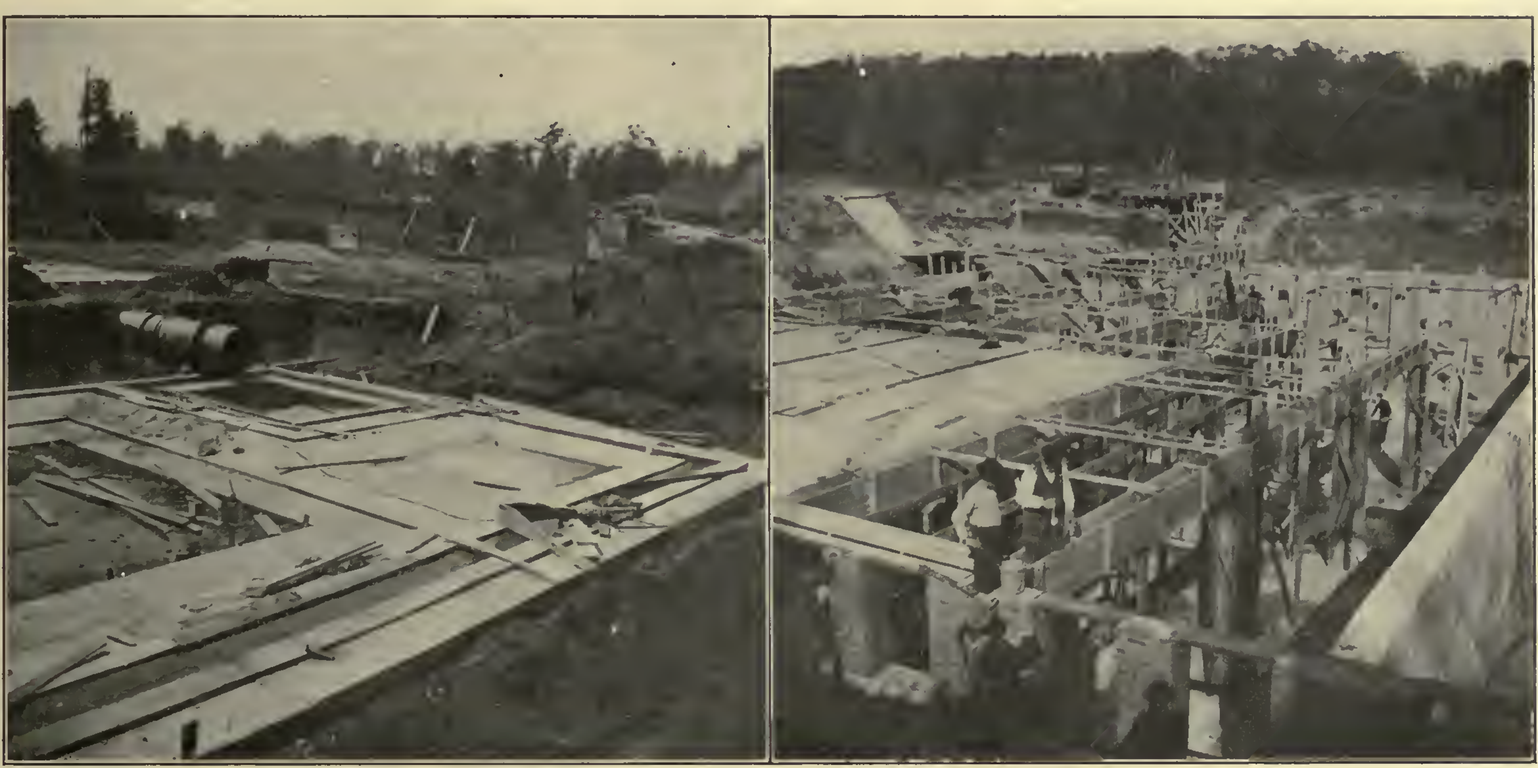
The filter beds and the clear-water reservoir are covered with flat slab-and-beam construction concrete-steel roofs, with unusually long spans, supported by concrete columns; and have inverted groined-arch floors. Thin walls were adopted and resist lateral pressures principally by beam action between the floors and roof. Above the surface of the filtering sand the beds have an unusual height, and the earth filling against the outside walls is not carried above the water level, although the roofs have 2 feet of earth on them. This arrangement permits the upper parts of the exterior walls to be pierced by a number of large windows, in order to afford ample ventilation and sufficient natural light for sand scraping and other work inside the filters and to avoid the incandescent lighting system or other artificial means of illumination which have been used in some filter plants. There are none of the sand entrances and runs which have been familiar features of covered slow sand filtration plants heretofore, and there are only two ventilators or manholes in the roof of each filter. The collector and piping systems also have features of interest.

An accompanying general plan shows the arrangement of the filter plant and its principal pipe connections, while other drawings reproduced herewith, or to be reproduced with the second part of this description, give many details of the design. The piece of 30-inch raw water pipe connecting the 36-inch raw water main to the 30-inch effluent suction main leading to the pumps, has been put in so that in case of accident to the filters or clear water reservoir, necessitating the shutting down of the plant, unfiltered water can be pumped. By opening one valve and shutting two others the filters can be cut out and water drawn directly from the lake as at present. The 10-inch blow-off is for the purpose of draining the clear water reservoir for inspection or repairs. As indicated, the filter and the operating gallery together form a rectangular building about 385x505 feet in plan, with a one-story superstructure, 6 feet 8 inches high above ground level, over the filters; over the pipe gallery there is a second story, and at the center of the gallery, a third story 50 feet long, providing space for the laboratory and office. Each filter is 82 1/3x180 feet inside at the level of the sand surface, and has a net filtering area of 1/3 acre. Practically the whole filter structure, excepting the exterior walls above ground level, is of Portland cement concrete.

The exposed portions of the exterior walls are of red bricks, 12 inches thick with 2-inch air spaces, except at the buttresses, which are 16 inches thick. These buttresses are 2 feet wide and in the north and south walls are 12 feet apart on centers, coming at the ends of the roof girders; in the east and west walls they are spaced 20 feet 2 inches on centers. In the north and south walls there are two windows, each glazed with twelve lights of 10x12-inch glass, in each panel, but in the east and west walls there is only one such window, in the middle of each panel. Each window has two sashes made to slide vertically, and the frames are made for double windows, so that a second pair of sashes may be put in if found necessary in order to maintain a proper temperature inside the filters in winter. Indirect light also is admitted to the filters through window openings in the walls next to the operating gallery. The exterior walls have a base course of concrete blocks cast in molds and a molded cornice formed in place in connection with the roof. Accompanying drawings show the forms and dimensions of the concrete walls, floors and roofs so plainly that they need but little description. All walls are notched to the floors and are rabbeted at their tops to receive the roofs, so as to furnish sufficeint reactions for the beam action of the walls previously mentioned.

The concrete walls are not reinforced, but the floors and roofs are reinforced with Ransome cold-twisted square steel rods of various sizes, furnished by the Aberthaw Construction Company, of Boston, some 928,000 pounds being required in all. In the filter floors there is a network of ¼-inch rods spaced 6 inches center to center each way, 1 inch above the bottom. As shown, the arrangement of the floor groins is slightly different from that frequently used, the distance between column footings being greater longitudinally than transversely. The roof of each bed is divided into seven bays 11 feet wide by six longitudinal girders 12 feet apart on centers, the concrete slab being 6 inches thick, except in the bays next to the exterior walls, where it is 7 inches thick, and around the manholes, where it is 8 inches thick in a square of 8 feet. The reinforcement in the slab consists of ½-inch rods transverse to the girders, spaced 5½ inches center to center in the outside bays and 6 inches in the others, and ⅛-inch rods parallel to the girders, five in each bay.

All the roof girders are 12 inches wide and 20 inches deep below the under side of the slab, and are reinforced in the manner clearly shown in one of the detail drawings. Each girder is supported by eight columns spaced 20 feet 2 inches apart center to center. Hence there are forty-eight columns in each filter, 14 feet 2 inches high from floor to soffit of roof. The joints in the girders are made in the tops of the columns with four ¾-inch rods 7 feet long embedded an equal distance in each part of the girder, as shown. The columns are eight-sided, the cross-section of the shaft above the normal sand level being a 19-inch square with its corners truncated so as to make the broader faces 12 inches wide. Each column is reinforced only by an 18-inch ring made of a ¼-inch rod 6 feet long embedded horizontally 2 inches below the bottom of the girder. Columns and walls alike have decided batters below the normal level of the sand, which is 4 feet 2 inches above the high points of the floor.


New Haven Filters: Floor of Clear-Water Reservoir and Inlet Well; Walls and Roof of a Filter during Construction.

A contract for building the masonry structures and performing certain parts of the work incident thereto was made with Messrs. Eglee & Bunting, of Boston, in May, 1903, for a lump sum, with stipulated unit prices for additional quantities of various items. This contract calls for the completion of the work by September 1, 1904. The water company did the preliminary grading of the site and is to do all other grading except placing the earth on top of the filters and clear-water reservoir; it is furnishing the cast-iron and vitrified pipes and valves and laying all pipes except those built into the concrete, which are being set by the contractors; it will furnish and place the filter sand and gravel, furnish and set the operating machinery and do all the plumbing. Alpha Portland cement is being used for the concrete; it is supplied by the contractors and paid for by the company at a contract price per barrel. The cast-iron pipes were obtained from the Warren Foundry & Machine Company, of New York; the Builders' Iron Foundry, of Providence, furnished the Globe special castings, and the gates were made by the Chapman Valve Company, of Boston, and the Coffin Valve Company, also of Boston.

Wall Form with Through Bolts.

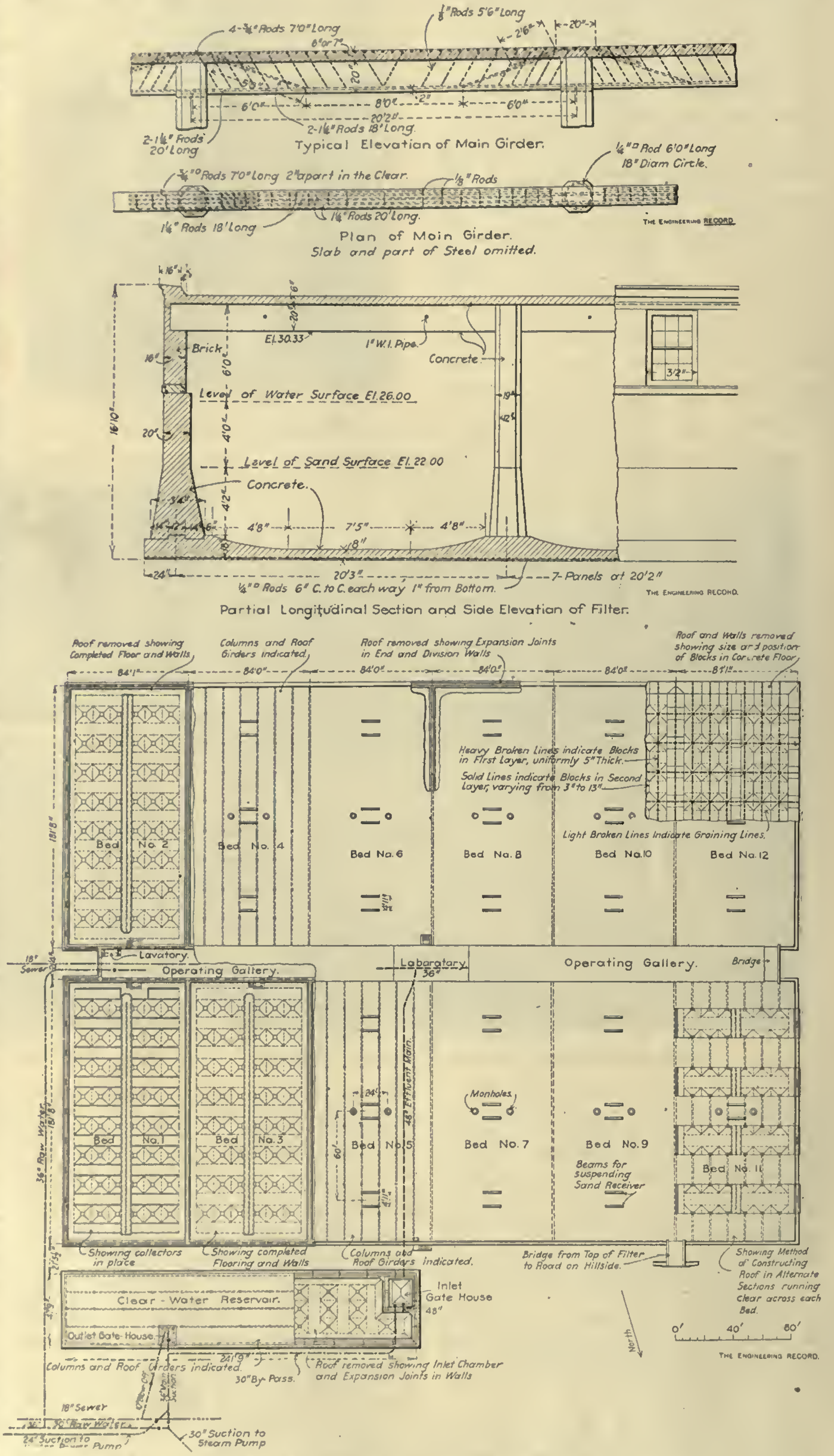
The filter site was occupied partly by the slope of a hill and partly by a springy marsh, which latter gave much trouble on account of the quicksand and water which it contained. By spreading dry coarse sand over the wet quicksand it was made possible to work over the marshy part of the area. The site was leveled by digging down the hill to a maximum cut of 30 feet and filling the marsh to a maximum height of 16 feet in layers 6 to 12 inches thick rolled with horse grooved rollers and a ten-ton steam roller. The material in the embankment is a mixture of very fine sand, boulder hardpan and sand from various parts of the excavation. This grading was done a year in advance so that the fill passed through a winter before any masonry was built on it, and about half the area of the fill, including the higher portion, is standing through a second winter before the remaining filters will be built. After the fill was built a low dike was made around it and water from the springs and hillside allowed to flood it, so that it stood from fall to spring under water. When the contractors began to work, after removing the few inches of surplus earth, the embankment was found in satisfactory condition. Very little further settlement under the load of the filters and water is anticipated. If any settlement should occur, it is confidently expected that it will not cause any trouble as the depth of fill increases gradually from one side to the other.

Concrete has been mixed wet, of one part Portland cement and not more than eight parts sand and gravel or broken stone, in such proportions as to give a dense mass. For the concrete of the roof the mixture is 1:2:4; for the floor 1:2½:4½, and for the walls the same mixture as for floor with one part of tailings from crusher added, or about 1:2½:5¼. A Smith revolving mixer has been used. That the concrete in the structures so far built is dense is attested by one or two holes cut for pipes through the walls, as well as by other evidences. Good sand is obtained from a bank about 1½ miles distant, owned by the company, and gravel suitable for concrete can be gotten from the same place. However, a sub-contractor bid such a low price for furnishing crushed trap rock from a quarry only a few hundred feet from the filter site, also owned by the company, that this has been used for the concrete in preference to gravel. To furnish the broken stone two rock crushers of the Blake type, made by the Farrell Foundry & Machine Company, of New York, and the necessary revolving screen, belt and bucket conveyor and bins for storing and loading the stone were installed near the northwesterly corner of the filter beds. At first "run of the crusher" was used, but it was found that the larger fragments of stone tended to separate somewhat from the finer as the crushed stone was drawn through the hopper bottom of the bins, so that in one cartload the larger sizes of stone would predominate, while the next load would contain an undue proportion of dust. Hence, in the ordinary course of events, it was not the "run of the crusher" which came to the mixer. To remedy this trouble the screen was used to separate out the stone ranging from ¼ to 2 inches. The dust was mixed with the sand in the proportion of about 1:3, and was used exclusively for the water table blocks cast in molds, for the lower surfaces of concrete roofs, the lower parts of the roof girders and in similar places. The tailings from the screen up to 5 or 6 inches long were embedded in the walls.

The forms were made of spruce boards planed on the side next the concrete and were usually taken down at the end of about twenty-four hours in warm weather, but were left in place about two days in the colder weather of the late fall. Concrete work was suspended soon after freezing weather commenced. Special pains are taken to secure smooth surfaces and the efforts in this direction have been successful. The 2-inch boards for the wall forms are slightly beveled on their edges, so that they can be driven close together, and the joints are calked, if necessary, with rags or jute to prevent the leakage of water and cement while the concrete is being deposited. The upright timbers are cut to fit the profile of the wall. As soon as the forms are removed any porous places discovered are promptly troweled with mortar and the surfaces of the walls are finished with cement grout rubbed with wooden floats. New concrete has been covered with burlap kept moist to insure satisfactory setting of the cement.

The walls are built in alternate monolithic sections 20 feet long of the full height. In the ends of sections which do not come against previously placed concrete a groove is formed about 6 inches wide and 6 inches deep. These grooves are smeared with asphalt pipe paint to prevent the adhesion of the concrete of the next section, so as to make sure that any crack caused by shrinkage due to the setting of the cement or changes of temperature will be formed at these places and will occur without breaking through the tongue of the next section and thus making a through passage for water. The thin parts of the walls forming the sides of the grooves and the corresponding tongues are reinforced with twisted rods. Almost all these joints in the walls built during the past season have opened slightly, but during the leakage tests have passed only minute quantities of water. None of these joints, however, were made at corners, but all corners are built monolithic with a portion of the walls extending in each direction.

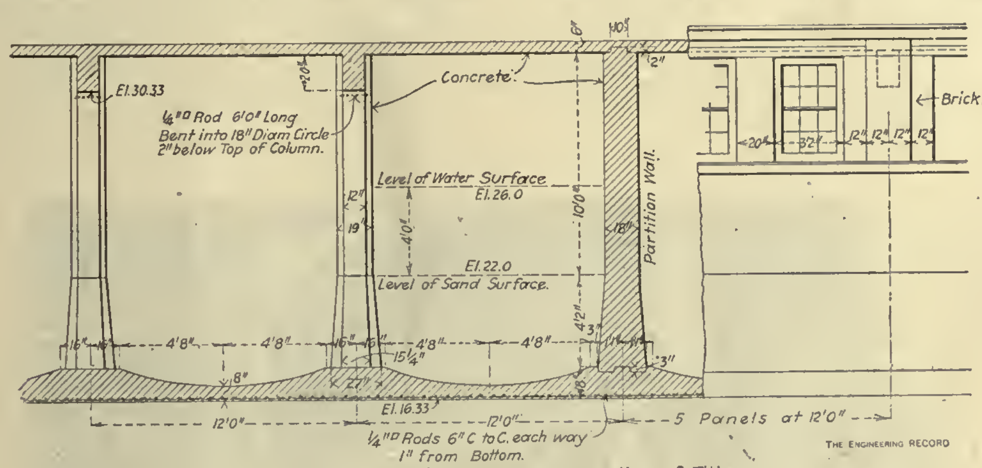
The wall forms were at first braced with wooden struts in the usual way to hold them in place, but they floated up slightly, opening a crack at the bottom, through which the mortar of the concrete could escape. To counteract this tendency the form for each section was weighted with two large boxes filled with stones. Then the braces were dispensed with and through bolts used to hold the sides of the forms against spreading. As an improvement bolts with a short hook section at each end, which could be taken out when the forms were removed, were tried. Later ⅞-inch bolts made in three pieces united by two square cast-iron sleeve nuts placed 1½ to 2½ inches in from the face of the wall were adopted and are now used. The two short outer pieces are easily unscrewed and taken out while the concrete is green, and the sleeve nuts act as cut-offs to prevent the water following along the bolt and through the wall. Of course, the small holes made in the faces of the walls are promptly filled with mortar. This method of wall construction is shown in one of the illustrations.


4-¾" Rods 7'0" Long
6" or 7"
⅛" Rods 5'6" Long
2'6"
20"
20"
6'0"
8'0"
2"
6'0"
20'2"
2-1¼" Rods 20' Long
2-1¼" Rods 18' Long
Typical Elevation of Main Girder.
¼" Rod 6'0" Long 18" Diam Circle.
¾" Rods 7'0" Long 2" apart in the Clear.
⅛" Rods
1¼" Rods 20' Long.
1¼" Rods 18' Long
Plan of Main Girder. Slab and part of Steel omitted.
THE ENGINEERING RECORD
16"
20'6"
El. 30.33'
1" W.I. Pipe
Brick
Concrete
18"
6'0"
3'2"
Level of Water Surface El. 26.00
16'10"
20"
4'0"
Level of Sand Surface El. 22.00
Concrete.
4'2"
4'8"
7'5"
4'8"
8"
24"
20'3"
7-Panels at 20'2"
⅛" Rods 6" C. to C. each way 1" from Bottom.
Partial Longitudinal Section and Side Elevation of Filter.
THE ENGINEERING RECORD
Roof removed showing Completed Floor and Walls
Columns and Roof Girders indicated
Roof removed showing Expansion Joints in End and Division Walls
Roof and Walls removed showing size and position of Blocks in Concrete Floor
84'1"
84'0"
84'0"
84'0"
84'0"
87'1"
Heavy Broken Lines indicate Blocks in First Layer, uniformly 5" Thick.
Solid Lines indicate Blocks in Second Layer, varying from 3" to 13"
Light Broken Lines Indicate Groining Lines.
181'8"
Bed No. 2
Bed No. 4
Bed No. 6
Bed No. 8
Bed No. 10
Bed No. 12
18" Sewer
Lavatory
Operating Gallery.
Laboratory
Operating Gallery.
Bridge
36" Raw Water
Bed No. 1
Bed No. 3
Bed No. 5
48" Effluent Main
Manholes
Bed No. 7
Bed No. 9
Bed No. 11
Beams for suspending Sand Receiver
Showing collectors in place
Showing completed Flooring and Walls
Columns and Roof Girders indicated.
Bridge from Top of Filter to Road on Hillside.
Showing Method of Constructing Roof in Alternate Sections running clear across each Bed.
Clear - Water Reservoir.
Inlet Gate House
Outlet Gate House
Columns and Roof Girders indicated.
Roof removed Showing Inlet Chamber and Expansion Joints in Walls
30" By-Pass.
North
0' 40' 80'
THE ENGINEERING RECORD.
18" Sewer
36" Raw Water
24" Suction to Steam Pump
30" Suction to Steam Pump

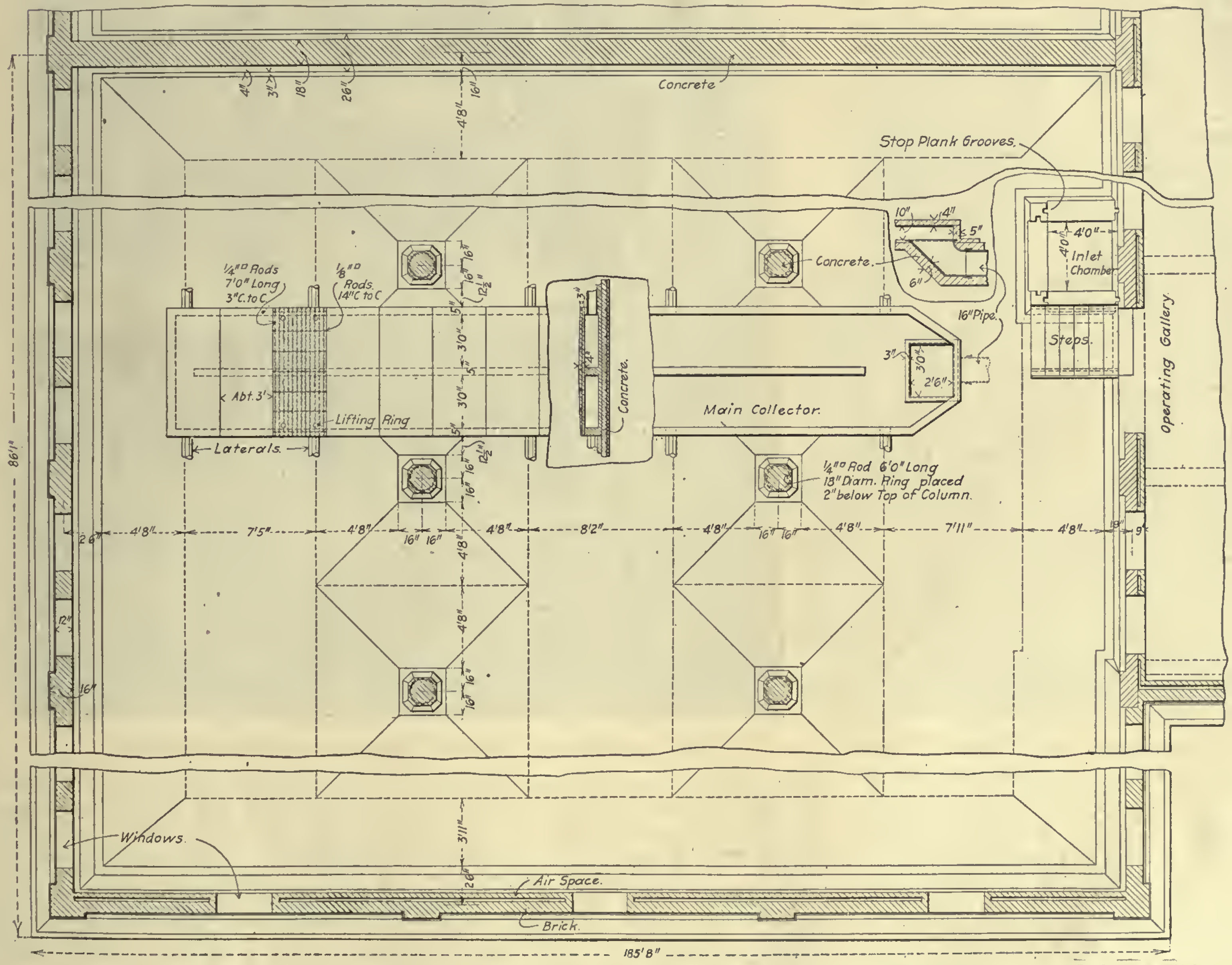
New Haven Filters: General Plan; Section of Outside Wall; Steel Reinforcement in Roof Girder.

The concrete for the floors of the filters and the clear-water reservoir is placed in two layers. The lower layer, 5 inches thick, is laid in alternate blocks, each the size of one bay with its corners at the centers of columns, and the intermediate blocks are not placed until the first blocks have set at least three days. In any part of the floors the second course is not laid until all the blocks of the first course have been in place at least three days. Before placing the second course the surface of the lower blocks is thoroughly cleaned with stiff brooms and a strong jet of water. The upper blocks are laid so as to break joints with the lower layer. Both layers of blocks are floated and troweled to a smooth surface, excepting the portions of the upper blocks under the columns.

The concrete-steel roofs are built in alternate monolithic sections, each the size of one bay across the bed, the joints being made at the center lines of the transverse rows of columns. The molds are not taken down until after the intermediate sections have been built and allowed to set to the satisfaction of the engineer. Only men skilled in this class of concrete-steel construction are allowed to be employed on this part of the work. After a section of roof has become hard, it is covered with a layer of earth at least 3 inches thick, which is kept wet for a sufficient length of time to furnish moisture for the setting of the cement.


El. 30.33
1/4" □ Rod 6'0" Long Bent into 18" Diam. Circle 2" below Top of Column.
Concrete.
Level of Water Surface El. 26.0
El. 22.0 Level of Sand Surface.
Partition Wall.
Brick.
El. 16.33
12'0"
4'8"
15 1/4"
27"
1/4" □ Rods 6" C to C. each way 1" from Bottom.
5 Panels at 12'0"
THE ENGINEERING RECORD

Partial Cross-Section and End Elevation of Filter.



Plan of South-east Corner Filter, Typical of all others. (Roof Removed.)

New Haven Filters: Detail Plan of One Bed; Interior Columns and Division Wall; Windows in End Wall.

The walls of the two manholes in each filter roof are of reinforced concrete 6 inches thick, built up from the roof slab for a height of 1 foot 10 inches. Each opening is 2½ feet in diameter at the top and has a cast-iron frame and top cover with a second cover 6 inches below of ⅜-inch steel plate. The manholes are in the middle of the length of the bed and 12 feet each side of the longitudinal center line. Between them, and also 60 feet each way from the transverse center line, there is a pair of beams formed on top of the roof, spanning the middle bay from girder to girder, as shown. The beams of each pair are 4 feet 11 inches apart on centers, 13 feet long, 18 inches wide and project 18 inches above the top of the roof. A ⅞-inch eye-bolt with a 9-inch square washer is embedded 3½ feet from each end of each beam so that the eye projects just below the roof. These bolts are provided in order to support the receptacles for washed sand, to be mentioned more at length later, and the beams are intended to distribute this concentrated load and transmit it to the girders.

The contractors' method for constructing the floors and walls of the filters has been, as indicated in one of the views, to set up the mixer near the middle of a bed and to erect two 60-foot-boom guyed derricks about the middle of each half. These derricks were driven by two Lambert hoisting engines and could handle the concrete from the mixer to any part of the floor or walls as well as taking skips of sand or stone from teams to the mixer. For delivering the concrete into the forms a drop-bottom bucket made by the Cyclopean Steel Company, of Jersey City, was used. The spaces occupied by the derricks and mixer were filled in after the plant had been moved.

Mr. George W. Fuller, of New York, is the consulting engineer for this plant, and the preliminary studies for the filters were made in his office by Messrs. William B. Fuller and John H. Gregory. Mr. Albert B. Hill, of New Haven, is the chief engineer of the New Haven Water Company and the detail design and execution of the work is under his direction. Mr. Charles A. Ferry is the resident engineer in charge of construction, and Mr. E. M. T. Ryder elaborated the details and made the contract drawings. All the grading and pipe work has been done by Mr. Edward Dillon, superintendent of the water company, and he has also had charge of the inspecting of the contract work.

(To be continued.)

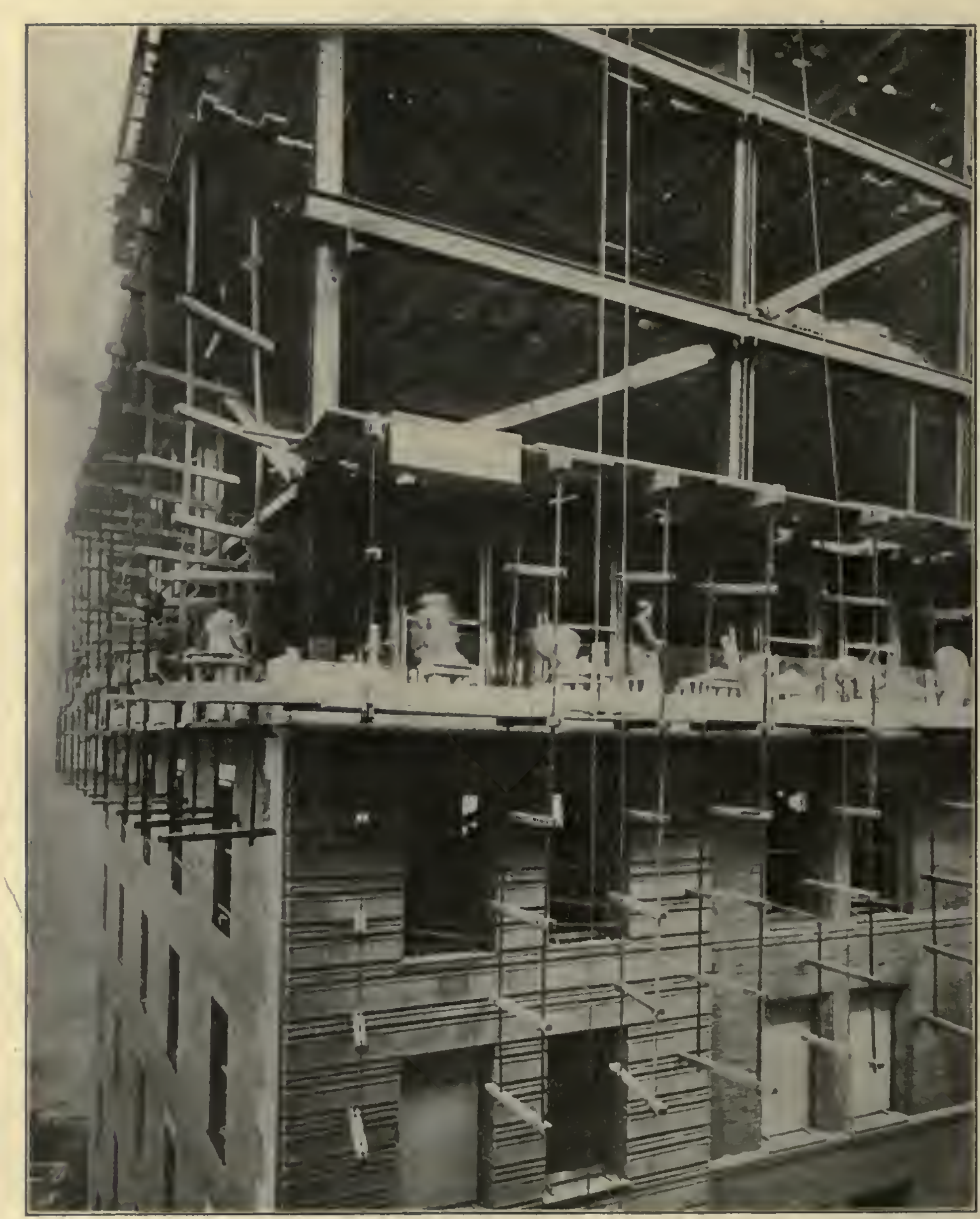
The Erection of the Wall Street Exchange Building, New York.

The Wall Street Exchange is a steel cage building about 100 feet square and 327 feet high from sidewalk to top of roof beams. The brick work extends about 14 feet higher, and the cellar excavation has a total depth of about 36 feet below the curb; there are two stories below street level and twenty-five stories above street level. The basement and the sub-basement are chiefly occupied by the power plant, mechanical installation and large safe deposit vaults, but contain a few tenants. The upper stories are intended for banks and general office purposes. The 3,300-ton framework has twenty-seven main rectangular steel columns erected in two-story lengths and seated on steel beam grillages or cantilever girders supported by concrete foundation piers with pneumatic caisson foundation. The main floor girders are single 20-inch I-beams carrying 12-inch I-beam floorbeams 5½ feet apart. The exterior walls are carried independently of the floor on 12 and 15-inch I-beams bracketed out from the columns. All field connections of floorbeams, girders, columns and column splices were made with bolts instead of rivets and although the kneebraces were bolted in position as fast as the framework was erected, the building was so tall and exposed to such heavy wind pressures that it was considered wise also to provide temporary wind bracing of diagonal timbers between wall columns.

The beams carry 12-inch hollow tile flat arches supporting concrete floors, which are not covered with wood. In the offices they have a granolithic finish with wooden plugs around the edges to receive the carpet nails. In the corridors the floors are paved with tiles or mosaic. The partitions are of 4-inch hollow tiles and the walls are of ordinary brick with special face brick, and average about 16 inches in thickness. The beams and girders are fireproofed by being entirely enclosed in the wall and floor masonry and the columns are protected by hollow tile jackets and plaster. The building is of special interest on account of the great rapidity with which it was constructed, enabling the first tenants to take possession within ten months of the time that the buildings formerly occupying its site was vacated.

As the building which previously occupied the site had no cellar and the adjacent tall buildings had comparatively shallow foundations, it was first necessary to underpin them, and some very interesting work was done, as described in The Engineering Record of September 27 and November 1, 1902. One 90-foot wall 35 feet long was supported on needle beams and jack screws while longitudinal girders and jack screws were inserted in the lower part of the wall to carry it from the old footings and provide adjustments to compensate for settlement during the time the new foundations were being built alongside. Afterwards these girders and jack screws were removed and the wall again supported on needle beams until the new footings had been built alongside the foundation caissons. The five-story wall of another building was underpinned in a similar manner by the use of permanent concrete cylinder piers sunk through the basement floor in a narrow hallway to support the ends of the needle girders. These piers were sunk by jacking against reactions connected to heavily loaded platforms. In both buildings the work was complicated by the necessity of arranging the needlebeams to clear the caissons for the new foundation piers.

After the old building was razed, the site was excavated to a depth of about 6 feet below the curb, sheet piles were driven to form a retaining wall on the street side and the excavation was braced by lines of horizontal timber struts at right angles to each other, which were supported at intersections and divided the area into panels from 8 to 20 feet in width, so arranged that the braces cleared the positions of the foundation piers. The upper tier of braces was decked over to form a working and storage platform, and a traveling derrick with four 50-foot 10-ton booms was installed on it to handle the wooden caissons and construction materials. The caissons and cofferdams were delivered whole at night on trucks and had maximum weights of 10 tons. They were sunk to hard pan at a depth of from 39 to 46 feet below the curb. The greatest speed of sinking attained was 2 feet an hour, and the thirty caissons were sunk in about 40 working days, including the delays occasioned by the shoring and underpinning of adjacent buildings. The caisson work was done by three eight-hour shifts of 12 men each, who made about 3,0000 cubic yards of excavation. The excavation outside of the caissons amounted to about 4,000 cubic yards and there were 2,000 cubic yards of hand-mixed concrete in the foundation piers. The caisson work and the general character of the steel superstructure were illustrated in this journal September 13, 1902.

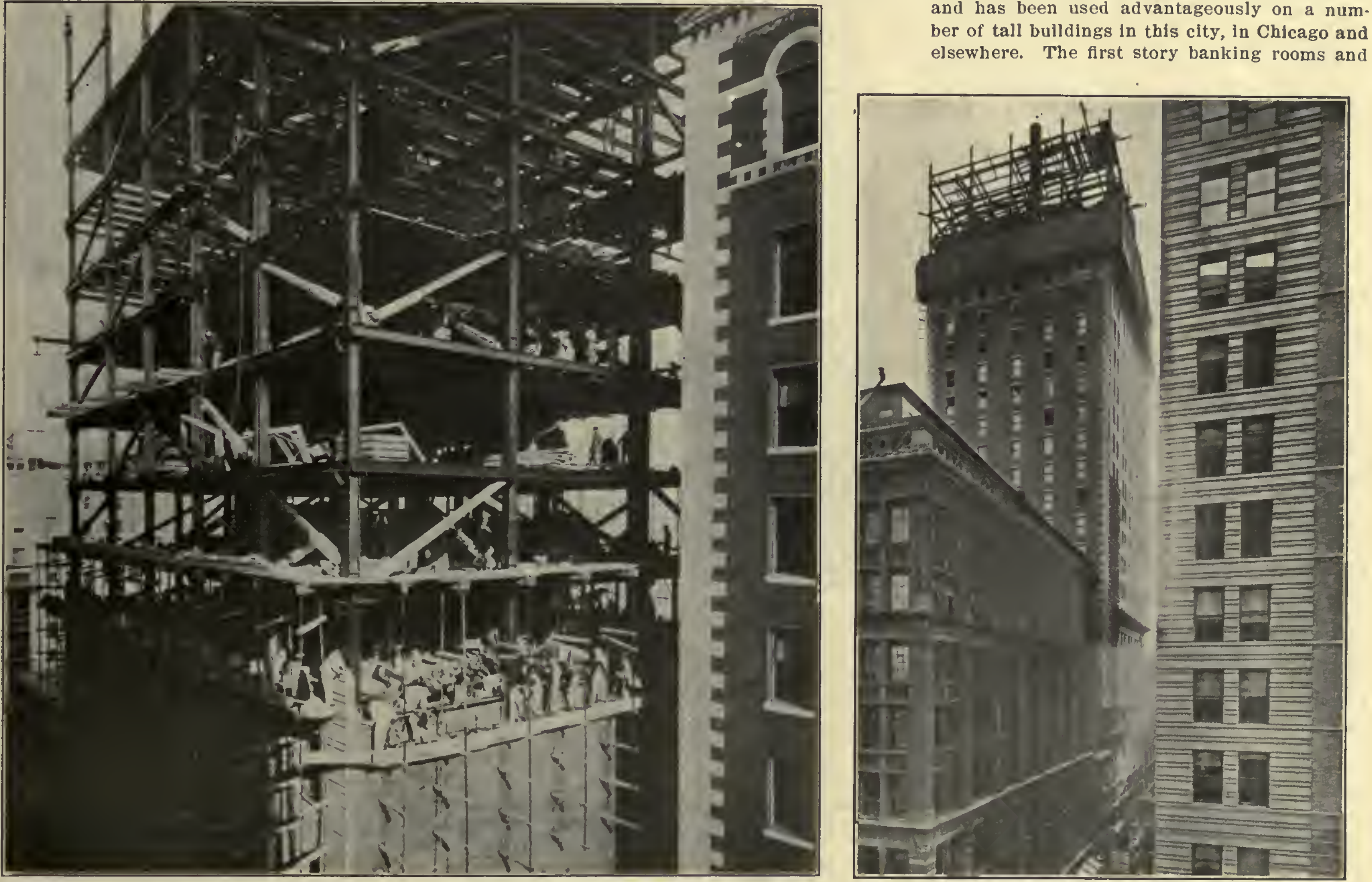


Wall Street Exchange: Showing Method of Using Bricklayers' Scaffold.

The steel grillage beams were set on the foundation piers in December, 1902, but the erection of the framework was not commenced until January. The steel framework was erected from the curb level to the top in about seven weeks, and the brick work was commenced in the basement in January and completed March 19. All the steel work was handled by two derricks with 72-foot masts and 65-foot booms, having a capacity of nearly 20 tons. The masts were each secured by nine steel rope guys attached to the tops of the columns with chains and turntable adjustments. Together they commanded the entire area of the building, handling 10-ton pieces at full radius. They were operated by separate two-drum hoisting engines with attached boilers, one of them built by the Lidgerwood Manufacturing Company and the other by the American Hoist & Derrick Company. They were permanently located, one on the first floor and the other originally on the first floor and afterwards on the fourth floor where it was moved to be more out of the way. Each derrick was served by a gang of about fifteen men, and its operation was directed by electric signals transmitted from the derrick to the engine man. The derricks were moved at every second tier, the boom being unshipped and guyed in a vertical position to serve as a gin pole for erecting the mast in the usual manner. One derrick was moved up two stories with an interruption to its service of only 2 hours and 10 minutes, although the average time was about 3 hours. The guys were adjusted so as to leave about 6 inches play to the top of the mast and great care was taken to avoid adjusting them too tightly in cold weather.

The concrete was mixed by hand, and, together with bricks, mortar and other supplies, was raised to the required level by five Thomas & Buckley material hoists established in the elevator shaft and extended as the erection advanced. The floor arch builders, concreters, fireproofers, plasterers and carpenters successively followed the bricklayers and a large number of them were simultaneously at work, the plasterers being well advanced before the erection of the steel work was completed. In many tall buildings where the walls are supported on girders at each story, the construction has been expedited by carrying on simultaneous bricklaying at several intermediate stories, usually separated by one or two floors. In this case it was deemed better to build the brick work from the bottom up, as in ordinary buildings, and it as accomplished in about ten weeks by 80 bricklayers working 8 to 10 hours a day.

The work was greatly facilitated by the use of Clark's patent scaffolding, which was suspended on all sides of the building from the steel framework above the points to which the walls had been carried, and afforded continuous platforms around the building without obstructing the streets or involving the use of heavy timber or long poles. On it the bricklayers all worked at the same level on three sides of the building, advancing to the fourth side while the platform on the first side was being raised and so progressing continuously in a spiral around the building from bottom to top without any delay for building the scaffold. Each setting of the scaffold framework provided for the support of working platforms covering a vertical height of wall of about 22 feet. This was usually divided into five spaces, at each of which horizontal supports were set from which the floor planks could be rapidly moved from the lower to the upper ones successively. The platforms were set about 2½ feet below the upper edge of the brickwork so that the men could commence bricklaying at each stage in the most advantageous position. After building a course of 4½ feet high, as far as they could conveniently reach, the platform was shifted to the next set of supports 2½ feet above and they resumed work without interruption at the same relative height as the previous course had been constructed, and so on. In this way one course of brickwork averaging 16 inches in thickness was built to a height of 4½ feet around the four sides of the building in an average time of about 2½ hours. When the weather was very cold or stormy the sides of the platform were enclosed with canvas, but it was not found necessary to use salamanders there, although the contractors have done so in other buildings.


Wall Street Exchange: Showing Temporary Wind Bracing, and Bricklayers' Scaffold Protected from Weather by Canvas.

The scaffold has a series of horizontal cantilevers about 8 feet apart on centers which project 5 feet beyond the face of the brickwork. From them are suspended pairs of vertical steel bars, 4 feet apart, which carry the transverse beams, or putlogs, supporting the platform planks. Each cantilever is made of two 3x10-inch planks about 18 feet long, which are supported across the top flanges of the wall girders and are anchored with a ¾-inch U-bolt to an interior floorbeam. The vertical suspenders are 3x⅜-inch bars, which pass between the cantilever timbers and are secured to them by single ¾-inch bolts. The bars have holes punched in them 9 inches apart from end to end and ¾-inch bolts through these holes support the horizontal putlogs 4½ feet apart on centers. The putlogs are made with pairs of 2x4-inch timbers bolted together with ½-inch separators. The vertical suspenders pass between the timbers of each putlog and the latter project by them about 1 inch at the outer ends and about 9 inches at the wall ends. They are merely supported on the bolts without being rigidly fastened and in order to remove them it is necessary to revolve them vertically in the planes of the suspenders around the bolt nearest the wall as a center, until the outer end clears the inner edge of the outer suspender, when they can be easily removed. The lower putlog projects farther beyond the wall vertical than the others do, so a to take bearing against the face of the brickwork. This throws the lower end of the inner suspender 12 inches away from the wall, while the upper end, pivoted to the cantilever, is only 9 inches from the wall, thus providing for a gravity bearing at the foot of the framework and securing clearance for all the upper putlogs so as to avoid the possibility of thrust against the wall before the mortar has set. The putlogs support a platform of loose 2x9-inch planks which are moved from the lower to the upper putlogs as the work progresses. This is done so rapidly that a section of the floor 100 feet long extending across the full width of the building was raised in only 15 minutes.

The projecting ends of the cantilever beams are covered with a solid deck of 3-inch planks which form a convenient working platform, but are especially provided to protect the bricklayers from danger of being struck by falling objects. This scaffold is very light, strong and simple; it is easily handled and secured, and is considered very safe and satisfactory in its operation. It was patented by Mr. C. J. Clark and has been used advantageously on a number of tall buildings in this city, in Chicago and elsewhere. The first story banking rooms and most of the other rooms below the seventeenth floor were ready for occupancy May 2, or less than four months after bricklaying was commenced. The maximum force of men employed on the construction of the building was about 500, nearly all of them working only 8 or 9 hours a day.

Messrs. Clinton & Russell were the architects of the building and Mr. J. Hollis Wells consulting engineer. The George A. Fuller Company was the general contractor for the building, which was erected under the supervision of Mr. C. J. Clark. The structural steel was furnished by the Carnegie Steel Company. The Foundation and Contracting Company, of New York City, did all the pneumatic caisson work.

The Erection of the Monongahela River Bridge, Pittsburg.

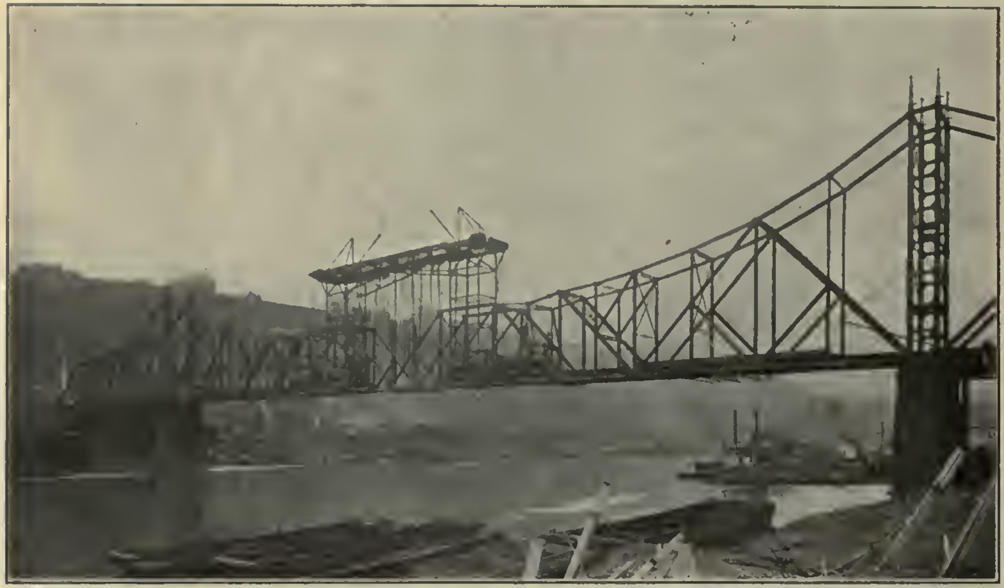
PART I.—GENERAL FEATURES, FALSEWORK, DERRICKS AND ERECTION OF ANCHOR ARMS.

The double-track bridge across the Monongahela River, at Pittsburg, for the Pittsburg, Carnegie & Western Railroad, is 1,504 feet long, between centers of anchorages, and has a channel span 812 feet long on centers of main piers. It is a through pin-connected structure of the cantilever type with secondary panels and trusses from 60 to 186½ feet deep and about 70 feet in clear height above low water. It is the largest and longest span of this type ever built, and forms a part of the extensive bridge construction of the Wabash system's entrance to Pittsburg. The design of the substructure and superstructure and the construction of the former were fully illustrated in The Engineering Record of January 3, 1903. The bridge presents many features of interest and shows special details and applications of advanced practice on large-scale work. The bridge has the longest truss span yet built on this continent and there are only two truss spans in the world which are longer, both of them being of an entirely different character with riveted connections, and erected by very much slower, more costly and less accurate methods. The 1,710-foot spans of the Forth Bridge were largely manufactured at the site and erected piece-meal by dangerous and difficult methods. The 820-foot span of the Lansdown Bridge, India, had its principal members partly built up in the field and partly assembled with an elaborate system of falsework, boats and cableways. The Monongahela Bridge was manufactured complete at the shops and was built entirely of standard structural shapes, except some of the eye-bars, of which the 14x1 25-32-inch bars are the largest ever made. The finished members were erected whole, assembled and pin-connected by the general methods usually employed in this country for similar shorter spans, but there was considerable departure from ordinary practice in the application of these methods and the details of the special erection plant.

The Monongahela Bridge is notable for its dimensions; for the peculiarities of design described in the previous article; for the great size of its separate members; for the devices used in making the erection adjustments; for the large steel travelers of novel pattern used in the erection; for the special tools and other plant used in assembling it; and for the very complete and thorough analysis prepared before the erection was commenced and accompanied by detail plans and instructions directing every important step of the erection and providing in advance for the details of the important operations. In erecting the lever arms and the suspended span, the chief difference from ordinary practice lay in the use of steel travelers running on the bridge floor. The usual overhead traveler, moving on the top chords of the span in process of erection, could not be employed here, owing to the exceedingly heavy loads to be lifted which would have required much heavier bridge truss members, in some cases, and owing to the sharp inclination of the top chords. Consequently, travelers running inside the trusses on the bridge floor were used, and on account of their necessarily great height and capacity, they were made of steel.

The superstructure weighs about 14,000,000 pounds, including the 2,175,800 pound center span 360 feet long. The riveted members were made at Penycod, Pa., and the large forged bars at Ambridge, Pa. All the steel work was delivered by rail to a storage yard about two miles up stream, classified and piled in reverse order to its sequence of erection, so that it did not require extra handling or sorting. From the yard the members were shipped to the site on barges and hoisted directly to the falsework or cantilever arms as required. This method was adopted because on the side of the river where the materials could have been delivered by rail, there was no space for storage, and on the other side where it could be stored, there were no tracks for its delivery. The largest members had a maximum length of nearly 130 feet over all, and a weight of about 101,000 pounds for the main vertical posts. These, however, were shipped in two sections each, the largest single member handled being the lower chord section 5-L 7-L, which is about 61 feet long and weighs 72,000 pounds.

Anchor Arm Falsework.—Very heavy falsework was built between the anchor and main piers on both sides of the river to support the anchor arms during erection. Work was commenced at the anchor piers where the shortest bents occurred. They were framed and bolted together horizontally on the ground, and the first three of them were revolved into a vertical position by means of tackles attached to their caps and passing over the top of the anchor pier. After they had been braced together to form a stable tower a wooden traveler was built on top of them, and with it the succeeding bents were erected. On the south side of the river the falsework for the 346-foot anchor arm had to be arranged to clear eight tracks of the Pittsburgh & Lake Erie Railroad, which were nearly at right angles to it, besides a trestle and slag pile of the Clinton Iron & Steel Company. This was accomplished by introducing 80-foot plate-girder spans supported on wooden trestles, and involved special framing of those bents. The bents were spaced 30 and 40 feet apart on centers to conform with the panel points and were braced together by numerous lines of horizontal longitudinal pieces, and, where practicable, by longitudinal X-bracing, forming several towers, as indicated in the general elevation. Comparatively light bents were set against the faces of the piers; the intermediate bents were made much heavier and were framed to correspond in general with the special bents here shown. Three kinds of bents were used, single bents under the 30-foot panels at the shore end of the span, where the weights to be supported were the smallest, double bents under the 40-foot panels at the river end where the maximum loads occurred and special auxiliary bents under the ends of the plate-girder spans. Besides these there were pony bents carrying the stringers over the plate-girders which spanned the railroad tracks.



Monongahela River Bridge: Travelers at Middle of Suspended Span.

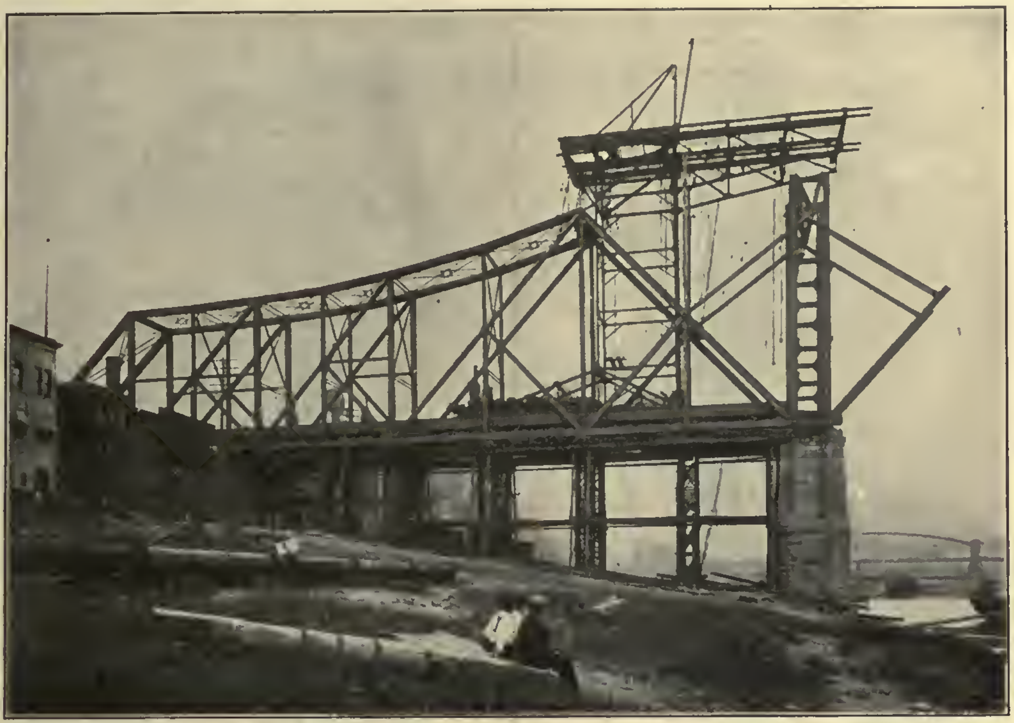
No piles were used in the falsework, all bents having transverse bottom sills supported on longitudinal and transverse sleepers bedded on the leveled surface of the ground or in shallow excavations. In general, the regular bents had two inclined posts, battered 6:1 and ten vertical posts in two separate groups supporting each truss and traveler track. The sills and top and intermediate cap timbers were made in two pieces spliced on the center line of the bent so as to be continuous, and, with the two stories of transverse X-bracing, united the otherwise independent halves to make a single wide bent. There was an exception to this rule where the slag pile extended under one side of the falsework to within about 8 feet of the center line of the bridge. Here, on the opposite sides, two similar bents, 5 and 6, were used to carry one truss and track, and only the opposite truss and track were supported on the plate-girder span. Bents 3 and 4 were located so near the walls of buildings that there was not clearance for the standard construction, and it was necessary to modify them by the omission of the batter posts so that they were only 52 feet wide over all instead of 72 feet as in other cases.

The vertical and batter posts, sills, grillage timbers and caps were made of 12x12-inch yellow pine timber. The 8x10-inch longitudinal timbers were 32 feet long. All diagonals were made of 4x8-inch timber from 28 to 38 feet long.

The scabs are made of 3x12-inch planks 4 feet long, except at the ends of the batter posts, where 3x½-inch steel plates are used. All connections were made by ¾-inch bolts. The middle caps are not properly caps at all, but are pairs of 6x12-inch timbers bolted on outside the scabs which splice the continuous sections of the vertical and battered posts. At the tops of the posts there are double caps, the lower one being made of oak and reaching only across the group of vertical posts and the upper one being much longer and extending from the batter post to the center of the bent. Similarly oak timbers 16 feet long are interposed between the tops of the bottom sills and the lower ends of the vertical posts. Twelve lines of 20-inch 65-pound I-beams were used as stringers for the traveler tracks and to support the trusses. These were seated on 1-inch steel bearing plates and lapped past each other at every bent. The upper stories of all corresponding bents were made alike and the lower stories were modified to correspond with the irregularities in the surface of the ground.

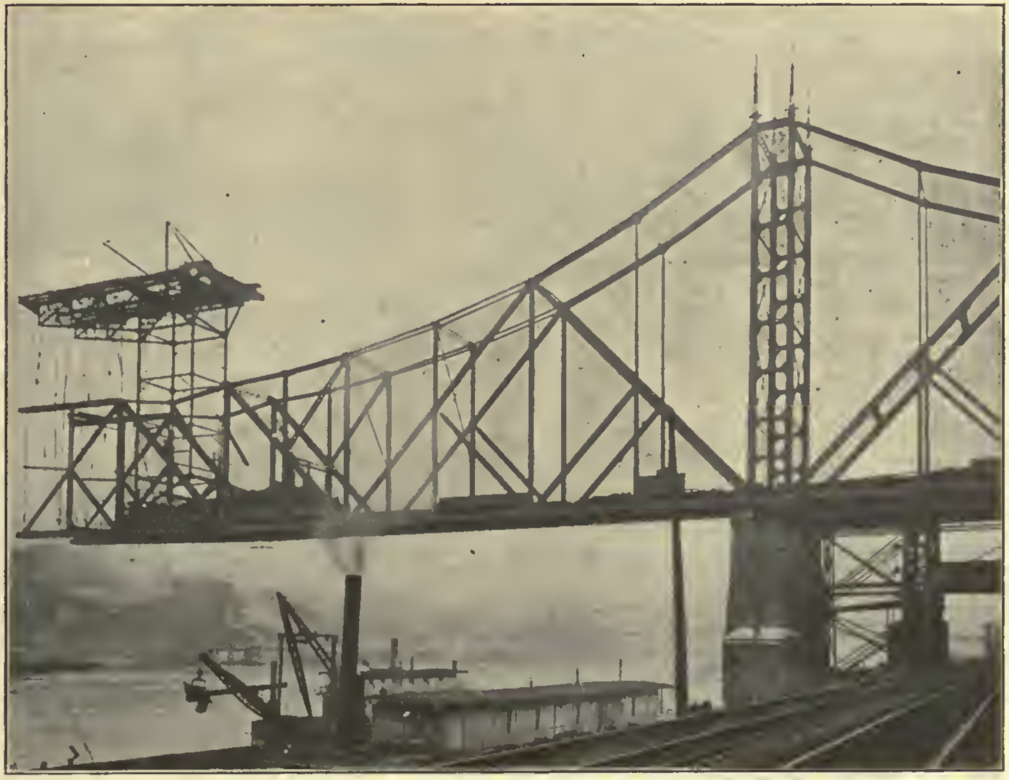
The falsework timber was not mortised or framed except by cutting the square and beveled ends to exact length, and being of commercial sizes and long lengths will be valuable for future use.

The plate girders over the railroad tracks are supported on single bents bolted to the faces of the double bents 8 and 11, as shown in the semi-elevation. They have single caps carrying pairs of 12-inch transverse I-beams on which the ends of the girders are seated. The girders are sway-braced together in two pairs under each truss, and are connected at panel points by pairs of 12x12-inch timbers spliced at the center to have a total length of 56 feet, giving an overhang of about 9 feet at each end. These timbers are secured against longitudinal movement by chocks bolted to their under sides so as to engage the girder flanges, and their cantilever ends are kneebraced to the lower flanges of the outside girders. At each panel there are two of these transverse timbers 6 feet apart which serve as sills for the pony bents for short towers which carry the main stringers. The intermediate vertical posts in these bents are seated on groups of short longitudinal I-beams which distribute the loads over grillages to transverse timbers covering about 12 feet in length of the girder flanges.



Monongahela River Bridge: North Anchor Arm and Falsework.

Over the slag heap and tracks of the Clinton Iron & Steel Company the position of the plate-girder spans is such that the top flanges are flush with those of the main stringers, and no pony bents are needed above them. Four girders are used in this span to carry one side of the bridge and traveler. Two of them are connected by sway-bracing and the other two are spaced closely together and separated by transverse timber struts, all of them being enclosed in a timber yoke which projects on one side to carry a cantilever material track. The falsework has a maximum height of about 50 feet, from bottom of grillage to top of stringer, and is built to correspond with the 1-per cent. grade. The erector was furnished with diagrams of elevations for the falsework caps, blocking, clearance of steel work, center line of pins under dead load, center line of pins under no stress and center line of pins elevated to allow for probable settlement in the falsework. These showed the positions of the camber curve and provided for a maximum settlement of 2 inches at the center of the span. The floor-beams and stringers were assembled and connected together before the erection of the trusses was commenced, but the floorbeams were in no case connected to the trusses until all the chord pins had been driven. Afterwards, when the anchor arm had been coupled up and all splices filled with bolts or drift pins, pairs of 100-ton hydraulic jacks were inserted in the spaces left between the camber blockings and wedges and were operated to take up settlement and lift the lower chord pins to the line of no stress, after which the floor-beam connections were riveted to the trusses.



North Cantilever Arm and End of Suspended Span.

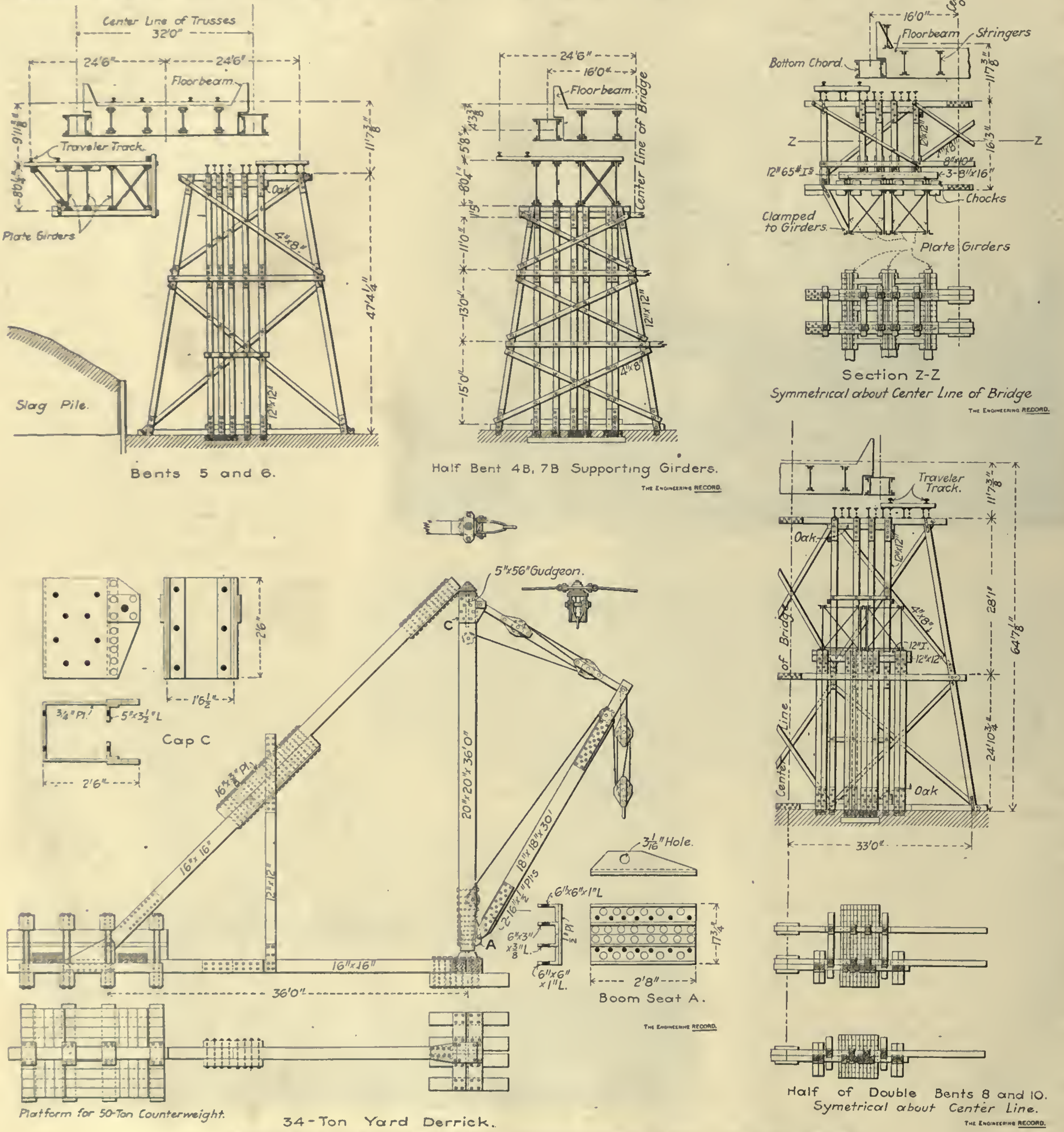
The falsework for the north anchor arm corresponded to that for the south anchor arm, except that there were no plate-girder spans in it and it was composed of six regular double bents and five single bents, besides the bents adjacent to the piers. There was no longitudinal X-bracing between either single or double bents, except in the second and third panels from the anchor pier, and there was only one tier of horizontal longitudinal struts. The hight to base of rail varied from about 32 feet at the anchorage to 57 feet at the river pier.

Derricks and Travelers.—On account of the large number of members in the main span, it was necessary to arrange them in the storage yard so that they could be delivered rapidly to the bridge site. They were stored in large and high piles and were handled in the yard and at the site by powerful derricks with long reach. Some steel boom derricks of standard construction previously adapted for heavy erection work were used, and special wooden derricks were built for this work and made so as to be also suitable for future extra heavy work. The materials were handled at the storage yards by a special 34-ton wooden derrick on the wharf. Timber platforms were built on the extremities of the sills at the foot of each stiff-leg and were loaded with 35 tons of counterweight. The stiff-legs were connected to the sills by 4-inch pins and pairs of ½-inch jaw plates thoroughly bolted to both members. Each stiff-leg was made, as shown, of two overlapping pieces spliced by thirty-five ¾-inch bolts through ⅜-inch washer plates. The sills were also made in two pieces spliced with pairs of 8x16-inch wooden fish plates 6 feet long. The top of the mast was fitted with a riveted steel box which provided for the connections there without cutting the timber, except to receive the 5-inch gudgeon pin. Special links and loops were made for the connections of the tackles to the boom and mast and two sets of thirteen-part tackles were provided, both of them rigged with ¾-inch steel rope, reeved through special steel blocks with large sheaves. The foot of the boom was beveled to clear the mast at an acute angle and had jaw plates engaging the 3-inch pin through lugs on a riveted base plate bolted to the foot of the mast.

The falsework traveler had a horizontal platform of heavy timbers mounted on wheels and provided with a vertical transverse bent in front, on which were erected two 50-foot booms. The traveler moved on several lines of riveted stringers, which later formed the permanent floor of the bridge and carried one four-spool hoisting engine. Two special steel derricks were erected on the falsework to hoist steel from the barges; one of them, of 30 tons capacity, had a 44-foot mast and 25-foot boom, operated by a 60-horse-power hoisting engine.

The other, of 12 tons capacity, had a 30-foot mast and 50-foot boom and was operated by a 35-horse-power hoisting engine.

The floor-beams and stringers were assembled on blocking at panel points by the wooden falsework traveler. Afterwards the wooden traveler was moved close to the 12-ton steel derrick and both together erected the main steel traveler as high as they could reach. The upper part of its tower was, however, assembled by a gin pole, and when it was completed a wooden boom derrick of 12 tons capacity was set on top. This derrick erected singly the 10-ton trusses of the overhanging arm, which were assembled complete in a horizontal plane on the top of the falsework, hoisted up and supported until the connections to the tower were bolted. This derrick was also used to erect the four transverse timber bents about 40 feet high, built on top of the tower to extend it sufficiently to assemble the upper part of the main pier vertical posts which could not be handled from the overhang. It was left in position during the erection of the bridge so as to be ready for use in taking the traveler down. As the traveler had a total height of about 150 feet and was assembled on a comparatively narrow base over 100 feet above the water, exposed to high winds and not susceptible of being readily guyed, its erection was a somewhat difficult task, but was successfully accomplished.



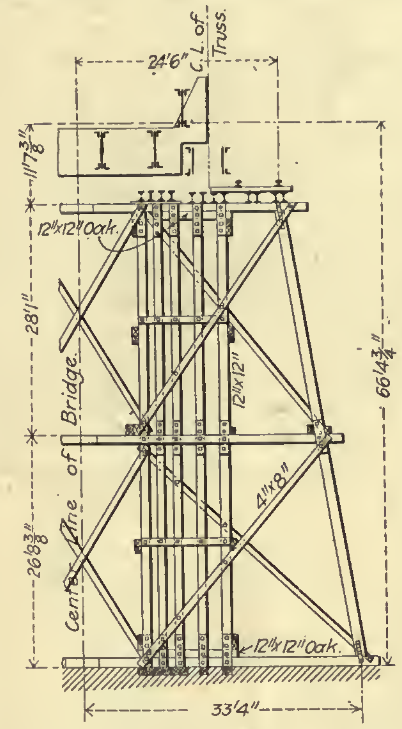
Monongahela River Bridge: Details of Yard Derrick and Falsework for Anchor Arms.

The traveler had a Z-shaped outline with a 22x31-foot steel tower about 109 feet high, an upper arm overhanging about 63 feet in front to carry the numerous tackles for assembling and supporting the truss members and a corresponding bottom arm on the rear which was counterweighted by the hoisting engines, boilers, etc. The traveler and rigging weighed about 228 tons, and had an 84-foot wheel base; although not guyed it was found perfectly stable in the strongest winds. The strain sheets specifications and drawings for it correspond to those for high class railroad bridge work; special steel was ordered for it and it was proportioned for a large factor of safety for the maximum loads.

Erection of the Anchor Arms.—The erection foreman was provided with complete diagrams of every position of the traveler from the anchorage to the center of the river, which showed the number and order of members to be lifted at each position and gave necessary instructions for special requirements or precautions to be observed. The members for the anchor arm trusses were distributed on the falsework by push cars on tracks outside the center lines of the trusses. The traveler commenced erecting the anchor arm at the anchor pier, and, moving between its trusses, finished the span complete behind it as it advanced to the main pier, special provision being made to prevent any omission of temporary sway-bracing in advance of the traveler or as it was in transit. Members assembled in advance of the traveler were generally handled by two sets of falls suspended from the upper transverse girders or from the bracket girders of the overhang. The top lateral bracing could not be assembled until after the traveler had passed out of its panel and was handled by tackles suspended from the rear overhang.

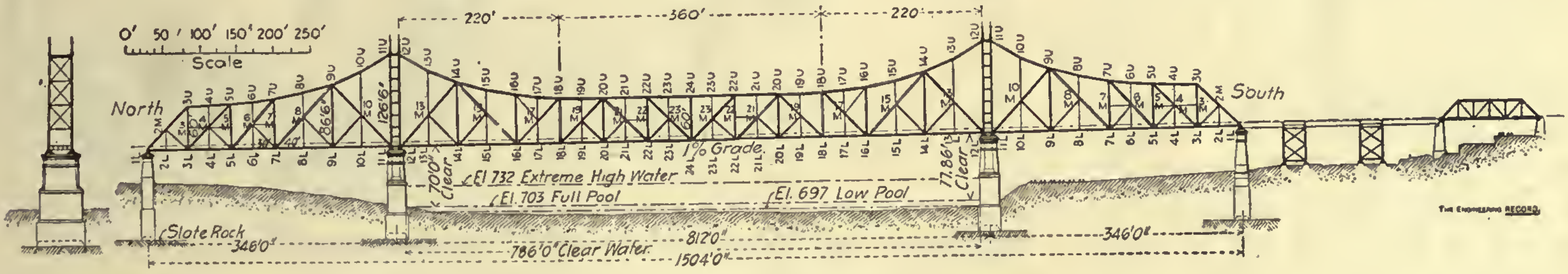
Beyond the main pier the truss members were principally hoisted by the traveler directly from barges in the river as they were required for assembling, but some of them were hoisted by the derrick to the top of the falsework and delivered by push cars on a material track laid on the bridge floor between the traveler tracks. The cantilever arm was assembled without false work by the traveler assembling a panel and a half of the trusses and one panel of the floor system in advance of its wheel base on the completed structure and then advancing on it, and so on until the cantilever arm and one-half of the suspended span was finished and the trusses from opposite sides of the river met.

On account of the large number and unusual size of the members at some of the panel points it would have been difficult to drive the pins by the ordinary method and so they were assembled on temporary pins of reduced diameter which were connected to the permanent pins with sectional pilot nuts. Temporary subdiagonals with special wedge adjustments were used for supporting the first panels of the cantilever arms and thus enabled the traveler to assemble the trusses with a one and one-half-panel overhang when a two and one-half panel overhang would otherwise have been necessary, but would have been very objectionable on account of the great length and heavy loads to be supported at the extremity. The erection adjustments for the final connection at mid-span of the ends of the opposite cantilever arms in the center panel of the suspended span consisted of screw operated wedge apparatus in the lower chord, and of screw toggles of novel design, commanding panels of false top chords at the ends of the suspended span. They were simple and economical and their operation was satisfactory and rapid.

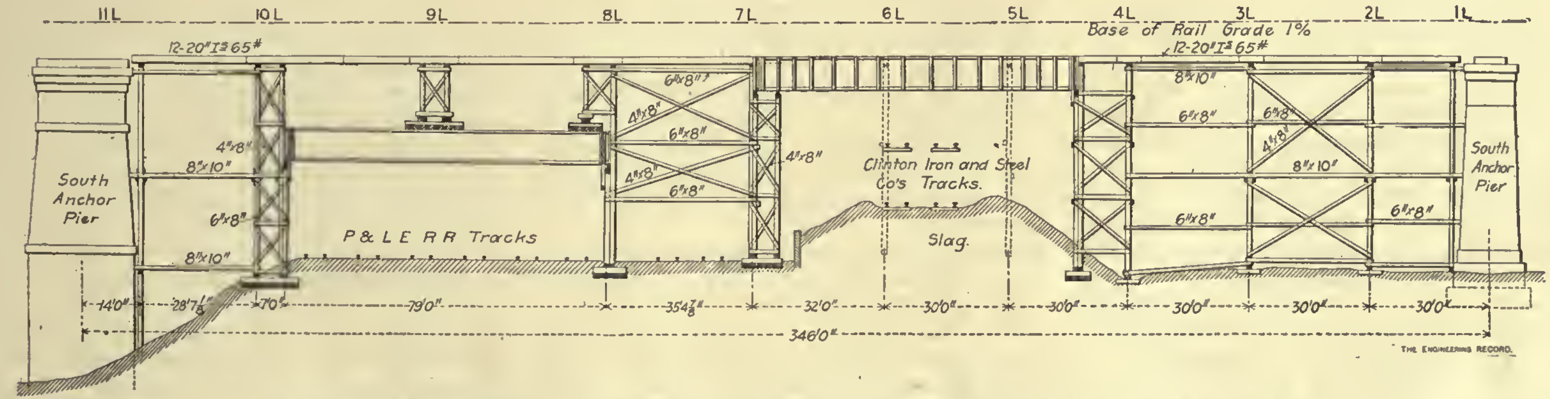


Half of Single Bents 3, 4, 5, 6 and 7 Symmetrical on Center of Bridge.

The Engineering Record.



General Elevation.



Monongahela River Bridge: General Elevation and Elevation of Falsework under South Anchor Arm.

The erection on the south side of the river was like that on the north side and was carried on simultaneously, the plant being the same as on the north side except that the wooden viaduct traveler there had a revolving instead of a fixed mast. The traveler on the south side of the river set its half of the bridge without event. On the north, or Pittsburg side, however, the traveler sustained an unfortunate accident which resulted in the death of ten bridge men, as described in The Engineering Record of October 31, 1903. On October 19, while the traveler was working well within its capacity, the lower chord of the cantilever truss collapsed and the overhang revolved downwards against the bridge trusses. After careful investigation the only reason to which failure can be ascribed is that the bottom chord of the overhang in the panel next the traveler tower had become injured a short time before by a blow, probably from the 2-ton steel ram, used in driving pins. This apparently buckled some of the lattice bars and forced the chord out of position, so that when it was subjected to live load the stress was greatly increased by the eccentricity and the member failed under a static load well within its normal capacity and much less than was safely sustained before and afterwards by it and by the duplicate traveler on the other side of the river. The bridge itself was entirely uninjured by the accident and the traveler sustained little damage except in the overhanging arm. The work of removing the wreckage was very difficult and expensive, and considerable trouble was experienced in securing men to perform it. This mishap caused a delay of several weeks in the erection of the bridge, which was suspended on the other side of the river until the traveler was again in commission. Work was actively resumed on the erection about the first of January this year, the final connection was made February 6 and the span was swung February 11.

The Monongahela bridge was designed by Messrs. Boller and Hodge, consulting engineers, of New York, and was fabricated by the American Bridge Company. The erection was performed by the American Bridge Company of New York, of which Mr. S. P. Mitchell is chief engineer, Mr. H. A. Greene, manager, Pittsburg division, and Mr. J. A. Sheedy, superintendent.

(To be continued.)

Constructing Engineers are desired by the Reclamation Service, U. S. Geological Survey, and an examination of candidates will be held on April 1 by the U. S. Civil Service Commission. The positions pay from $3,600 to $4,800 a year. The subjects of the examination and their relative weights are as follows: Education and technical training, 10; professional experience in general engineering, 20; professional experience in construction, 50; detailed technical description of the most important piece of engineering work done under the competitor's supervision, 20. The examination can be taken anywhere. It is hoped to fill the positions with engineers of wide professional reputation, and in rating the examination papers the Commission will be assisted by a board of eminent engineers. Engineers desirous of taking the examination should write at once to the U. S. Civil Service Commission, Washington, for form 304 and special form.

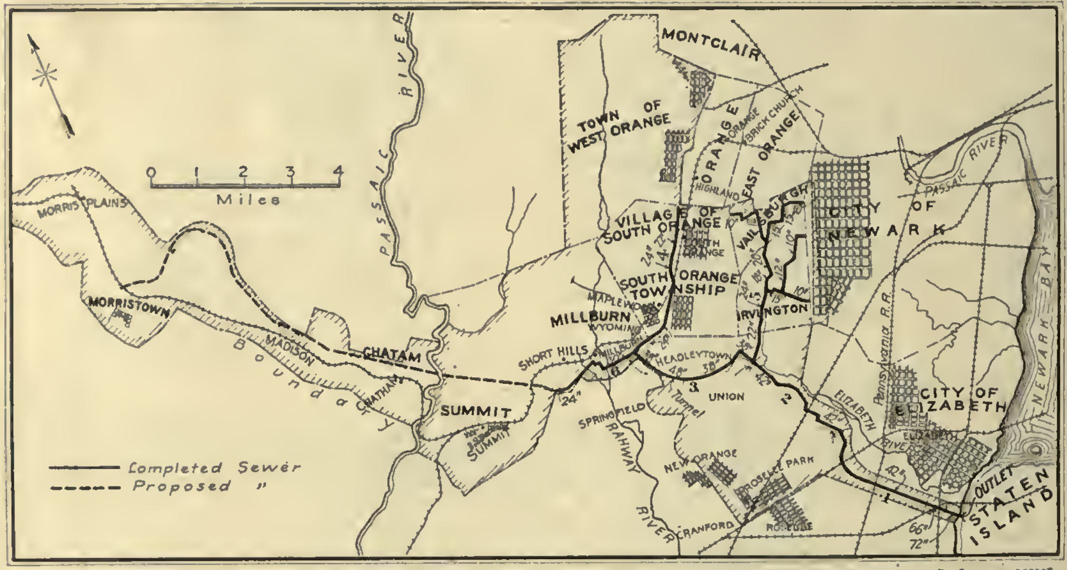
Construction of a Joint Trunk Sewer System in the Valleys of the Rahway and Elizabeth Rivers, New Jersey.

The joint trunk sewer, constructed for the benefit of the municipalities of Summit, South Orange, West Orange, Vailsburgh, Irvington, Millburn, Roselle Park, a portion of the city of Newark and the city of Elizabeth, all in the drainage basins of the Rahway and Elizabeth rivers in the northeastern part of the State of New Jersey, is completed with the exception of 300 feet of a 3,750-foot tunnel through the divide between the two river valleys. The sewer was made large enough for the admission of Morristown, Madison, Chatham and Morris Plains, which, with the major portion of Summit, will have access to the sewer by a tunnel two miles long through Hobarts Notch.

The territory which is served and the various branches of this sewer system are shown on an accompanying map. The Irvington-Newark branch has been completed for several months, and this portion of the sewer is now being used by Irvington, Vailsburgh, and a portion of Newark and South Orange. It is hoped to have the entire sewer in operation by the end of this month. The scheme is said to have originated with the town of South Orange in 1896, then one by one other municipalities desired to come in, thus necessitating restudy, additional surveys and re-design some eight times or more before the system as built was finally determined upon. The total territory for which the constructed sewer provides has an area of about 51 square miles, with a present population of nearly 40,000, while the proposed branch to Morristown, shown on the map, will drain an additional 15 square miles. The total cost of the system, exclusive of the lateral sewers built in each town, will be approximately $750,000. The joint trunk sewer with its branches constitutes a high-level gravity system, with only one siphon, on one of the smaller branches, and this has only a small drop, as shown by one of the drawings. Above Elizabeth all the contributing lateral sewers have been built on the separate system, but, owing to local conditions, provision had to be made in the joint sewer for taking off storm water also from Elizabeth. The joint sewer was designed to allow about one-third of its capacity for the infiltration of ground water, but measurements indicate, now that the system is nearly built, that this contribution will probably not be more than 15 per cent. of the capacity. Located, as shown on the map, the outlet end of the sewer is 1½ feet above low-water level and discharges into 22 feet of water in Staten Island Sound at a point where favorable currents carry the sewage out into the bay. On one side of the outlet there are copperas works, and on the other a fertilizer factory, neighbors whose contributions to the sound are such as to mask the fresh sewage and from whom there is small likelihood of complaints.

The organization effected to construct this sewer had many points of originality about it. A general law, introduced on behalf of the municipalities in interest, was passed authorizing two or more municipalities to build and maintain a joint outlet or trunk sewer and permitting each town to issue bonds to the extent of 10 per cent. of its assessed valuation to provide payment for the joint trunk sewer and the lateral sewers in the municipalities themselves. The law was not mandatory upon any of the towns interested and the early struggles and preliminary work in getting so many municipalities with conflicting interests to agree upon an acceptable basis of procedure would make an interesting tale, but it is beside our purpose to discuss this side of the question.

Mr. Alexander Potter, consulting engineer, of New York City, has been identified with the scheme from its inception, as chief engineer, and the plan of apportioning the cost of construction recommended by him was adopted. He suggested the capacity which each town should have in the outlet sewer, and with few modifications, the proportions suggested were adopted. The method of apportioning the cost was determined on the basis of the assumptions that each town build its own independent line to a common outlet at tide water; that wherever the sewage of two, three or more towns could be merged into one sewer, the municipalities using the sewer join in the payment of the cost of that sewer in proportion to the capacity each had reserved therein; and, furthermore, that the ownership of the capacity reserved by each town be vested in that town as absolutely as if it built an independent line. This scheme recognized the advantage of location. Each municipality contributed to the payment of only such sewers as it could use, and only in proportion to the capacity made available for its service. This basis of apportionment disposed of the inequalities introduced by the method of paying in proportion to the assessed valuation. All the municipalities desired sewerage facilities which could not be secured without the cooperation of the others.



Map of Joint Trunk Sewer System in Valleys of Rahway and Elizabeth Rivers, New Jersey.

Little opposition or delay was occasioned in the discussion of the advantages or disadvantages of the various methods of assessing the expense of construction. The board having executive control of the work was legally made up of the boards of aldermen and the councils of the various communities, but practically each of these bodies was represented by one of its members.

Although the cooperating municipalities were clothed with ample powers of condemnation for right of way across private land and through foreign municipalities, counsel advised against hastily invoking the law, which possibly might jeopardize the success of the scheme by injunction and certiorari proceedings, the end of which might have been to tie up the work indefinitely, involving as they would the question of the constitutionality of the act under the authority of which the work was undertaken. Under this procedure rights of way cost more than the preliminary estimates. The cost of the right of way in cash was $40,000, in addition to which $30,000 was expended in increases in the size of the sewer for the benefit of Elizabeth, the construction of roads in Union Township, the building of new roads over the sewer in Millburn Township, and the securing of new water supplies for farms, all of which were in part considerations for rights of way. Besides these direct expenditures, rights were also granted certain other municipalities and private individuals to make use of the sewer without compensation, to the extent of 2 per cent. of its capacity. With other contingent expenses the cost of the right of way was brought up to $83,000, or an average of 74 cents a foot over the entire line.

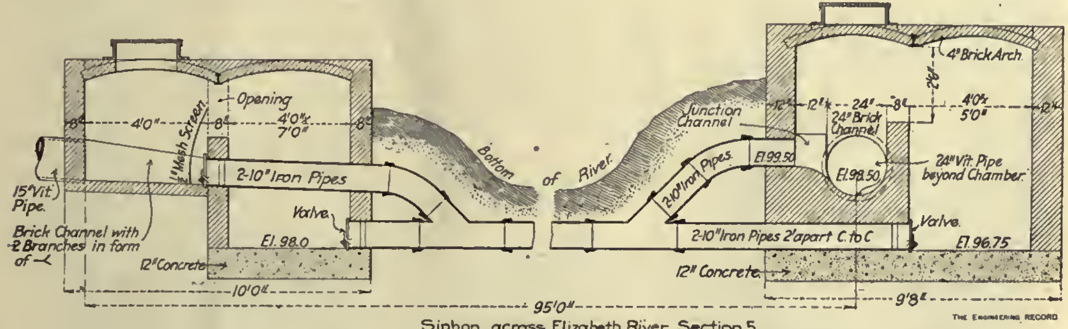
The total length of sewers constructed conjointly, not including the systems of lateral sewers built by each municipality within its own boundaries, was a little over 23 miles, and consisted of the following sizes and lengths:

2,275	feet,	3-ring brick,		72-inch
1,145	"	3-ring "		66-inch
3,754	"	2-ring "	(tunnel)	48-inch
29,770	"	2-ring "		42-inch
590	"	2-ring "		38x56-inch
9,282	"	2-ring "		38-inch
1,625	"	cast-iron pipe,		36-inch
5,778	"	2-ring brick,		30-inch
26,444	"	vitrified pipe,		24-inch
8,201	"	"		22-inch
4,406	"	"		20-inch
1,715	"	"		18-inch
7,514	"	"		15-inch
8,507	"	"		12-inch
10,717	"	"		10-inch

Construction was commenced in May, 1902. The work was divided into six sections.

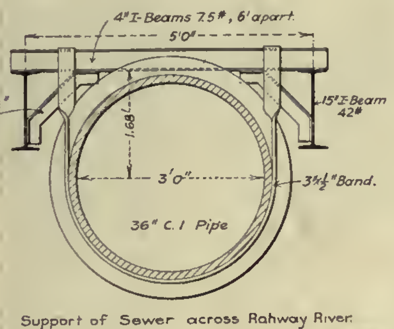
Section 1 included the construction of 2,275 feet of 72-inch circular brick sewer, 1,135 feet 66-inch sewer, and 15,613 feet of 42-inch circular brick sewer. The 72-inch sewer extends to within 30 feet of the dock line established by the Riparian Commission, and is prolonged by a 36-inch cast-iron pipe carried down below low water mark, which conveys the normal sewage flow to the end of the dock, where a strong current is always running. The principal feature in connection with the construction of this section was the use of a steam shovel to do the excavating for about two-thirds of the trench. A Victor steam shovel, made by the Toledo Foundry & Machine Company, Toledo, O., of 1 cubic yard capacity was mounted on a platform on wooden rollers, which straddled the ditch. The shovel pulled itself ahead by means of a ⅝-inch steel rope running through a block, fastened to a deadman ahead. A modification of the cross-section of the sewer was necessary where one of the streets crossed beneath a railroad. Bayway, at the crossing of the Pennsylvania Railroad, is so depressed that it was impossible to maintain the regular sewer section without lowering the flow line of the sewer, and so a concrete-steel section 6 feet wide by 18 inches high was substituted, for a distance of 150 feet, with proper approaches on either end. The contractor for this section was Mr. Thomas J. Shea, of Quincy, Ill.

On section 2 the principal point of interest is the crossing of the Elizabeth River. The line was kept out of the river bottom on this section. From the point where the two main branches of the sewer come together the grade selected is such as to gain on the fall of the river a sufficient elevation to carry the sewer by gravity to a deep water channel, which, along any other route, was difficult of attainment. This diversion of the line from the river bottom also reduced the amount of the troublesome drift material and quicksand for which this section of New Jersey is most justly famous. Across the river 42-inch cast-iron pipes were substituted for the brick construction, and massive concrete abutments were built on either side of the stream channel, which was considerably widened. The pipes are supported by posts of bent 60-pound rails footed in large blocks of Portland cement concrete, as shown in one of the drawings herewith. The posts are spaced 12.2 feet apart so as to place one under each pipe near its bell. The use of rails was resorted to in order to give as great a clearance between supports as possible. The ends of the 3x½-inch wrought-iron bands around the pipe are brought to a 1¼-inch square section and bent at right angles into hooks. A 1-inch U bolt with threaded ends passes through a hole in the rail and through holes in a 6x2¾-inch plate placed over each bent end of each band and is bolted down tight. It is possible with this device to take up any slack occurring from time to time. The river was widened to give a clearance under the pipe sufficient for the volume of the flood passing down the river. The tributary watershed at the point of crossing is about 600 acres. While in times of freshets the water rises nearly to the top of the pipe, there is little impact against the structure, because during such times the high water is caused by the damming up of this branch of the river by the east branch which joins it 300 feet below the crossing and has a tributary territory six times as great. The crossing has been constructed for a year and a half and has not been affected in any way, notwithstanding the fact that there has been in that period a flood or two of almost unprecedented volume. The contract for this section was awarded to the Harrison Construction Company of Newark, N. J.



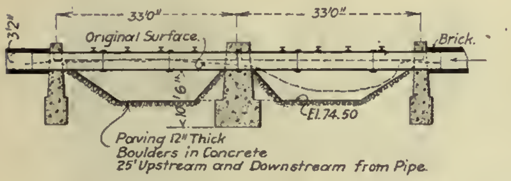
Siphon across Elizabeth River, Section 5.

THE ENGINEERING RECORD



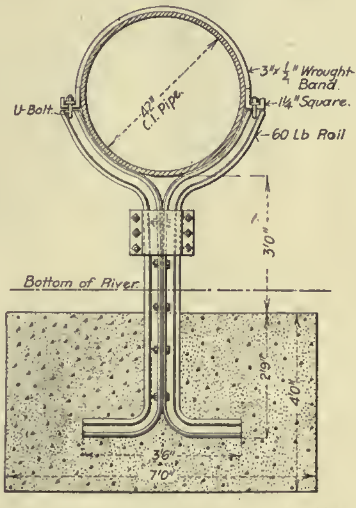
Support of Sewer across Rahway River.

THE ENGINEERING RECORD.


3'2"
33'0"
33'0"
Original Surface.
Brick.
6"
10'
El. 74.50
Paving 12" Thick Boulders in Concrete 25' Upstream and Downstream from Pipe.

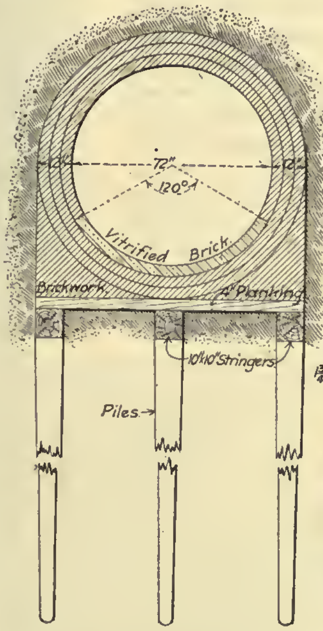
Longitudinal Section of Rahway River Crossing.

THE ENGINEERING RECORD.

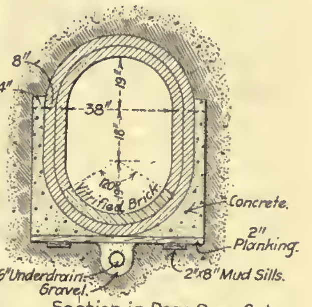


Support of Cast-Iron Pipe at Elizabeth River Crossing on Section 2.

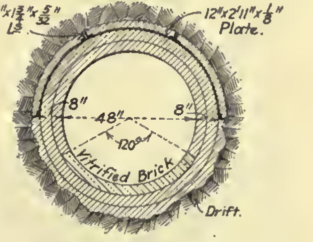
THE ENGINEERING RECORD.



Near Outlet of Section 1.



Section in Deep Open Cut, Adjoining Tunnel.



Section in Tunnel with Steel Plate Lining.

THE ENGINEERING RECORD

Joint Trunk Sewers: Details of Three River Crossings; Cross Sections in and Near Tunnel and Near Outlet.

Section 3 was by far the most difficult section to build and is more varied than any other in its constructive features. Fully 80 per cent. of its open cut brick sewer was built upon a quicksand foundation, and it embraces a tunnel 3,754 feet long, a 1,625-foot cast-iron pipe sewer supported above the surface of the ground, and a river crossing with the flow line of the sewer having a clearance of 18 inches above the normal water level of the river. The sizes of the sewer on this section are 48-inch, 38-inch and 36-inch. It is upon this section that the sewage is carried through the divide from the valley of the Rahway River into the valley of the Elizabeth River. The borings along the line originally surveyed for the sewer convinced the engineer that the excavation would prove to be of the most difficult nature, a large proportion of the material being a drift composed of clay, sand, quicksand, boulders of a great variety of sizes, and water, in varying percentages, sometimes differing widely in character within short distances. The line was changed, therefore, to reduce as much as possible the excavation of a greater depth than 22 feet, considered in this case to be the economical limit of tunnel construction, although by so doing the length of sewer was somewhat increased. The wisdom of this change was clearly demonstrated when work was started on the tunnel by the open heading method.

The contractor sank a shaft and attempted to drive a heading from it by the ordinary methods for timbering in soft ground, but in four months excavated only about 30 feet of tunnel, at an expense of between $4,000 and $5,000. The timbering was so badly displaced and twisted as to be only an obstacle in the way of any further operations at that place. When the utter uselessness of proceeding further by this method was realized, work on the tunnel was temporarily abandoned. The suggestion of the chief engineer to adopt the use of compressed air was concurred in by Mr. W. M. Brown, Jr., engineer of the Metropolitan Sewerage Works, of Boston, who was called in consultation, and the size of the sewer was increased from 38-inch to 48-inch, which allowed the brickwork to be completed as the excavation advanced, thus simplifying the construction. An auxiliary agreement was entered into with the contractor giving him an increase over his original bid on a 38-inch tunnel commensurate with the proportionate increase in the capacity of the sewer, and a sub-contract for the compressed-air work was made with Mr. C. M. Haskins, of Boston, who installed the necessary plant.

Since the adoption of compressed-air methods, the work in the tunnel has been conducted from two new shafts, one 40 feet deep, the other 22 feet deep. The former was made by open excavation to a depth of 25 feet through gravel into compact material. A 12-inch timber deck was constructed at this level, upon which was bolted a 4-foot steel cylinder, extending to the surface, to the upper end of which a T-shaped, double chambered air lock was attached. The deck was cut out inside the cylinder, and when air was admitted a brick casing was carried down under the deck to the level of the sewer. The major portion of the plant was located at the deeper shaft and a 5 and 6-inch line of pipe for compressed air was run to the second shaft. The plant at the main shaft consisted of the following machinery:

A 75-horse-power upright and a 60 horse-power horizontal boiler, a 6x4x6-inch Worthington feed pump, a 6x8-inch automatic engine, a General Electric Company's 30-kilowatt generator for lighting, a Davidson 10x16x16-inch compressor, an Ingersoll-Sergeant 16x20x24-inch spray compressor, a Knowles 12x16x8-inch water-jacketed compressor, an air receiver, a 6x8-inch double-drum Flory hoisting engine, and a 6x4x6-inch Worthington pump. This shaft was fitted with a 5x5x12-foot T-shaped steel plate lock, with two chambers. The machinery at shaft No. 2 comprised a 20-horse-power Mundy boiler, a 6x8-inch Flory single-drum hoisting engine, a

4½x2¾x6-inch Blake pump and a 10x20x24-inch Knowles compressor. On this shaft there was a vertical, single-chamber cylindrical air-lock 6 feet in diameter with a door in its bottom opening directly into the top of the shaft. Through this door cylindrical buckets of 6 cubic feet capacity were lowered and hoisted to convey the spoil from the excavation and the materials for the tunnel lining. Work was started at the first shaft in June, 1903, and at the second shaft in October, 1903. Up to the first of this month 2,400 feet of completed sewers were built from the first shaft, and 1,040 feet from the second shaft, the progress averaging 12 feet for each working day.

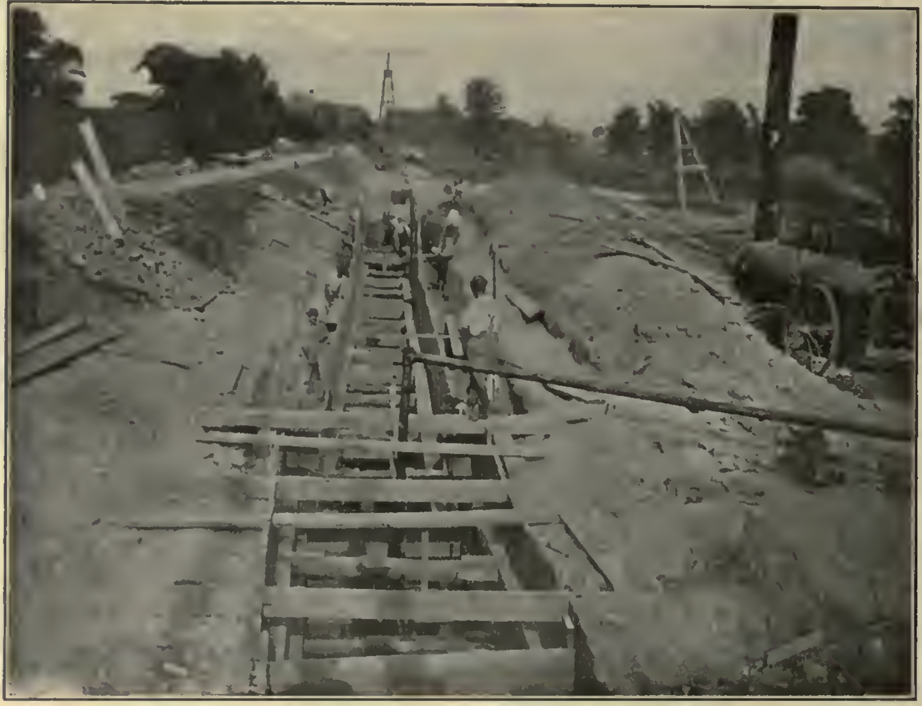
Where the tunnel went through drift the material was so homogeneous that the air losses were small, and the excavation proceeded without the use of plates or shields, excepting where quicksand was encountered, and then roof plates were necessary. These were made of ⅛-inch sheet steel and were stiffened on their edges with 1¾x1¾-inch angles, which also served as flanges and had bolt holes spaced 6 inches apart. Each plate is 1 foot wide by 2½ feet long. Alternately two and three plates were used in a course in the roof of the heading, the longitudinal joints being staggered and the spaces at the ends of the two-plate courses filled with small pieces of thin board. These plates were temporarily held in place by extension braces, the bottoms of which rested on timber blocking. As rapidly as the plates were placed all joints between them were bolted and then covered with blue clay, of the consistency of putty smeared on by hand, to prevent air leakage. The roof of the tunnel at one point comes to within 10 feet of the surface and the air was held at this place with extreme difficulty. Wherever possible the plates were removed as the lining was built; in other places the brickwork was built against them.

The air pressure required varied from 10 to 15 pounds per square inch. This expelled the ground water so thoroughly that the materials which had given such insuperable difficulty when attacked by the open-heading method could now be excavated comfortably and expeditiously, much of the time not even requiring boards at the faces of the headings, although the diameter of the excavations was about 5½ feet. However, nests of boulders gave some trouble and occasionally an unusually large boulder had to be blasted. The spoil and the materials for the lining were transported to and from the shafts in small cars, pushed by hand along a narrow-gauge track. Near each shaft the vertical diameter of the lined tunnel was made slightly greater than 4 feet as a matter of convenience during construction. Excepting the bricklayers, the men employed in the tunnel were colored laborers and worked in two twelve-hour shifts. Excavation and lining followed each other successively in each heading in alternate shifts. When the work was well organized and no unusual difficulties were encountered, from 15 to 20 feet of tunnel were excavated and lined in each heading per day. The tunnel was illuminated with incandescent electric lights. This method of tunneling has proved so successful that this portion of the sewer has been built more expeditiously and economically than some of the portions in deep open cut.

The quicksand encountered, locally known as bull's liver on account of its dark red color and its characteristic quaking when jarred, is a treacherous and deceptive material. Trenches can be cut in it nearly vertically if the water has been properly drained out in advance of excavation and provided no large boulders are encountered, the removal of which will cause jarring. The sides of such trenches will sometimes stand for hours unsupported if kept properly drained and not disturbed, but it was found that for safety it is absolutely necessary to sheet and brace them promptly, for if water were allowed to act on this material, or if it were severely jarred, it would run almost like a liquid. The specifications for the various sections provided that an additional payment of $1.25 should be made for the excavation of all material classed by the engineer as quicksand.

The open-cut work immediately east of the tunnel proved to be so difficult that when grade was reached it was decided to construct the sewer of a capacity equal to that of the tunnel. This was done without widening the trench by building 18-inch vertical walls above the springing line of the invert before setting the arch.

Fifteen hundred feet west of the tunnel the sewer comes to the surface and crosses the land of the Elizabeth Water Company above the surface. The sewer is built of cast-iron pipe supported on concrete piers with sufficient waterway under the pipe to take about one-half the flood volume of the Rahway River. The reason for the adoption of this grade elevation is that although the sewer intercepts the river channel about 9 inches below the tops of its banks and about 18 inches above the normal river level, across the valley, 2,000 feet from the river, the ground is 4 feet lower than the bank of the river. Dependence is placed for the safety of the crossing upon the fact that when bank high the river is not confined to its channel, but is spread out for a width of 2,000 feet, so that a large part of the flood volume passes under the long line of cast-iron pipe. The river crossing itself was not completed in time to be tested by the flood of October 8, 1903, but the spring flood should demonstrate the proficiency of the structure as planned by the engineer. Another reason for this type of construction was the necessity for keeping all sewage out of the water company's land, which contains many driven wells. Two plans presented themselves, one the construction of an inverted siphon across the river, the other the lowering of the grade of the sewer to pass under the river. As the sewer is constructed on a minimum grade for 2½ miles below the river crossing the deepening of the sewer at least 6 feet would have involved an additional outlay of $60,000. The advantage of the gravity flow line over the siphon line was considered to be so great that it should be constructed, even should it afterward be found necessary to replace it with a siphon on account of the obstruction to the waterway and the failure of the flood volume to peacefully seek the path laid out for it by the engineer. Some details of this river crossing are shown in an accompanying drawing. The river channel was widened and somewhat rectified in the vicinity of the crossing, and its bed was paved as indicated for a distance of 25 feet upstream and downstream from the line of the sewer. With good gravel within 100 feet of the work, the foundations for the piers were made heavier than originally proposed. The entire space within the timber crib work was filled ith concrete up to the level of the bottom of the river, since this was less costly than building forms inside the cribs. The contractors for section 3 as the Costa Construction Company, of Summit, N. J.

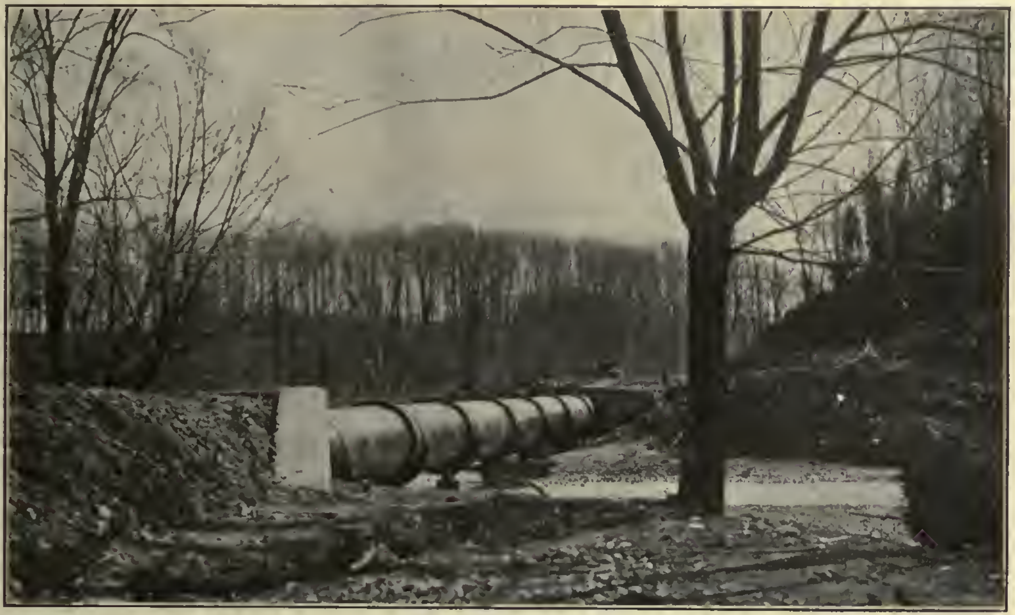


Joint Trunk Sewers: Deep Trench through Drift East of Tunnel.

Section 4 extends along the Rahway River through South Orange township and village and up to the line of the town of West Orange. It is built of 24-inch and 22-inch pipe laid with tar cement and double gasket cement joints. It is below the bed of the river for almost its entire length, and in close proximity to it on account of the numerous intersecting streets where connections will be made to the sewer. All siphons were thus avoided but the difficulties of construction were greatly increased. The material encountered for almost the entire distance was an open gravel, freely admitting the water. Mr. James P. Hall, of Jersey City, was the contractor for this section.

Section 5 consists of 8 miles of pipe sewers ranging in size from 24-inch to 10-inch. About 75 per cent. of the work on this section was constructed through rock, drift or quicksand. The trenches in the drift and quicksand were excavated to a depth of 6 inches below the pipe. Timber cradles each consisting of four pieces of 2x4-inch lumber from 12 feet to 16 feet long depending upon the nature of the bottom, spaced 6 inches apart on centers were employed, upon which were nailed 4x4-inch cross pieces of lengths varying with the size of the pipe. The pipe was laid on these cross pieces, and the spaces between the 2x4-inch longitudinal pieces and also the space below the pipe acted as an underdrain during the laying of the pipe. A vitrified pipe underdrain in the soup-like material encountered could not be kept alive for more than 50 to 100 feet and did not give as continuous a foundation as was obtained by the method adopted. Messrs. Earle & Dougherty, of Jersey City, were the contractors for section No. 5.

Section 6 extends through Millburn township, and consists of 5,778 feet of 30-inch double-ring brick sewer and 8,627 feet of 24-inch pipe sewer. No special difficulties different from those previously mentioned were encountered on this contract. Much of the brick sewer was built above the surface of the ground and much quicksand was encountered at many parts of the work. The Harrison Construction Company, of Newark, was the contractor.



Joint Trunk Sewers: Cast-iron Pipe across Elizabeth River, Section Two.

In one deep and troublesome piece of trench an excavating machine was tried, but the contractor preferred to cast out material from stage to stage. At one place five men were seen successively shoveling material from the bottom of the trench to stages and from the top stage to the spoil bank along the side. At another place a trench 18 feet deep was dug with the aid of one set of 16-foot sheeting by excavating the upper 2 feet of the trench to a greater width before starting the sheeting, this being more economical than putting in an additional set of short sheeting and bracing.

The timber cradles used beneath the sewer in some wet places made it possible to put together outside the trench two or more lengths of pipe and to make their joints under favorable conditions, thus considerably reducing the number of joints to be made under difficulty in the bottom of the trench. This method produced a more rigid pipe-line, demanding more uniform support. It was found that quicksand or other very fine sand, when carefully settled into place with water, made an excellent refilling under and around the pipes, affording a uniform and firm support, which was far cheaper and in some respects much better than concrete. Concrete, however, was used in some places where the foundation was poor. Of course, some breaks occurred on the pipe sewer lines, chargeable partly to lack of care and partly to imperfect pipes which had passed inspection, but altogether the breaks probably did not exceed 3 per cent. of the length of the pipe sewers. The only serious collapse occurred on a stretch of sewer laid with great care according to the more common practice, with an underdrain embedded in broken stone and a backfilling of earth under and around the pipes. Before this occurrence the contractor had not been in sympathy with the newer methods suggested by the engineer, but afterwards he was satisfied that in the materials traversed by the sewer line the older method was not so successful.

The pipe joints were made with gaskets of oakum and 1 to 1½ Portland cement mortar, for the most part. Late last autumn, however, Mr. Potter tried some experiments with a mixture of nearly equal parts of sulphur and fine sand, with a small quantity of pine tar, melted together. These experiments were so successful that this material was adopted and used in some of the joints on the large pipe sewer laid late in the season. The mixture is poured into the joint hot, hardens at once, and thoroughly fills the joint space. At a temperature of 230 degrees Fahrenheit it is about as fluid as heavy petroleum. Some briquettes made of this mixture of sulphur and sand showed a tensile strength of about 700 pounds per square inch. In some experimental pipe joints which were broken, the body of the pipe or the material in the joint could be split more easily than the jointing material could be separated from the pipe. At one place sections consisting of two or three 24-inch vitrified pipes were made up with this sulphur-sand compound, either on the ground beside the trench or on high blocking in the trench, and were then lowered to position like one pipe and set with the aid of a derrick, thus reducing the number of joints to be made under less favorable conditions.

Joint Trunk Sewers: Steam Shovel Digging Trench Twenty Feet Deep.

For the mortar in pipe joints and brickwork and for the concrete used on various parts of the works, Alpha, Atlas and Vulcanite Portland cements were used. The brick sewers were plastered all around on the outside with Portland cement mortar. The invert of brick sewers, including one-third of the inner ring, was laid with vitrified bricks. The cast-iron pipes used at the various places mentioned, and in a few other difficult places, were furnished by the Warren Foundry & Machine Company, of New York.

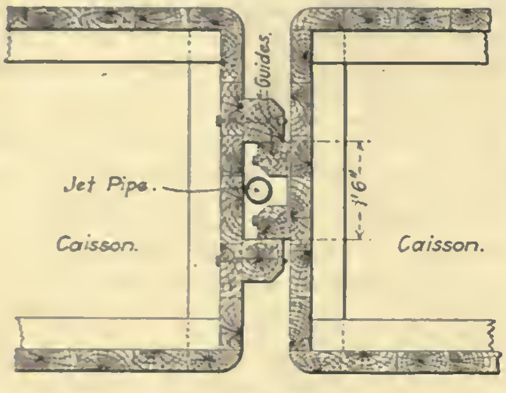
It is essential to the management of the system that the flow of sewage be measured at various points along the line of the sewers to determine the amount of sewage being contributed by the different municipalities interested in the project. These measurements are to be made at each point by means of a Dibble recording gauge set over a brick chamber about 4½ feet square inside, built to include a short piece of the sewer, to which it is connected by two small openings in the side of the sewer. The cross-section of the stream of sewage is not changed at the chamber, excepting when the sewer is running nine-tenths full, or more, when it is affected by the opening made in the top of the sewer to afford access to the interior. There is a recess left in the chamber for a weir over which the exact flow in the sewer can be determined for different depths. Knowing the grade of the sewer and its size, the quantity of sewage passing can be determined with sufficient accuracy.

Provision for equalizing tanks, at points where it was thought they might become necessary at some future time, has been made by introducing on each section short pieces of sewer having very steep grades.

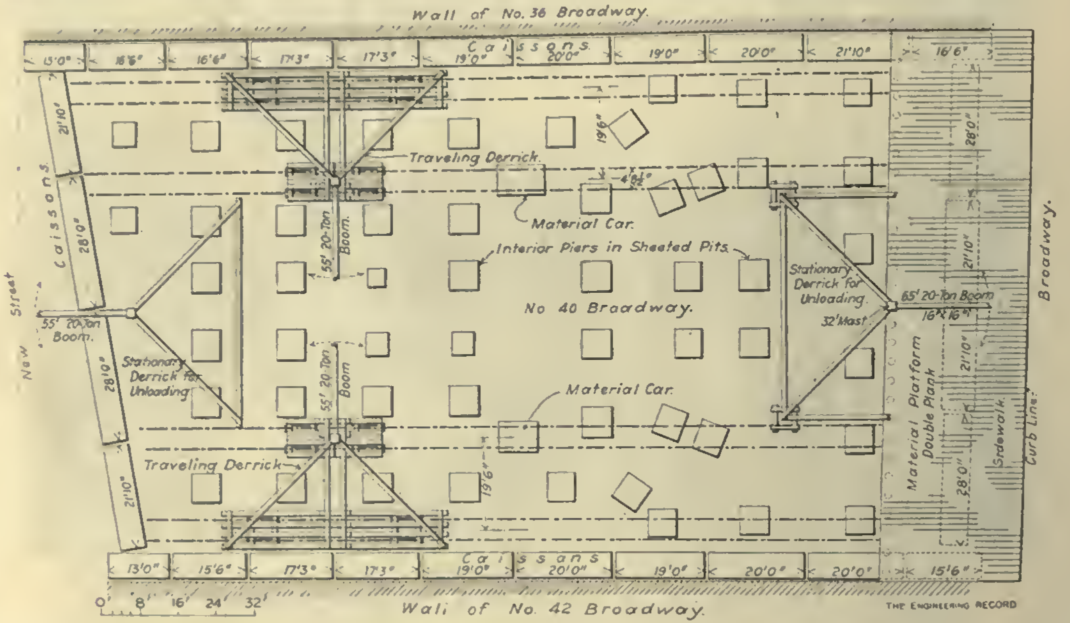
It is of interest to mention that the engineer has carried these works through to a satisfactory completion without creating trouble among the various municipalities concerned and that settlements have been made with the contractors and the former owners of the rights of way without litigation or serious dispute. This has been possible largely because of the fair-minded policy of the board representing the communities and its backing of the engineer. Mr. David Goldfogle was principal assistant engineer, and Mr. Irving Hawkins was in charge of the tunnel work.

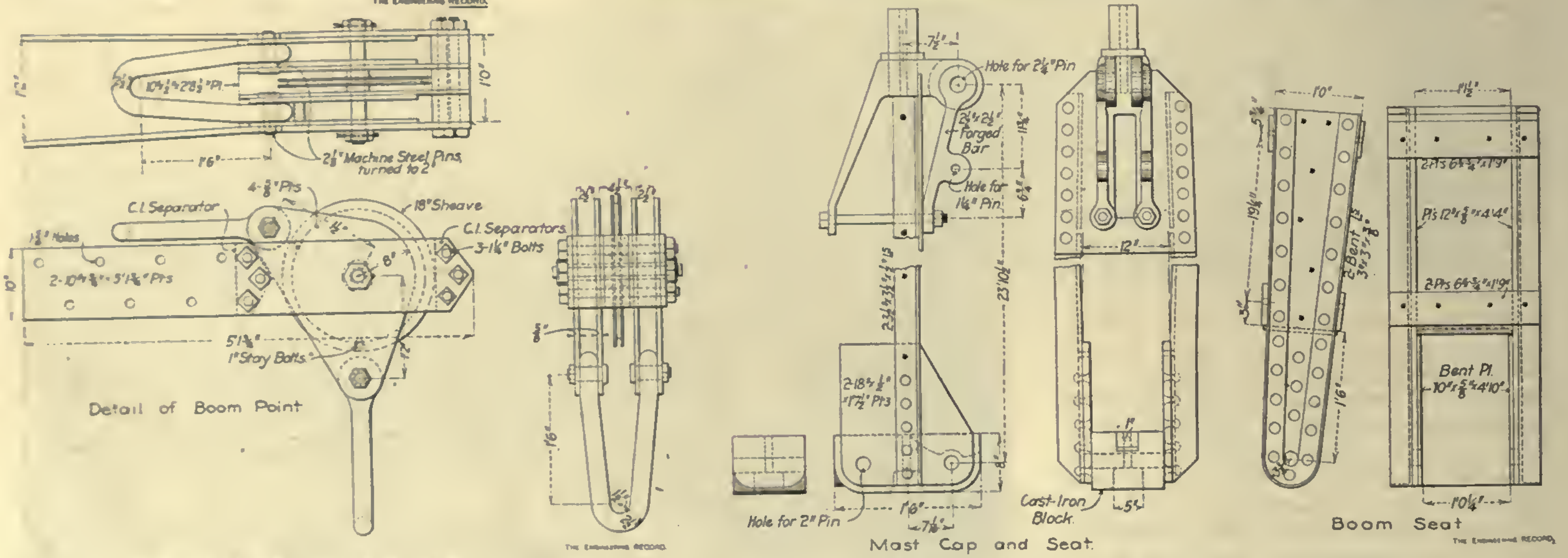
Caisson Foundations for a Large Steel-Cage Office Building on Broadway, New York.

The steel-cage office building at No. 40 Broadway, New York, occupies a lot with a front of about 114 feet on Broadway and reaches through to New Street, thus having a depth of about 200 feet. The foundations for the wall columns are twenty-nine rectangular wooden pneumatic caissons carried down to hardpan at an average depth of from about 32 to 35 feet below the New Street curb, which is about 13 feet above the ground water level. The caissons are from 13 to 28 feet in length and have a uniform width of 5½ feet, except two of 7 feet on the Broadway front. They were all built of timber, excepting a few tie-bolts and connection angles. They were designed with great simplicity of detail so that their construction was easy and rapid and was precisely the same in all cases, except for the variation in dimensions. Each had a working chamber 6 feet high in the clear with a roof of two solid crossed courses of 8x8-inch timbers. The lower edge was stiffened by an inside frame of 4x12-inch timber with the horizontal lower edge flush with that of the wall sheathing so as to make, instead of the ordinary beveled cutting edge, a flat surface 8 inches wide. The bottom of the sheathing was faced on the outside by an 8x1-inch steel plate which projected 1¾ inches below the lower edge of the timber.



Typical Joint between Caissons.





Building No. 40 Broadway, New York: General Plan of Foundations; Details of Caisson Joint and of Special Derrick Fittings.

The sides of the caisson were made of vertical 4-inch planks 12 inches wide and were continued above the roof to form the walls of the cofferdam. The sheathing was bolted to horizontal intermediate frames of 6x8-inch timbers halved together at the ends, and braced across the caisson by 6x8-inch struts 6 feet apart. These struts butted against the faces of the timbers and were secured by top and bottom 2½x½-inch plates. Adjacent and parallel to each of them, a ⅞-inch tie-rod passed through the caisson and was screwed up on outside countersunk washers so as to produce initial compression in the strut. The caissons were made 10 feet high and the cofferdam sections were from 12 to 18 feet high. Each of them had top and bottom cross frames made with 6x12-inch timber flush with the ends of the sheathing and connected at the corners by inside vertical angles. These pieces served as connection flanges and were pierced with holes for ¾-inch vertical bolts 10 inches apart to tie the adjacent sections together.

The outside of the sheathing was planed and was thoroughly greased before the caissons were sunk. The corners were rounded to a radius of 4 inches and the joints were calked with oakum. Each sheathing plank was fastened by two ⅝-inch round-headed bolts through every cross timber with nuts inside. The caissons weighed about 20 tons each, were built in the Brooklyn yards of the sub-contractors and were delivered to the site by the Meade Transfer Company on trucks drawn by twelve horses each. Their dimensions and those of the cofferdams were so great that sufficient clearance could be found in only one place down town for them to cross under the elevated railroad tracks, and difficulty was encountered in turning them around the corners of narrow streets where it was sometimes necessary to push the truck wheels transversely with hydraulic jacks. They were delivered at Broadway and at New Street to boom derricks, which lifted them from the trucks and swung them to place or loaded them on cars running across the lot from Broadway to New Street.

When the buildings which formerly occupied the site were removed, the existing vaults under the Broadway sidewalks were retained. A row of 15-inch piles 40 feet long were driven about 4 feet apart on centers across the end of the lot about 15 feet within the street line. They were capped and braced together and longitudinal and diagonal horizontal struts were set against them to brace the vault walls. They also served to carry floor-beams which rested on the ground beyond the vault walls and were carefully fitted against the edges of the Broadway pavement 10 feet beyond the curb line, a precaution which was necessary because the constant and heavy street traffic tends to force the pavement towards the sidewalk. The beams were covered with two crossed solid courses of 4-inch plank. This formed a platform at street level which served for the sidewalk, for loading and unloading wagons, and for receiving caissons and coffer dam sections. The platform was about 25 feet above the cellar floor of the old building, where large bins were built for stone and sand and filled through chutes from the street above. Opposite the middle point of this platform, and adjacent to it, there was built on the cellar floor a tower 20 feet high, and on it was set a stiff-leg timber derrick with a mast 32 feet high and a 16x16-inch boom 65 feet long with a capacity of 20 tons. This boom unloaded the caissons and coffer dams from the trucks and deposited them in place through holes temporarily cut in the platform, or delivered them inside the platform to be distributed along the side walls of the building.

At the opposite end of the lot a steel derrick with a 55-foot boom was seated on the cellar floor and in like manner commanded the New Street front and handled the larger number of caissons and coffer dams which were delivered there. Near each side of the lot there was laid a pair of parallel standard-gauge tracks 19½ feet apart on centers which extended from Broadway to New Street. On each track there moved a stiff-leg derrick with a 55-foot, 20-ton boom and a 24-foot mast. These derricks either handled the wall caissons directly from the street derricks or received them from trucks running on the same tracks and set them in position for sinking. Each derrick had a horizontal platform built of 12x12-inch timbers, arranged as shown in the sketch, and supported on four two-wheeled trucks, two under the mast and one under the extremity of each stiff-leg.

The derrick fittings were special and included a cast-steel foot block with eight vertical webs to distribute the load from the bearing 9 inches in diameter on the horizontal base 18 inches square. This block was slotted at one side, where a pair of riveted horizontal angle irons were bolted on to carry the sheave which received the lead lines coming down through the pivot of the most. The boom point was made, as shown in the detail, with heavy bolted side plates and double pairs of triangular plate links, each of which had separate pins for the connections to the shackles receiving the hoisting and topping-lift tackles. The center of the boom was slotted to receive a large sheave on the pin which connected the links. This sheave was arranged so that it could either take the lead from the six-part hoisting tackle, or it could receive the single line used for handling the caisson buckets. It was always in position ready for service, and the shackles were very easily removed and the line changed so that little trouble or delay was required to change from the slow heavy tackle to the quick single line. The mast was made with two 3½x3½x½-inch full length vertical angles calculated to receive the maximum tensile stress and to be sufficiently stiffened for compression by the timber to which they were secured by ¾-inch through-bolts 20 inches apart. The angles were riveted to the cap and base plates, as shown in the detail, in such a manner that no cutting or framing was required for the timber.

Wooden Wall Caissons, Air Locks and Unloading Derrick, Looking from New Street.

The wall caissons were sunk in simultaneous groups of three, so arranged as not to occupy consecutive positions. They were loaded with pig-iron up to about 350 tons and were sunk with a clearance of about 10 inches between adjacent ends. The cutting edge was sunk to about 1 foot below the upper surface of the hardpan, and the excavation was carried down 2 feet further and the caissons filled with concrete in the usual manner. After the alternate caissons were sunk, it was intended to sink the intermediate ones with pairs of vertical timbers bolted to the outsides of their end walls to facilitate making joints between the caissons. It was found that owing to the occasional deviations from the perpendicular it was difficult to do this and the ends of the caissons first sunk were provided with a pair of vertical guide timbers bolted to them and sunk with them as shown in the detail of a caisson joint. The adjacent caissons were sunk as close as convenient to these projecting guides and after they were concreted, a 4-inch jet pipe was sunk to hardpan in the rectangle enclosed by the ends of the adjacent caissons and a pair of guide timbers. This pipe was attached to a pair of vertical 6x6-inch timbers spaced 8 inches apart by horizontal iron bars countersunk in and bolted across them about 3 feet apart. The lower ends of these timbers were beveled so as to draw towards the caisson last sunk and they were driven in contact with it and in engagement with the guide timbers fixed to the adjacent caisson.

The timbers were easily sunk by the water jet and by loading with a 2,000-pound pile driver hammer seated on top. When they approached the hardpan, it was sometimes necessary to help the sinking by striking them light blows with the pile driver hammer. It was found possible to place these timbers in contact with the fixed guide timbers and the other caissons throughout their entire length, so as to form a comparatively tight joint closing the space between the caissons. When this had been accomplished, the water was blown out of the jet pipe by compressed air and the pipe was extended 30 feet above the tops of the caissons and filled to the top with grout of neat Portland cement. It was at first attempted to force the cement through the pipe by means of air pressure, but the cement blew out and the method with a pressure head, as above described, was substituted. When the grout overflowed the top of the pipe, the latter was lifted 2 or 3 feet and more grout poured in and so on until the caisson joint was filled to the tops of the coffer dams. After the general excavation had been made, it was found that in some cases, some of the grout had escaped, and, mixing with the sandy soil, formed a mass of excellent concrete, filling the space between the ends of the caissons and extending beyond the side walls. In some cases as much as 24 bags of cement were used for one joint. Four men and a pile driver could finish one joint a day. This method produced a joint which, although not entirely water-tight but absolutely sand-tight and was considered satisfactory and much cheaper than the joints made by stock ramming in the Mutual Life Building and in the Commercial Cable Building, which were described in this paper April 26, 1902, and May 8, 1897.

The caisson sinking was commenced September 13, 1902, and would have been completed by October 20, except that the sinking of four of the caissons was delayed by waiting for the adjacent building to be underpinned. The last caisson was finished November 8, and the joints between the caissons were made as rapidly as they were sunk. The principal quantities involved in the caisson contract were 3,600 cubic yards of excavation in the caissons, 2,063 cubic yards of concrete in the caissons and coffer dams, 286,000 feet, board measure, of timber in the wall caissons, 75,000 linear feet of oakum calking. The principal items of the plant installed for the caisson work included one Rand and one McKiernan air compressor, a large receiving tank, an air cooling apparatus, three Worthington pumps, four Lidgerwood hoisting engines, one pile driver and engine, two standard-gauge dump cars for stone and sand, one truck for distributing caissons, six ½-yard cylindrical steel buckets for caisson excavation and concreting and three 1-yard square steel buckets for coffer dam concreting. The working force included three 8-hour, 10-man shifts of sand-hogs, two 10-hour, 40-man shifts of laborers, three 8-hour, 5-man shifts of hoisting engineers, one 8-hour, 3-man shift of pile drivers, three 8-hour, 5-man shifts of derrick men, three 8-hour, 8-man shifts of carpenters, three 8-hour, 15-man shifts of concrete mixers, and three 8-hour 5-man shifts of pipe fitters.

At sub-grade coffer dams were built for the interior piers. They were forced down by loading with the granite blocks provided for the pier masonry. As the wall caissons formed a continuous dam around the lot, no fear was felt of undermining the adjacent buildings and no danger resulted from the inflow of material in the interior coffer dams. The first few of these piers required a large amount of pumping, but the later ones required little pumping. The masonry piers were built in the open coffer dams, and columns were seated on them in the usual manner.

Mr. Sylvanus Cobb is the architect of the building, and the Geo. A. Fuller Company is the general contractor. The Foundation & Contracting Company is the sub-contractor for the wall caissons, which were sunk under direction of Superintendent, Mr. L. L. Brown.

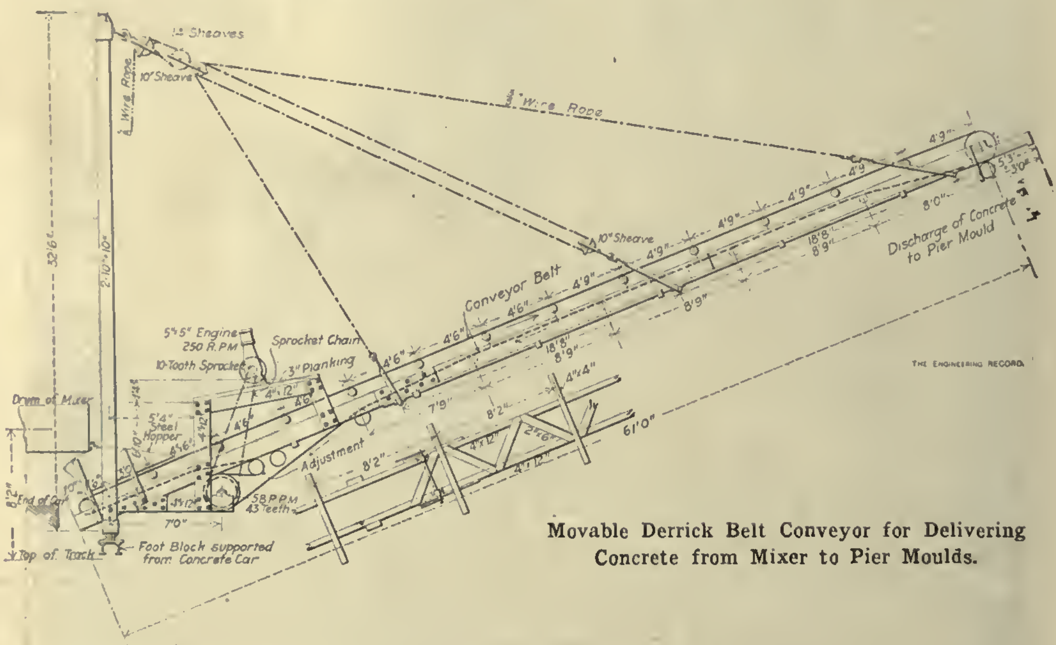
Concrete Plant for the New Union Depot, Washington.

The new union depot in Washington, D. C., will have a maximum height of about four stories and will cover an area of 760x340 feet, including the 620-foot head house 120 feet high, described in this journal October 31, 1903, and January 30, this year. The sub-structure will consist of many large concrete piers in longitudinal and transverse rows and in irregular positions. These will be carried down to about 5 feet below the surface of the ground and will extend from 25 to 40 feet above it. A special plant has been designed and constructed for mixing, handling and conveying the 15,000 cubic yards of concrete which will be required for them. The general plan involves the storage of sand and broken stone in one or more large piles, where it will be dumped from cars running transversely across the depot site. Mast and boom derricks will be set so as to deliver the materials from the storage piles to a concrete track, running transversely across the site between rows of columns, which will be shifted by 60-foot longitudinal displacements, equivalent to three rows of columns, as the work progresses. An ordinary flat car travels on the concrete track and carries the storage bins, mixing machines and a conveyor which delivers the concrete to the pier moulds as required. This equipment has a capacity of 600 yards of concrete in 10 hours, with a working force of about four men to operate the machinery, exclusive of those who deliver the materials from storage and those who receive the concrete.

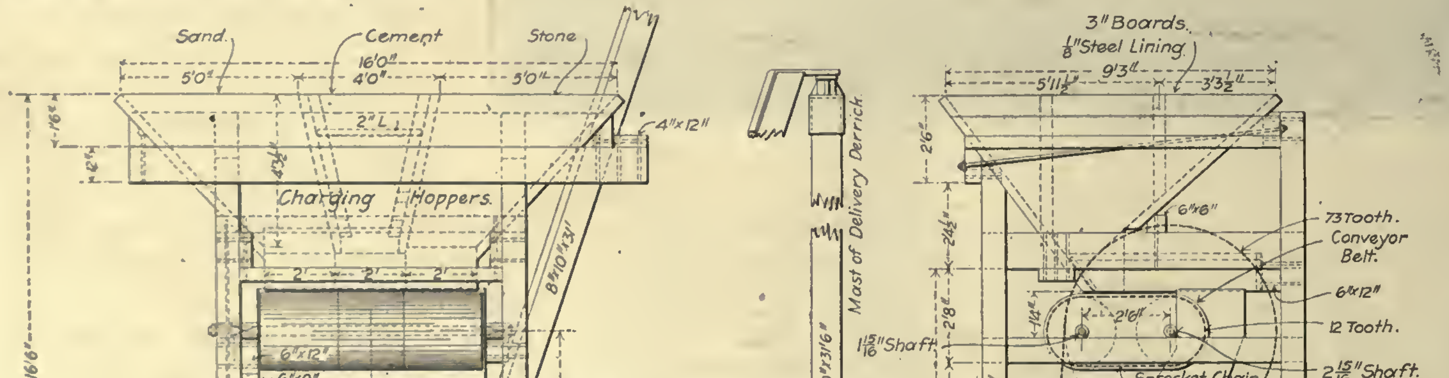
The accompanying diagrams of the plant are reproduced from the designers' preliminary drawings and show the general arrangement and method of operation without giving precise details. The concrete car carries a wooden tower about 10 feet square and 16 feet high, which supports an elevated bin 9 feet wide and 10 feet long. This has a hopper bottom, is lined with thin steel plates and is divided into three compartments for the stone, sand and cement respectively. The delivery from each division is commanded by a sliding gate which may be set to exact position so as to permit an accurate control of the discharge. The gates permit these materials to fall on the upper surface of a horizontal belt conveyor, which delivers them through a steel chute to the continuous cylindrical mixer. The mixer discharges through a chute to a belt conveyor carried on the boom of a special derrick. The derrick is carried by the concrete car and the boom is swung with the outer end over the mould which is to be filled. The conveyor then delivers a steady stream of concrete to the mould and the operation is continuous, except when stopped to swing the derrick or move the car or when the delivery from the mixing machine is temporarily interrupted without stopping its revolution. The mixing machine is gear-driven by a 9x9-inch Orr & Sembower vertical steam engine, class B, mounted on the concrete car. This engine also actuates, through sprocket chains, the belt conveyor under the storage hopper. This conveyor is of special construction made with steel links driven directly by a sprocket wheel and carrying short steel plates to receive the materials. These plates are about 7 inches wide and 2 feet long and are arranged in separate parallel lines fitting closely between the side plates of the three chutes. The center plates are blocked up 2 inches higher than those on each side so as to carry the cement without danger from moisture.

The delivering derrick is of special construction and its foot block is supported on a pair of I-beams suspended from cantilever girders on the concrete car. The boom is made with two parallel timbers braced together about 2 feet apart in the clear and pivoted to an axle passing through the foot of the A-shaped mast. It is supported by a three-part wire rope bridle attached to the extremity and to two intermediate points and reeved through sheaves arranged to secure a uniform stress throughout. The bridle is attached to one block of the topping-lift tackle so that the boom can be raised or lowered by hand through an angle of about 20 degrees when it is occasionally necessary to adjust it to the height of the pier moulds. The boom carries a rubber belt conveyor 2 feet wide, which discharges at the upper end of the boom and is operated by a sprocket chain driven from a 3x5-inch Orr & Sembower class B engine seated on a platform built over the conveyor and supported by the boom.

The plant was designed by the Ransome Concrete Machinery Company, New York, for the Thompson-Starrett Company, New York, subcontractors for foundations.



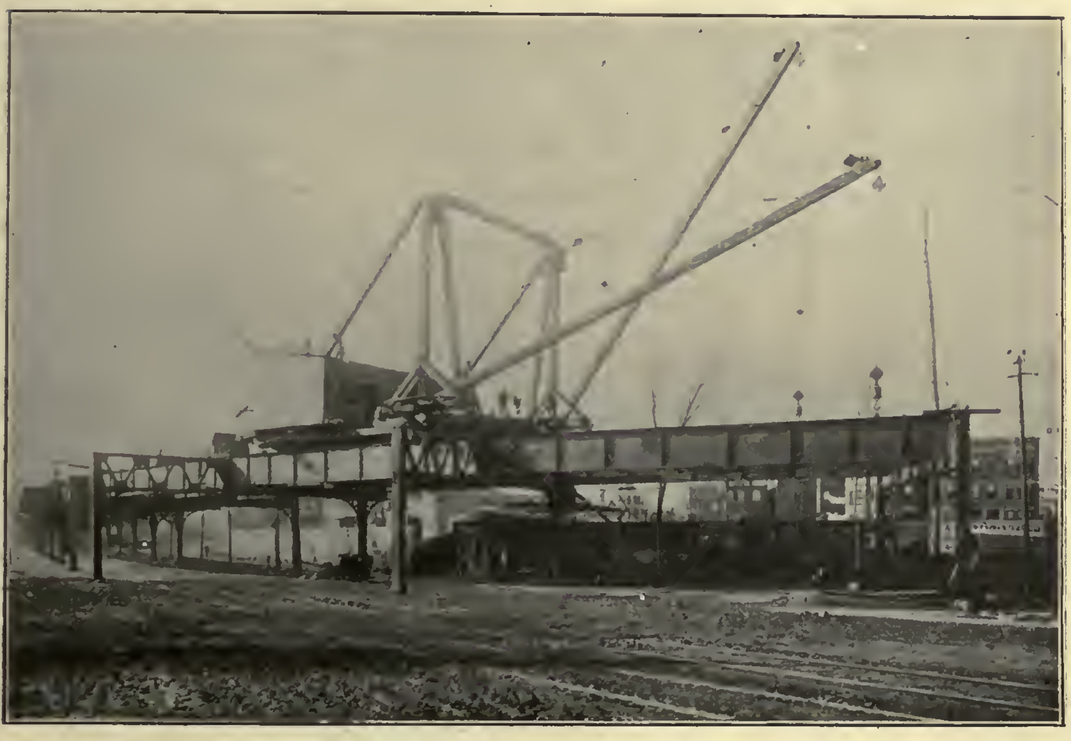
Movable Derrick Belt Conveyor for Delivering Concrete from Mixer to Pier Moulds.



CONCRETE PLANT FOR UNION DEPOT WASHINGTON: SPECIAL CHARGING HOPPER AND CONTINUOUS CONCRETE MIXER.

Erection of the Westchester Elevated Railway.

Section No. 10 of the New York Rapid Transit Railroad is a three-track plate-girder viaduct extending from One Hundred and Forty-ninth Street about three miles to Bronx Park. It is supported on two lines of H-shaped columns made with a 16-inch web plate and four bulb angles. The columns have an average spacing of about 29 feet transversely and 50 feet longitudinally. On curves where the irregular distances require special construction, they are connected by long transverse lattice girders, but in the regular sections they have plate girders with the end sections of the web extended over 4 feet below their lower flanges and riveted between the angles of the columns so as to form also the upper portions of the column webs and make solid kneebraces giving great transverse rigidity to the structure. Here the columns extend to the top flanges of the cross girders. In other cases the columns extend only to the lower flanges of the cross girders, and the girders are seated on the tops of the columns and continue across them with solid web kneebraces on both sides. The transverse girders are web-connected to six lines of longitudinal plate girders, two in the center and two at each end of the girders. The columns have an average height of 22 feet and a maximum height of 50 feet, and the girders average 5 feet in depth. The girders have a lateral bracing of diagonal angles riveted to the top flanges only and each span has four panels of vertical transverse sway bracing. The total weight of this section of the viaduct is about 16,000 tons.



Westchester Viaduct, Showing Traveler Used for Erecting the Steelwork.

The steel work was delivered by trucks from the lighters and distributed along the line, half on each side of the road in the position required for erection. Operations were commenced at bent 108, where a guyed derrick with a 70-foot boom and 85-foot mast was set up and erected the first panel of the structure, afterwards assembling on it a timber traveler, which erected the viaduct northwards from this point. After this traveler had moved to the next panel, the derrick erected, in its former position, a small traveler with a horizontal platform 30 feet long having one axle at each end. At the forward end the second traveler had an A-frame 30 feet high with steel back-stays and guys to the ends of its transverse sill. Its derrick erected a second traveler on top of the elevated structure, which moved south, erecting the columns and girders one panel in advance as it proceeded.

The large traveler has a timber platform about 34 feet wide and 40 feet long mounted on four single-flange wheels with wide treads. At the front it has a transverse vertical frame 30 feet high and two 14x16-inch booms 65 feet long, each of which can handle material on either side of the street, and, revolving 370 degrees, can set the hoisting engines on the rear platform. The 14x14-inch vertical posts of the frame are pivoted top and bottom and serve as masts for the booms. They are fitted with Terry's patent foot-blocks and have wooden framed braced bull wheels, by which they are revolved from the hoisting engines. The stiff-legs and sills are made of 12x12-inch timber and the smaller braces are 8x8-inch. The diagonals in the vertical frame are pairs of 1¼-inch sleeve-nut rods pin-connected at the upper end and having screw and nut bearings at the lower ends. The principal connections are made with steel pin-plates bolted to the timbers. The rear of the derrick has a platform supporting a double-drum Lidgerwood hoisting engine for each boom, and between them there is a small boom derrick projecting over the rear to hoist lateral angles,, sway-brace frames and other material. The platform is provided with clamps engaging the top flanges of the girders, operated by the ordinary vertical screw and hand-wheel adjustment. The traveler has stability for safely lifting a 3-ton load with each boom without being anchored to the girders. The traveler and equipment weighs about 60 tons and required a total force of 22 men, namely: one fireman, two engine men, five bridge men for the rear derrick and seven men for each of the two main booms. A ladder suspended from the traveler moves with it and constantly gives convenient access to it from the street.

Just as soon as one panel of the viaduct structure is completed, the traveler is moved forward by winding up on a single line attached to the last transverse girder, and almost before it comes to a stop, the main booms each lift a column and set it in place. The wide bases of these columns afford them sufficient temporary stability without bracing, and one boom immediately picks up the transverse girder and holds it while it is drifted and bolted to the columns. Meantime the other boom arranges the material in the street, if necessary, and then both booms simultaneously erect the longitudinal girders, which are bolted in position as fast as they are set. Simultaneously the lateral angles and sway braces have been set in place by the rear derrick. As soon as the steel is all in position, the anchor clamps are released and the traveler is pulled forward to the end of the structure and the operation repeated, one complete panel having been assembled in 15 minutes and as many as twenty panels having been erected in one day. This is equivalent to about 1,000 tons of steel in eight hours.

The traveler at the south end of the viaduct is of a different type from the one at the north end, which is illustrated in the accompanying engraving. It has a horizontal timber platform about 50 feet long and 32 feet wide, mounted on four single-flange wheels traveling on the longitudinal girders. At the front there is a vertical transverse A-frame 40 feet high with a horizontal cross-piece about 16 feet above the sill. The ends of the cross-piece are directly over the forward wheels and are connected to the sill by short vertical posts. A 14x14-inch vertical mast is pivoted to the centers of the sill and the cross strut, and to it is connected a 14x14-inch boom 67 feet long which is king post trussed on all four sides with single ⅞-inch rods. The top of the mast is braced with a pair of stiff-legs and a pair of 1¼-inch pin-connected tension rods parallel to them, engaging the connection plate which is bolted to the under side of the horizontal strut and receives the gudgeon in the top of the mast. The tops of the inclined legs in the A-frame are connected together by short sections of heavy channels bolted to the under surface and having their upper ends projecting beyond the timber and bent into a vertical plane, where they are bolted together and receive the pin-connection for the topping-lift shackle and for the pair of 1½-inch back-stay rods. This traveler, although fitted with only a single boom, has been found efficient and satisfactory.

Some danger exists from two naked live trolley wires that run parallel with the viaduct just below the girders, and it is necessary to protect the steel work by covering the lower flanges with boards wherever there is danger of contact with the wires, and the workmen, of course, exercise great care to avoid touching them or swinging the tackles against them, some of the hoisting rope having been burned in this manner. Each connection between the transverse girders and the columns has about two hundred ⅞-inch field rivets and there are in all about 800 field rivets in each pannel of the structure. These rivets are driven by eight four-men gangs following the traveler and using Boyer pneumatic hammers. Each gang drives about 200 rivets in eight hours. The hammers are operated by air at 100 pounds pressure delivered by a surface main, which is extended as the work progresses. The air is compressed in a stationary Ingersoll-Sergeant machine with a capacity of 250 cubic feet per minute, using steam from a 60-horse-power locomotive boiler.

The viaduct is being built for the New York Rapid Transit Railroad Commissioners, Mr. William Barclay Parsons, chief engineer; Mr. George S. Rice, deputy chief engineer; Mr. St. John Clark, general inspector of designs; Mr. Eugene Klapp, division engineer; and Mr. J. O. Reynolds, assistant engineer in charge of this section. The steel work is built by the American Bridge Company, and the Terry & Tench Company is the contractor for its erection.

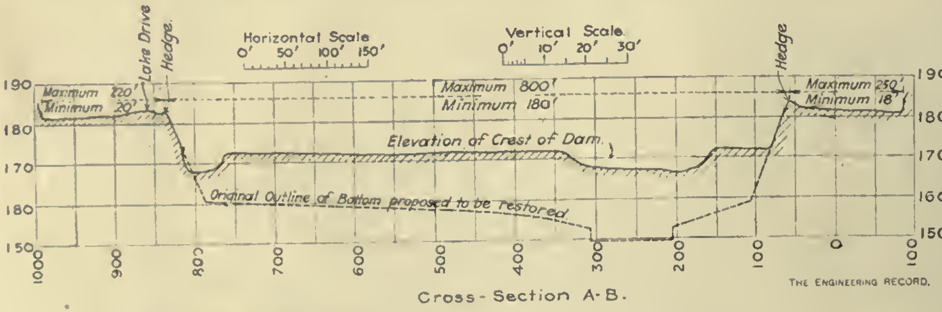
Dredging at Loch Raven, Baltimore.

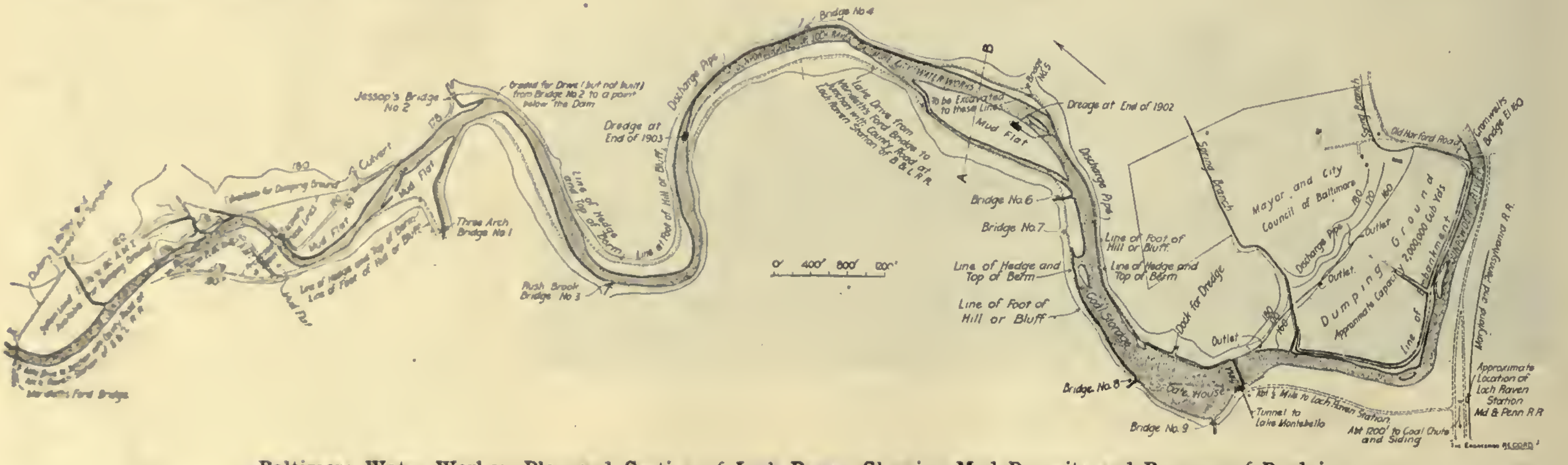
By Alfred M. Quick, Water Engineer, Baltimore.

Loch Haven is the impounding reservoir on the Gunpowder River, the principal source of Baltimore's water supply. It is a narrow winding lake following the original course of the stream in a valley with steep hills rising immediately from the banks. It is about 3½ miles long and from 150 to 700 feet wide. Its nominal capacity is about 510,000,000 gallons. The construction of the lake was completed in 1880, and it was put in service shortly thereafter. A watershed of about 260 square miles, the greater part of which is cultivated land, drains to the lake; consequently every rain washes large quantities of silt into the lake. In 1895 the silt had accumulated to such an extent that it had cut off more than two-thirds of the storage capacity and had banked up all along the shores to a height of from 2 to 4 feet above the level of the dam, leaving only a narrow channel.

When the lake was built the Water Department bought nearly all the land adjoining it, and for some distance back from its banks. Unfortunately, however, at one or two points on one side of the lake near its upper end, some adjoining land was not acquired. Consequently in addition to cutting off about two-thirds of the capacity of the lake, the accumulation of silt led to a number of suits being brought against the Water Department by people owning property at the points mentioned, for damage to their land and crops by the lake overflowing its banks after heavy rains. The courts held that the construction of the dam had caused the accumulation of silt and consequently the flooding of the land, and awarded heavy damages against the city.

To remedy this condition the Water Department, in 1895, started to buy up this land and also awarded a contract to the Harbor & Inland Improvement Company, of Baltimore, to dredge the lake for about 1,500 feet of its length above the dam, and to practically its original average depth of 15 feet. The contract price for the dredging was 22½ cents per cubic yard. For this work the company built a suction dredge at the lake with a capacity of about 100 cubic yards an hour. This contract was completed in 1896, about 300,000 cubic yards of material having been removed. All of this material was discharged over the dam into the stream below. This led to damage suits aggregating nearly $200,000 being brought against the Department by persons owning property adjacent to the river below the dam. These suits were compromised by buying one farm of about 168 acres immediately below the dam, and by the payment to other property owners of a large sum to compensate them for all further damage.





Bridge No 4
Jessop's Bridge No 2
Graded for Drive (but not built) from Bridge No 2 to a point below the Dam
Dredge at End of 1903
Discharge Pipe
Culvert
Mud Flat
Three Arch Bridge No 1
Line of Hedge and Top of Berm
Line of Foot of Hill or Bluff
Rush Brook Bridge No 3
Meredith's Ford Bridge
0' 400' 800' 1200'
Lake Drive from Meredith's Ford Bridge to Junction with County Road at Loch Raven Station of B & L R R
To be Excavated to these Lines
Mud Flat
B
A
Bridge No 5
Dredge at End of 1902
Bridge No. 6
Bridge No. 7
Line of Hedge and Top of Berm
Line of Foot of Hill or Bluff
Line of Foot of Hill or Bluff
Line of Hedge and Top of Berm
Discharge Pipe
Coal Storage
Dock for Dredge
Spring Branch
Mayor and City Council of Baltimore
Discharge Pipe
Outlet
Outlet
Outlet
Dumping Ground
Approximate Capacity 2,000,000 Cub Yds
Line of Embankment
Gunpowder River
Old Harford Road
Cromwell's Bridge El 160
Maryland and Pennsylvania R.R.
Bridge No. 8
Gate House
Dam
Abt ½ Mile to Loch Raven Station
Tunnel to Lake Montebello
Bridge No. 9
Abt 1200' to Coal Chute and Siding
Approximate Location of Loch Raven Station Md & Penn R R
The Engineering Record

Baltimore Water Works: Plan and Section of Loch Raven Showing Mud Deposits and Progress of Dredging.

In 1897, the Department, believing that it could do the dredging work itself for much less than it would cost by contract with the dredging company, purchased the dredge from the company for $17,000. This dredge was operated every year thereafter, excepting in 1898, up to the year 1902, the following approximate amounts of material being removed each year: 1897, 80,000 cubic yards; 1899, 9,000 cubic yards; 1900, 130,000 cubic yards; 1901, 90,000 cubic yards; the cost of dredging ranging from 4 to 5.5 cents per cubic yard.

Shortly after being appointed water engineer, early in the year 1900, after a thorough investigation of the matter I found that, notwithstanding all the dredging work which had been done, the net result had been to keep cleared of sediment only a small basin at the lower end of the lake. I had a survey and soundings made which showed that there were about 2,500,000 cubic yards of sediment remaining in the lake, and that about 125,000 cubic yards accumulated there each year. As dredging could be carried on only about 200 days of each year, on the average, and as the old dredge could not remove under average conditions over 1,200 cubic yards a day, it was evident that it would take with that machine over twenty years to clear the lake of sediment. Consequently an appropriation was obtained and plans were prepared for a modern dredge of sufficient capacity to clear the lake in two or three years. The contract was let to the Atlantic, Gulf and Pacific Company in 1901, to build for the Department at the lake a suction dredge of an average capacity of 350 cubic yards an hour, with coal scow, gasoline launch, twenty pontoons and about 10,000 feet of 22-inch discharge pipe, for $98,000. The hull was launched in December, 1901, and the dredging plant was completed in May, 1902. It was then given a ten days' trial run and showed a capacity 40 per cent. in excess of the contract requirement of 350 cubic yards an hour. The dredge was put in commission on regular work June 17, 1902.

Description of Dredging Plant.—The dredge has a wooden framed hull 122 feet long, 34½ feet wide and 9 feet deep, the forward end being cut out for the excavating ladder. In the hull are the main engine, centrifugal pump, discharge pipe, feed water heater and blacksmith shop. On the main deck are the winding machinery, cutter engine, fire and feed pumps, dynamo, machine shop, boilers and coal bins. On the upper deck are the pilot house forward, and the forced draft fan and the captains and engineer's cabins aft. The main engine is a 200-horse-power compound vertical engine made by Brown & Miller, Jersey City, N. J., with 16 and 34-inch cylinders and 18-inch stroke, having a nominal speed of 200 revolutions per minute. This engine is direct-connected by a 6½-inch steel shaft to a standard Atlantic, Gulf and Pacific centrifugal pump having a 74-inch cast-steel four-arm runner. There are three 125-horse-power Scotch internal-furnace boilers, carrying a steam pressure of 160 pounds, made by Brown & Miller. The forced-draft fan is of the Buffalo Forge Company's make and so arranged as to be driven either by its own steam engine or by belt from the shop engine. The winding and cutter engines are both 10x12-inch double-cylinder Lidgerwood engines. The fire and feed pumps are both 7½x4½x10-inch outside-packed plunger pumps made by the Buffalo Steam Pump Company. The dynamo and shop engine is a vertical single 7x9-inch engine of the New York Safety Steam Power Company's make. The dynamo is a 9-kilowatt General Electric machine, furnishing current for seventy-five 16 candle power incandescents, two arc lights and a search light. The machine shop tools are an 18x14-inch engine lathe, a 36-inch radial combination drill and a pipe cutting and threading machine. In the blacksmith shop, located in the starboard forehold, are a Champion forge, large anvil, blacksmith bench with vise and a full set of blacksmith tools. Over the main engine and pump is a traveling crane for handling heavy parts of the machinery. Two coal bins having a total capacity of about forty tons are located aft of the boilers.

The coal scow is fitted up with a derrick, winch and buckets, and has a capacity of about forty-five tons. The launch is 33 feet long, has a 6-horse-power gasoline engine, and was built by the Metropolitan Boat & Launch Company, of Astoria, L. I. It is used for towing the coal scow from the coal shed on shore to the dredge, for shifting pontoons, and for carrying men and supplies to and from the dredge. Other parts of the plant furnished by the Atlantic, Gulf & Pacific Company under their contract are: Twenty pontoons 24x8x2½ feet in dimensions; also the following quantities of riveted 22-inch discharge pipe, viz.: Twenty lengths of ponteon pipe 32 feet long, with flexible rubber joints, and 625 lengths of shore pipe, each 16 feet long, with telescopic joints.

In order to insure that the dredge could be kept continuously in operation it was necessary to provide some arrangements for the transfer and storage of coal. Consequently a coal shed was built on the bank of the lake about 2,000 feet above the dam, to store about 100 tons of coal, or about two weeks' supply, with chutes on the lake side of the shed through which to load the coal scow. Also at the nearest railroad siding about three-quarters of a mile from the dam, a coal pocket was built underneath the track, with a chute, so that the coal cars can be unloaded directly into the coal carts.

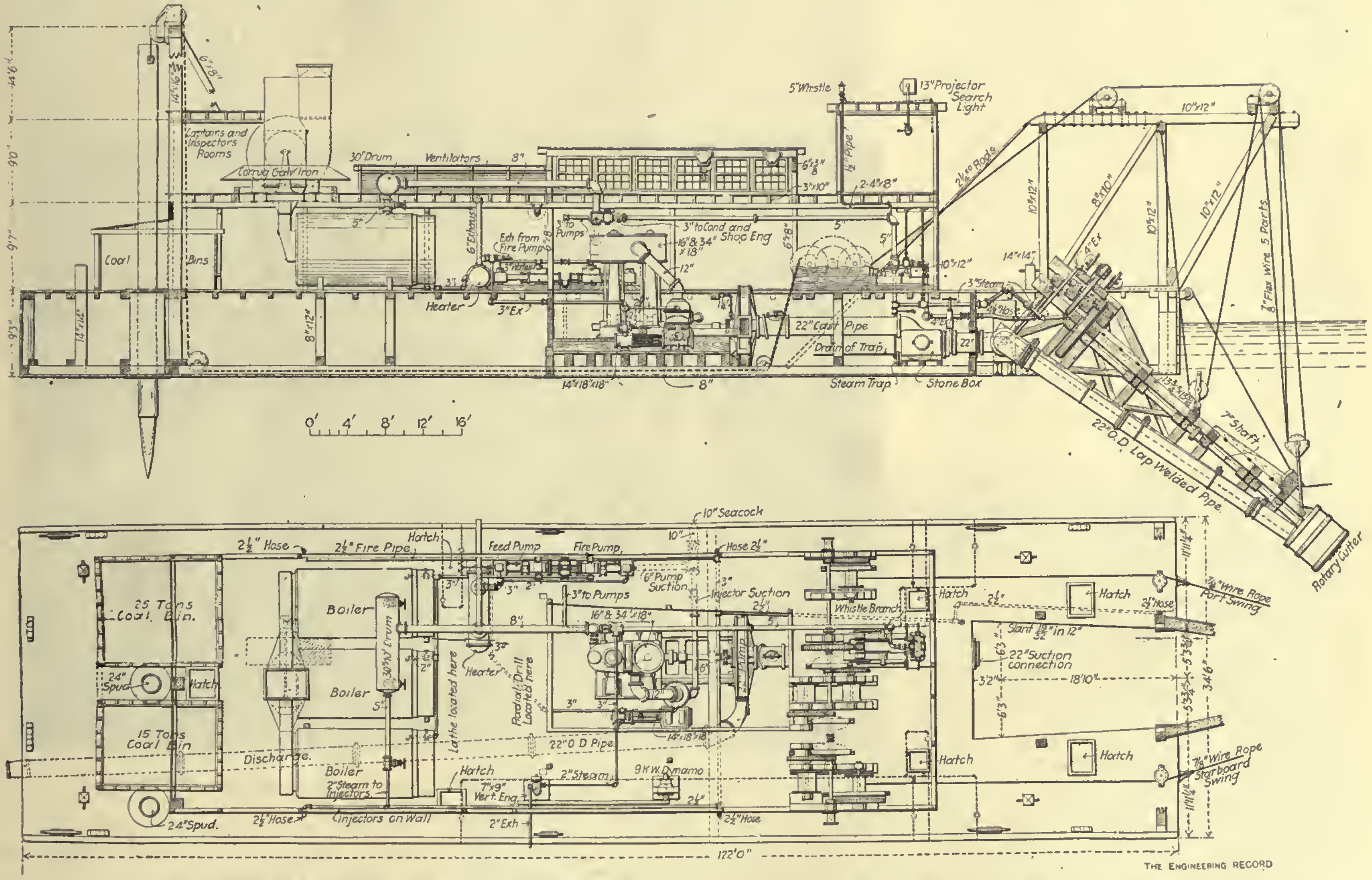
Operation of the Dredge.—The dredge is operated by two crews working eight hours each, from 4 A. M. to 8 P. M., the electric light plant and search light making it feasible to operate at night. Each crew consists of an engineer, runner, fireman, oiler, mate and two deck hands. In addition to these men there is a superintendent who has charge of the whole work and a watchman to look after the plant between 8 P. M. and 4 A. M., when the dredge is not running. Work was begun at the dam, and the dredge has worked its way up the lake, the discharge pipe being laid on shore just above the high-water line. Where the deposit of sediment is continuous and sufficient in quantity the dredge makes a cut averaging 150 feet wide and 4 feet deep. A survey is made and soundings are taken at the end of every month over the ground covered by the dredge during the month and for some distance ahead of the dredge, so as to determine the amount of material excavated during the month. Samples are taken at frequent intervals at the end of the discharge pipe to determine the proportion of solid matter pumped. This proportion is found to vary from about 10 to 60 per cent., with an average of about 35 per cent. The solid matter is composed of fine sharp sand and silt in almost equal proportions, with some stones, but no clay or gravel. Occasionally a log or dead tree branch is struck and frequently the stone box has to be emptied of large stones, but so far practically no damage has been done to the cutter or the pump runner.

About the first of December work has to be stopped and the dredge docked on account of ice; dredging is resumed about the first of April. The dredge was operated about six months in 1902, and during about one month of that period it was excavating its own dock in the bank of the lake, with space in the dock also for the pontoons and coal scow. About 411,000 cubic yards were excavated in 1902, at an average rate of about 350 cubic yards an hour of actual operation of the pump. In 1903 the dredge was operated for seven months, excavating about 538,000 cubic yards at an average rate of about 323 cubic yards per hour run.

Up to May, 1903, the dredged material was discharged over the dam into the stream below, with an elbow on the end of the discharge pipe giving some siphon action. When dredging down near the dam with only a few hundred feet of pipe out, the pressure in the discharge pipe at the pump was about five or six pounds. As the dredge worked up the lake the pressure increased at the rate of about one pound for every 345 feet of additional discharge pipe, equivalent to about one foot additional friction head for every additional 150 feet of pipe. In May, 1903, finding that the dredged material was filling up the stream below the dam near the waste water outlet from the gate-house to an objectionable extent, the discharge was turned on to a low field immediately below the dam, on the farm bought at the time the damage suits previously mentioned were instituted, berms having been thrown up around this field to hold the sediment, with waste weirs to run the water off into the river. As there was about a 10-foot fall from the dam to this field the 18-inch discharge pipe from the old dredging plant was used to run from the end of the 22-inch discharge pipe at the dam to the point of discharge on the field. With about 1,600 feet of this pipe added it was found that the pressure at the pump on the dredge was increased by about 1½ pounds over what it was when pumping over the dam at the average rate.

The dredge is now just about half-way up the lake, and is pumping through 9,165 feet of 22-inch and 1,632 feet of 18-inch discharge pipe, or a total length of 10,797 feet of pipe, which is by far the longest line of discharge pipe any suction dredge ever pumped through. The pressure on the discharge at the pump is now about 28 pounds. No difficulties have developed except an occasional choking of the discharge pipe with sediment. When this has occurred and it has been impossible to locate the point of stoppage, the dredge has been run down the lake and connected to the discharge pipe line to blow out the choked material, moving from one point to another until the pipe was relieved.

It is confidently expected that it will be possible to run for about a mile farther up the lake and still continue to pump the dredged material to the field, and it may be found possible to go still farther up the lake and pump the material to the lower end, by discharging over the dam again and putting a section of pipe below the elbow on the end of the discharge pipe to give the maximum possible siphon action. While it is preferable to pump all the material to the lower end of the lake, if pos-



THE ENGINEERING RECORD

Baltimore Water Works: Plan and Sectional Elevation of Hydraulic Dredge for Removing Deposits in Loch Raven.

sible, it is not absolutely necessary to do this, as there is a sufficient area of low ground on the city's property at the upper end of the lake to hold all the material to be taken out at that end.

Cost of Dredging.—During the winter, several men from the dredging crew have been kept at work making repairs to the dredge, scows and pontoons, moving the discharge pipe from the shore of the lake to the top of the banks, coating the pipe with fish oil, etc. The cost of all this work is charged to the dredging. The cost of dredging in 1902 was $6,532.54 for labor, $4,839 for fuel and other supplies, $1,025.33 for insurance and $102.91 for repairs, a total cost of $12,499.78, or 3.04 cents per cubic yard for the 411,000 cubic yards dredged during the year from the time that the plant was accepted and work started on June 17. During that period, the dredge was in actual operation in dredging the lake for only about five months. Also about 12,000 cubic yards of the total 411,000 was dredged for the dock from the bank of the lake, being of course much harder cutting, taking much longer time to excavate than it would have taken to dredge the same amount of material from the bed of the lake, and consequently making the cost per cubic yard a little higher than it would otherwise have been.

In 1903 the cost of dredging was $15,784.75 for labor, $8,339.14 for fuel and other supplies, $1,076.33 for insurance and $1,129.28 for repairs, a total cost of $26,320.50, or about 4.89 cents per cubic yard for the 538,000 cubic yards dredged during the year. The increase in the cost of repairs was, of course, due to the additional year of service; the increase in the cost of fuel was due partly to the greater amount of work done, and to a greater extent to the increase in pressure because of the longer pipe line. The increase in the cost of labor was due in part to the greater amount of work done and the longer pipe line, and also to the cost of throwing up the berms on the discharge field, which was about $2,096. The total cost of the work done to January 1, 1904, has been $38,820.28 for about 950,000 cubic yards dredged, or about four cents a cubic yard. The total cost of the plant, including coal shed at the lake and coal pocket at the railroad, has been $101,084.98. Including the interest on this amount at 3½ per cent. the cost of dredging has been about 4.46 cents per cubic yard.

At the time when the matter of securing a new dredging plant was taken up, bids were asked from dredging companies and dredge builders, both for building a plant for the department to do the work with, and for building a plant, dredging 2,500,000 cubic yards, and selling the plant to the city after doing the work, with either a scoop dredge or a suction dredge. The lowest bid received on the basis of the contractor's doing the dredging was for a suction dredge, a charge of 13.4 cents per cubic yard for the dredging and 15 cents per cubic yard for berms, and the plant to be sold to the city for $15,000 after completing the work. As compared with what the cost would have been under that proposition there have been saved on the work already done about $90,000, and on the cost of dredging the whole lake there should be saved nearly $200,000, or more than double the cost of the plant.

THE COAL CONSUMPTION of the two municipal plants of Frankfort-on-Main, Germany, was as follows in 1902: In one case, 3.59 pounds per kilowatt-hour for some 15,770,000 kilowatt-hours; and in the other, 3.75 pounds with a normal output of 400 kilowatts direct current and 1,000 kilowatts alternating. The cost in the first case was 0.72 cents per kilowatt-hour.

Section Five A, Second Division, New York Rapid Transit Railroad.

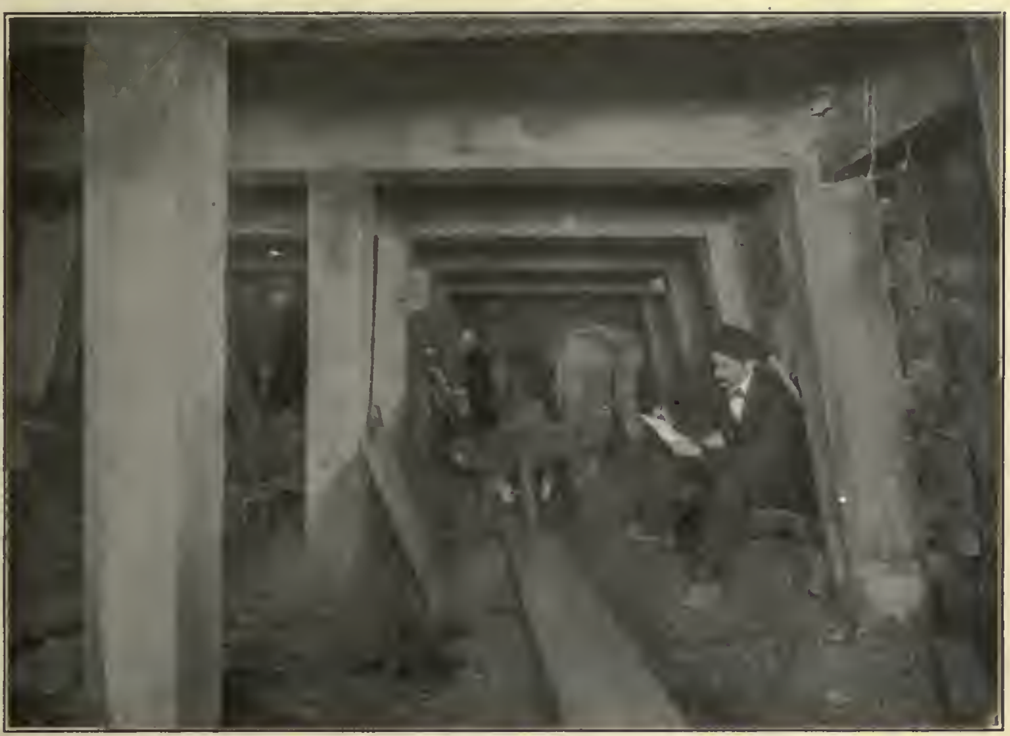
Section 5A of the Rapid Transit subway extends from Forty-first Street and Park Avenue about 4,300 feet to Forty-seventh Street and Broadway. The structure was designed and constructed under the direction of Mr. William Barclay Parsons, chief engineer of the Rapid Transit Railroad Commissioners, and Mr. George S. Rice, deputy chief engineer. Mr. Alfred Craven was the division engineer, and Mr. Robert Ridgway was senior assistant engineer until March, 1903, when he was succeeded by Mr. John H. Myers. Mr. William E. Swift was assistant engineer in direct charge of construction until March, 1903, when he resigned and Mr. Laurence C. Brink was appointed to succeed him. The Degnon-McLean Contracting Company was the sub-contractor for the work, which was awarded to the Rapid Transit Subway Construction Company, Mr. N. J. McDonald, president; Mr. S. L. F. Deyo, chief engineer. Mr. H. C. Sanford is the chief engineer for the Degnon-McLean Company, Mr. Waldo Briggs, assistant engineer.

Excavation for Madison Avenue Station, South Trench Commanded by Cableway.

At the Forty-first Street end the two east tracks were united to the Madison Avenue section by about 75 feet of concrete arch, having spans from 26 to 30 feet. The axis of this arch was curved to a radius of less than 300 feet. The concrete had a thickness of 2 feet at the crown and 3 feet at the sidewalk. The excavation was an open rock cut about 30 feet deep. The two west tracks joined one of the Park Avenue tunnels with a separate steel beam construction similar to the standards previously described for other sections of the subway. Where the four tracks swing from Forty-second Street into Park Avenue, they intersect the substructure of the twenty-two-story Belmont Hotel and beyond it are arranged so that two of them pass between and the other two on the outside of island station platforms 350 feet long between the Grand Central Depot and Madison Avenue. Beyond these platforms the tracks again converge and a stub end is added, making a set of five tracks for a length of several hundred feet, long enough to accommodate a full-length train. There are also at this point cross-overs connecting the different tracks, as at all express stations. The construction here was made with steel beams and columns built generally in open cut to the end of the five-track section. Beyond this point the remainder of section 5A conforms in general to the standard four-track beam construction. At the crossing at Fifth Avenue the roof beams are made extra heavy to carry the 24 feet of cover.

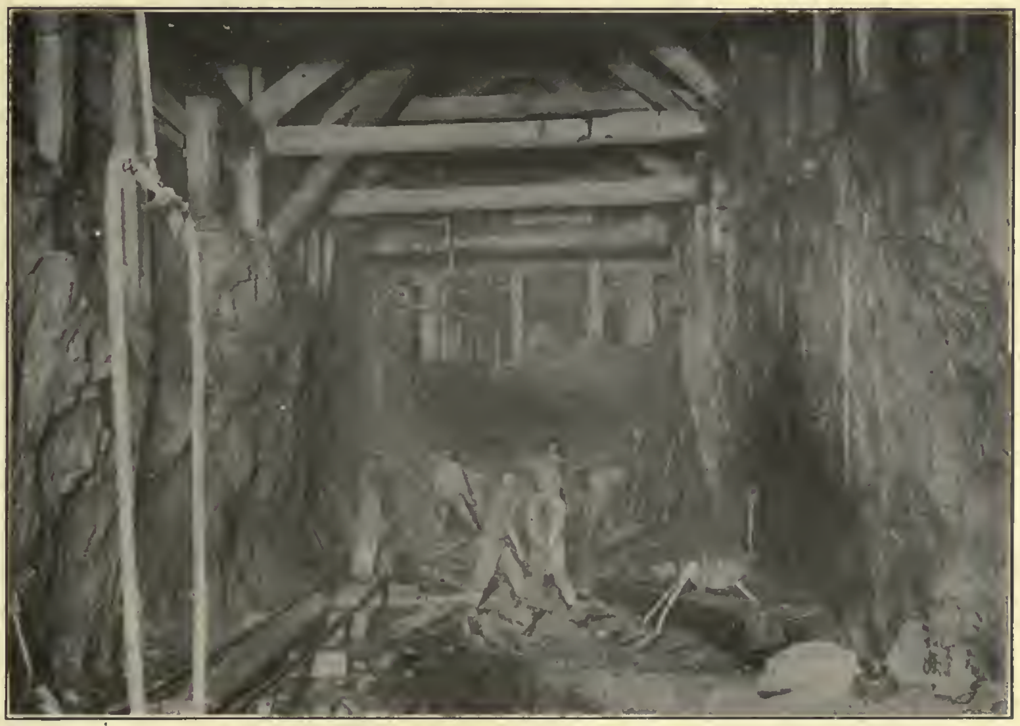
At Hotel Belmont the west track was adjacent to, and just outside of, the deep cellar excavation which was carried down about 25 feet below sub-grade to a total depth of about 55 feet below Forty-second street. At this point the stratified rock dipped sharply towards the excavation and the side of the latter was supported by a curved retaining wall of solid concrete 6 feet thick. On the subway side of this wall the tracks and roofs were supported on columns and girders, which also carried the superstructure for that corner of the tall hotel building. As it was not deemed advisable to build these column piers on the upper surface of the sloping rock, they were carried down to a depth of about 55 feet in a large open excavation, thus seating them at the same level as the other columns in the hotel. On the opposite side of the subway the columns beyond the outer track of the curve were replaced by a heavy concrete retaining wall. The 1:3:5 concrete for the retaining walls and arch construction was made with Giant Portland cement, mixed in a Ransome machine located several blocks away on Forty-second Street and delivered to the site in wagons. The arch being built to a transition curve, its cross-section varied at every point and necessitated the use of special falsework at all places so that none of it could be transferred, and the expense was thus unusually large. The frames were set radially and spaced 4½ feet apart. They were covered with lagging cut in long lengths and carefully sprung to the approximate curve of the soffit and secured in place by wedges driven against the centers. The lagging was planed on three sides with beveled edges to allow for swelling by moisture and much care was taken with it and very satisfactory results were secured.

The excavation for most of this section was made, as described in The Engineering Record of July 19, 1902, with successive longitudinal and transverse cuts covered with temporary platforms. The construction of the subway at the intersection of Fifth Avenue and Forty-second Street was complicated by the presence of two 48-inch and two 36-inch water mains in Fifth Avenue and by the safe deposit vault of the Columbia Bank on the southeast corner This vault was a heavy masonry structure extending about to the middle of Forty-second Street and Fifth Avenue and having a depth of 15 feet below the curb, so that its foundations were about 4 feet in the clear above the subway roof. Excepting over the roof of the vault, the intersection of the streets was covered by a timber platform, laid at night, with only sufficient excavation to put it at grade. The upper part of the excavation for the south local track was drifted in from the west across Fifth Avenue, the roof being supported by lagging and timber bents in the usual manner.



Stripping Rock Surface by Drifts under Timber Deck Carrying Street.

The caps were about 5 feet below the street surface, which was not disturbed, and the excavation was carried down to the surface of the rock, giving the drift a depth of about 6 feet. Special care was taken to support the water pipes on shores as they were undermined by the excavation. After the earth was thus removed, the excavation was blasted down to sub-grade in the usual manner and the concrete and steel work for one track of the subway was completed before the excavation was finished for the adjacent tracks. When the roof was completed, a heavy masonry pier was built on it to permanently support the four water mains before mentioned. After this portion of the structure was completed, the upper part of the excavation on the opposite side of Forty-second Street under Fifth Avenue was commenced by drifting in from the finished excavation on the east. This drift was made under the timber platform, supported by vertical shores set on the surface of the rock which formed the bottom of the drift. As soon as the rock surface was thus stripped by the drifting operations, lines of 24-inch I-beams about 50 feet long and 12 feet apart were set parallel to Forty-second Street underneath the water mains and were each supported by several vertical shores seated on the surface of the rock and on the bottom of the finished excavation at the east end, the water mains being carefully wedged up on them. Simultaneously drifts were driven from this excavation south under the vault which projected into Forty-second Street and in them similar steel needlebeams were set and shored up from the rock surface. The rock was then blasted out from the bottom of the drifts to sub-grade, and special care was taken to replace the shores and set additional ones to insure abundant support for the needlebeams in case any of the original supports were disarranged by the blasting.



Excavation across Fifth Avenue Ready for South Part of Steelwork.

The excavation for the Madison Avenue station was about 88 feet wide and occupied nearly the full width of the street. It was made with two separate side trenches about 25 feet wide, each of them extending from the middle of the sidewalk to the car tracks. These were made in open excavation and the spoil was handled by a Lidgerwood cableway about 300 feet long, over the[illegible]ter line of each, thus avoiding any obstruct[illegible]he two street-car tracks between the trenches. The sides were sheeted and braced to the surface of the rock, and where necessary the foundation walls of the buildings were underpinned. At the northeast corner of Madison Avenue the surface of the rock dropped nearly to sub-grade and the building there required very heavy underpinning. The rock was blasted out to sub-grade in the usual manner, care being taken to use light charges and protect the blasts by rope mats and logs. After the trenches had been completed, needlebeams were drifted across between them to support the roadway and street-car tracks and were carried on vertical shores set on the bottoms of the trenches. The earth and rock were then drifted out from between the two trenches, the excavation completed and the full cross-section of the subway structure built at one operation. Masonry piers on the roof were provided to carry the street-car tracks. A 48-inch pipe on Madison Avenue was originally laid in a narrow trench excavated to a depth of about 8 feet below the surface. The subway excavation at this point required the hard rock to be blasted on three sides of the main and very close to it, which was a rather delicate operation. The pipe was suspended from two parallel A trusses, spanning one of the subway tracks, which were subsequently replaced by two pairs of 24-inch I-beam needles carried on vertical shores.

At Sixth Avenue and Forty-second Street four lines of street railroad tracks were intersected, a large number of gas and water pipes were encountered and two columns of the elevated railroad tracks and two columns of its station were undermined and had to be temporarily supported during the construction of the subway, thus making the most difficult and complicated work on this section. The method of supporting the elevated railroad structure was described in The Engineering Record of August 2, 1902, and the pipe work and other special construction was successfully carried out by very careful and accurate operations.

At Forty-second Street and Broadway the excavation is enlarged to accommodate a curved station for the local trains, the tracks are carried at a depth of about 25 feet below grade and special provision was made below them for the construction of a future Broadway branch. The tracks passed under the corner building, which was removed and restored after they were completed. At this point provision was also made for a future tall building by carrying the excavation to a considerable depth below sub-grade and building in it a heavy concrete retaining wall on the line of the inside subway columns. The tracks also passed through one of the basement stories of the new "Times" building. A lower basement story extended across the tracks underneath, and special arrangements were made here to support the subway structure and the building with entirely different and independent columns seated at a uniform level in an excavation 50 or 60 feet below the level of the street, thus preventing the transmission of vibrations from one structure to the other. These operations involved the excavation of three very deep pits separated by comparatively narrow piers of rock, and great care was taken in the shoring of the street and the surface tracks to prevent any settlement.

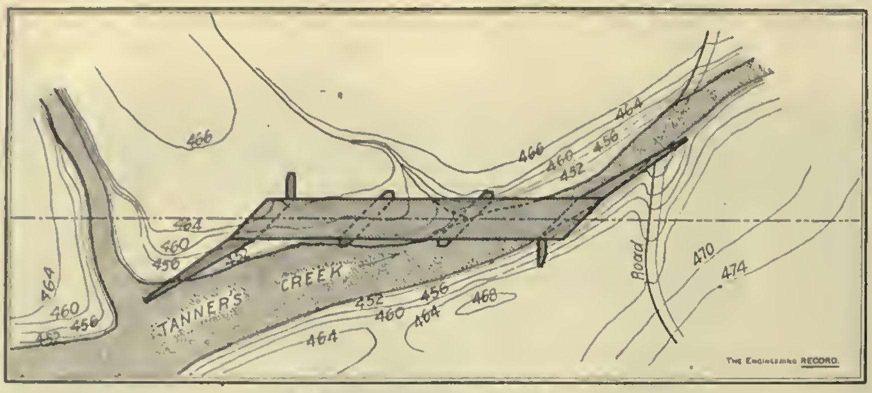
The Improvements on the Big Four Line between Lawrenceburg Junction and Sunman.

The original location of the portion of the Chicago division of the Cleveland, Cincinnati, Chicago & St. Louis Railway immediately west of Cincinnati was made in 1849 and 1850. The work was well done when considered from the point of view of low first cost regardless of curvature, but the line was expensive to maintain and uncomfortable to ride over with the heavy traffic and high speeds of the present day. The accompanying map and profile give the general features of the line. For 22 miles west from Cincinnati to Lawrenceburg Junction it follows the general level of the Ohio Valley; rectifications of this part of the line have been planned, but need not be considered here.

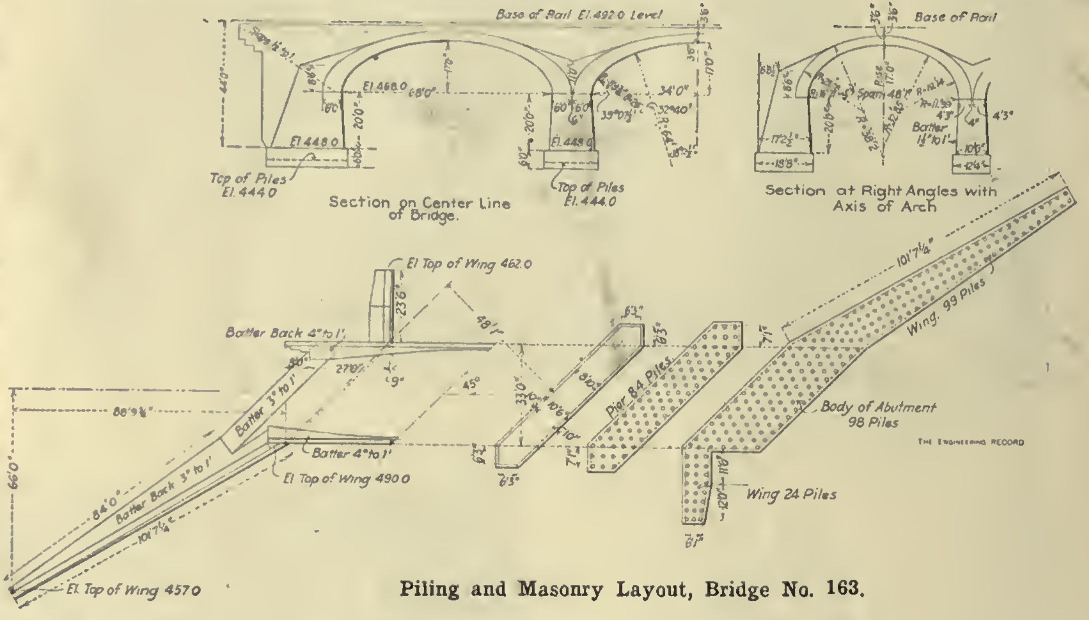
Beyond Lawrenceburg Junction the line turns sharply to the north and crosses by a cut-off a low saddle in the hill into the valley of Tanners Creek. This cut-off was built in 1877 to shorten an older location. It goes over the hill with 1 per cent. ruling grades, with a rise of 42 feet and a fall of 35 feet. Tanners Creek is confined in a narrow, crooked valley between high hills, and is a flashy stream subject to sudden and violent floods during the winter and spring, although it can be crossed dry-shod at almost any point in summer. The road runs along the valley to Guilford without rising more than a few feet above the level of the line down the Ohio valley. From Guilford the line still follows Tanners Creek in a northwesterly direction but the grade is heavy up to the head of the creek and the level of the Indiana plateau, which is reached one mile east of Sunman. The grade along this section has a ruling maximum of 1.25 per cent. or 66 feet per mile, and the total rise in 11½ miles is 506 feet. A pusher-engine is maintained at Guilford to help all fully loaded freight trains and some passenger trains going west, and also some eastbound trains over the cut-off.

In preparing plans for the improvement of this line it was realized that no satisfactory result could be obtained by making patchwork changes, but that the situation had to be examined as a whole with a view to obtaining the best obtainable line for a modern railway, regardless of the existing location. When the new line was finally selected it was found to occupy the existing roadbed at but two points and for a total length of less than one mile in the entire length of 18 miles. There were three conditions governing the relocation: first, a difference in elevation of about 500 feet had to be overcome between the valley and the plateau; second, Tanners Creek offered the only route; third, the topography did not permit lengthening the long hill grade up to Sunman, so that its rate would be reduced to an amount with which a pusher-engine would become unnecessary. Economical operation would be obviously most completely attained by shortening the pusher grade and reducing its maximum rate as much as possible, as well as by reducing the heavy curvature.

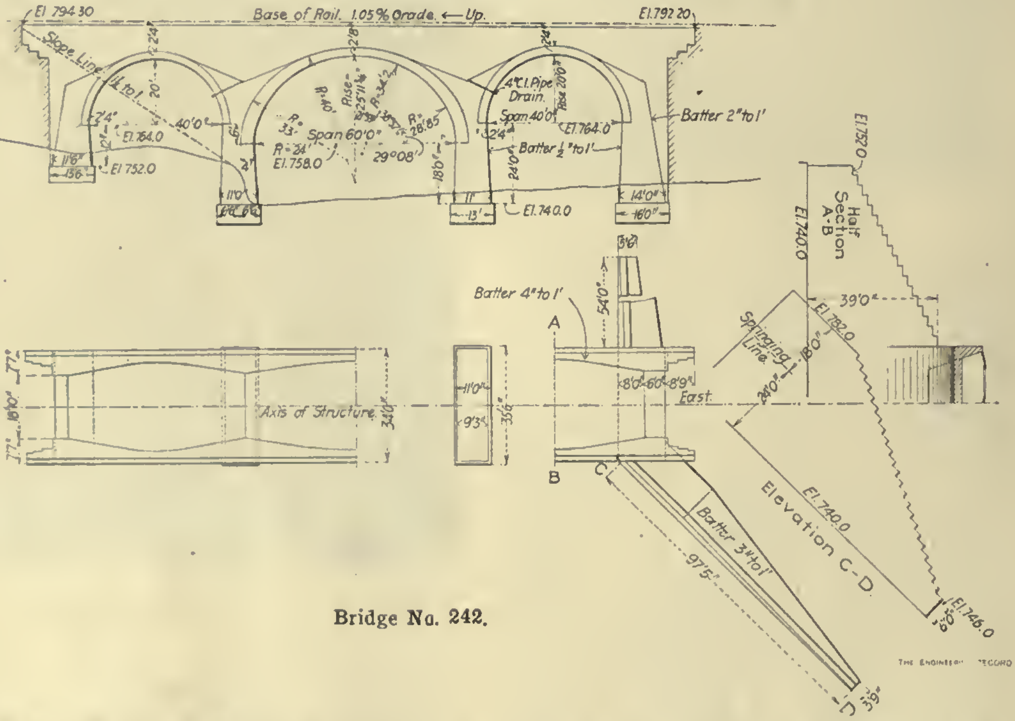
In the new location the pusher grade has had its rate reduced to 1.05 per cent. or 55 feet per mile, and its length has been reduced from 11 to 7 miles, with a total rise of 380 feet. The lower end of the pusher run has been shifted westward from Guilford to Manchester. The grade from about a mile east of Guilford to Manchester is 0.5 per cent. The latter rate is also that of the new location of the cut-off, and can be climbed without a helper by any trains which can be hauled over the division.



Location of Bridge No. 163.



Piling and Masonry Layout, Bridge No. 163.



Bridge No. 242.

The change in curvature between the two locations is very great. The maximum curve has been reduced from 5 degrees 30 minutes to 2 degrees 30 minutes, and this latter only occurs on the cut-off where the central angle is 121 degrees. Elsewhere the new maximum is 2 degrees. In the 18 miles of the old line there were 73 curves having an aggregate central angle of 2,291 degrees, 20 of these being of 5 degrees or more. The new line has 16 curves with a total central angle of 781 degrees, half the line being curved and half tangents. The reduction in curvature is 1,510 degrees, more than four full circles.

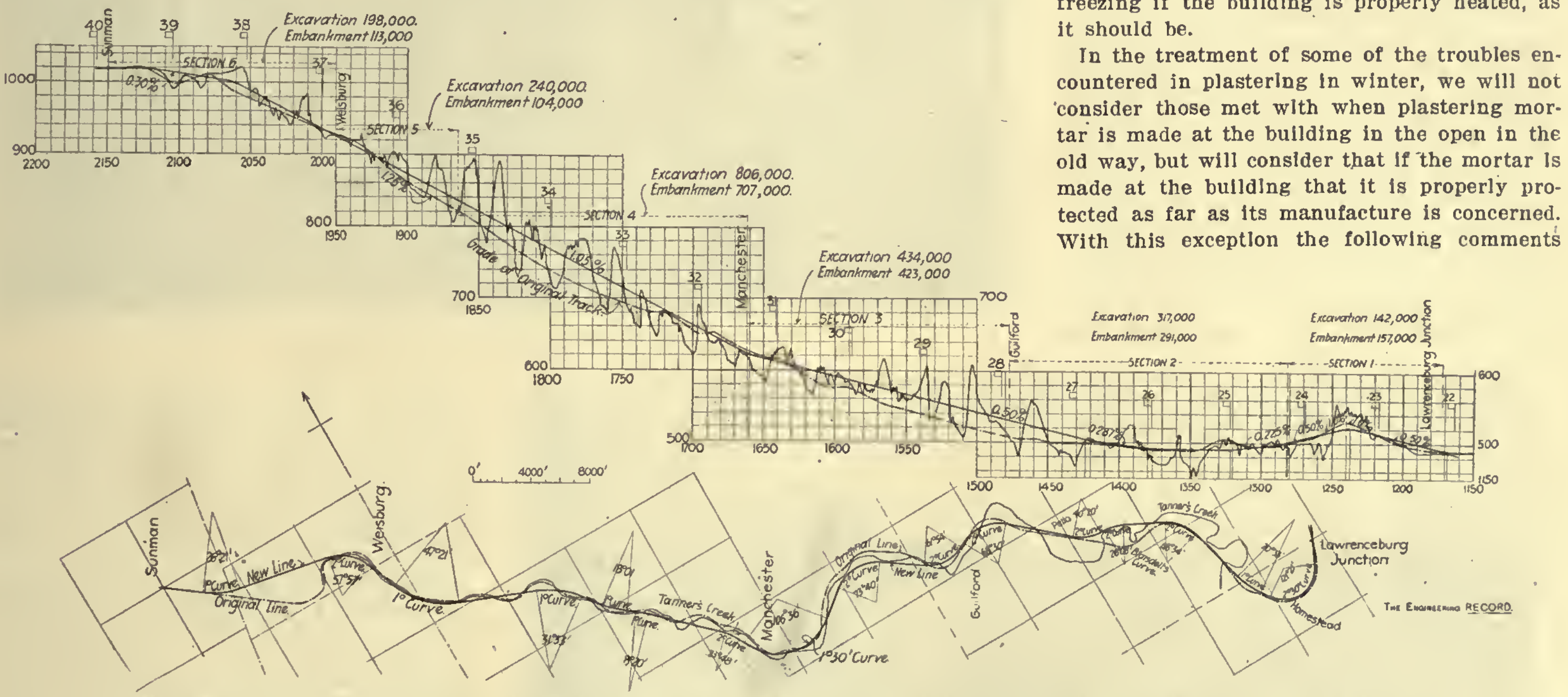
The new location crosses the present track sixteen times and is 6,800 feet shorter. It also crosses Tanners Creek sixteen times, and eight more crossings will be avoided by making changes in the channel of the stream.

The roadbed and structures are designed for two tracks and permanent construction. The width of the roadbed on enbankments is 33 feet and in cuts 39 feet, with side slopes averaging 1½ to 1. The heavy character of the grading is evident from the quantities given on the profile. There is over 2,000,000 cubic yards of excavation, mostly in loose rock, and the depths of the larger cuts range from 50 to 85 feet at center and over 100 feet on upper slope.

Over 970 tons of cast-iron pipe will be used for the minor culverts. A few of somewhat larger size will be rail-covered boxes, and one of the bridges over Tanners Creek will probably be steel. All other structures of this class will be concrete arches with spans ranging from 8 to 68 feet and requiring a total of about 50,000 cubic yards of concrete. Illustrations are given of a few of the larger bridges. No. 163 is one of the most interesting. It has three 68-foot elliptical spans of 17 feet rise, on a skew of 45 degrees. There are several bridges with 60-foot spans, some of them elliptical and some semi-circular, and with various skews. Pile foundations are used for the structures below Guilford, while the others have rock or blue clay foundations. The illustrations show clearly the rather unusual fan-shaped centers for some of the arches. The arches contain no reinforcement and their monolithic character has much simplified the design of the skew spans. Care is taken to have the arch rings laid continuously. Lehigh and Atlas Portland cements were used on these bridges.

The concrete work is all executed under the standard specifications of the maintenance of way department of the company. Masonry below ground is of 1:2:4 natural cement concrete. All masonry above ground, except in the arch rings, is mixed 1:2½:5, using Portland cement; the concrete in the rings has proportions of 1:2½:4. Both gravel and broken stone are used, as the mixture seems to give a more uniform and homogeneous concrete than one with stone alone. Hard blue limestone, broken so that no piece exceeds 2 inches in its greatest dimension, is used; the stone is the run of the crusher, except that dust and loam are separated. The gravel contains from 33 to 38 per cent. of sand and is used just as it comes from the pit, without screening out or adding sand. The natural cement tested neat is required to have a tensile strength of 50 pounds, at 1 day, 100 pounds at 7 days and 200 pounds at 28 days. The grinding must be such that 85 per cent. passes a 100-mesh sieve. The Portland cement tested neat must show 125 pounds at 1 day, 450 pounds at 7 days, and 25 per cent. more at 28 than at 7 days, the strength in no case to be under 560 pounds. A very wet mixture is employed, but no specially rich facing.

The work is being done under the general direction of Mr. Geo. W. Kittredge, chief engineer of the Cleveland, Cincinnati, Chicago & St. Louis Railway. Mr. A. O. Selby, assistant engineer, is in direct charge, and this article is based on information furnished by him. The Shutt Improvement Company, Houser Building, St. Louis, has the grading contract, while the concrete bridges are being constructed by the Moore-Mansfield Construction Company, Stevenson Building, Indianapolis, and J. D. Tuttle, Cleveland.



Map and Profile of the Sunman-Lawrenceburg Junction Improvements, Cleveland, Cincinnati, Chicago & St. Louis Railway.

Difficulties and Methods of Plastering in Winter.

By D. L. Haigh.

Plastering in winter is always attended with more or less unsatisfactory results. The walls possibly do not become hard or they are disfigured by yellow stains or smoked a dark gray color from the fires used to keep the house warm, or there is an unusual amount of cracking; the white or finish coat rubs off like whitewash or most of the plaster peels from the walls, requiring it to be entirely replaced. These and many other defects are due to very simple causes, which with little care can be easily remedied. So little attention has been paid to the question that the causes of the ill results in winter plastering are little understood.

Heretofore wall plaster has been a mixture of varying proportions of slaked lime, sand and hair made at the building, usually out in the open with no protection from the elements. If cold weather came on the mixture would freeze and could not be used until thawed out, with consequent injury to the binding qualities of the material; or, as often happens, the frozen mixture is applied to the walls to soon come off as the frost thaws out. Then, too, the quality of lime used varies greatly, and poor lime is cheap. Sand also differs greatly in quality, and sand that contains a large percentage of loam requires less time to bind it together; but loamy sand makes a very inferior plastering mortar. When lime of the best quality is obtained and good sharp sand is at hand, the proportions that enter into the mixture are uncertain and are guessed at by the laborer who does the mixing. This laborer is the unskilled workman of the job, and if he does not properly manufacture the mortar all the skill in the world in applying it to the wall by skilled workmen will avail little.

This unsatisfactory state of affairs in making plastering mortar has now been overcome, as many manufacturing plants have been established throughout the country which slake lime by machinery, dry the sand, card the hair, automatically weigh the proper proportions of each and mix the whole together thoroughly by machinery and deliver this mixture in a dry state to the building in suitable containers, usually jute bags. As the material so prepared requires only water to be added at the building to make it ready for use it does away with a great many of the disadvantages of the old way, and has the great advantage of insuring a uniform plastering mortar of very superior quality that is easily handled.

Plastering mortars prepared in this way can be taken into the building and mixed with water in water-tight boxes on the floor where it is to be used, and this avoids all chance of freezing if the building is properly heated, as it should be.

In the treatment of some of the troubles encountered in plastering in winter, we will not consider those met with when plastering mortar is made at the building in the open in the old way, but will consider that if the mortar is made at the building that it is properly protected as far as its manufacture is concerned. With this exception the following comments apply equally to all kinds of plastering mortar.

Plaster is necessarily applied in a wet state and the surplus water has to evaporate or be dried out of it. It is this surplus water and other dampness in a new building that are the chief causes of trouble in winter plastering.

In winter when the temperature is low evaporation takes place slowly or not at all. In most cases the building is cold, is not enclosed, or possibly the windows have only muslin screens, but at any rate the conditions are usually bad for drying out the moisture from the plaster and from the other parts of the building. If very cold weather comes on, the damp plaster freezes, and then there is trouble.

The amount of dampness in a building is very much greater than is usually supposed. In frame structures there is moisture in pretty much everything that enters into it, the brick in the chimneys, the cement concrete in the cellar and bath rooms, even the lumber contains much moisture. In the larger brick or stone buildings with thick walls, concrete or tile floors the amount of moisture is very great. The greater part of this moisture will have to be dried out of the building sooner or later, but until this is done it is liable to be a source of trouble, and this is particularly the case in winter.

The methods used to get rid of this moisture are for the most part crude, and in many cases are the causes of greater trouble than the moisture itself. In hardening, the plaster of paris and lime in wall plaster combine chemically with some of the water, either in the form of water of crystallization or in formation of hydrates. Therefore, all of the water added to wet the plaster does not have to dry out. The so-called hard or patent plasters all contain more or less plaster of paris, they do not require as much water to be dried out as other plasters that do not contain plaster of paris; in other words they dry quicker. This chemical change or hydration takes place gradually, and it is not desirable to dry the plaster so quickly as to prevent its taking place properly. An overheated building is quite if not more injurious than an underheated one. The majority of builders regard the ideal drying conditions in winter an overheated tightly closed building with no circulation. This is far from being right. Circulation of air is, if anything, more important than heat, if the outside atmosphere is above freezing. On such days as the atmosphere outside is very damp and moist, it is better not to open the windows.

The ideal condition is to have a gentle heat to keep the atmosphere warm, and allow sufficient circulation of air to absorb and carry off the moisture. It is especially important that the heat should be kept up during the night. The proper way to accomplish this is to have the heating apparatus installed in a building and in working order before any plaster is applied. Temporary connections can be made and heaters placed in the middle of the room. By doing this and observing the simple precaution of opening the windows from the top during the day time to allow a free circulation of air to let the moisture out, the greater part of the troubles of winter plastering would disappear. No time is gained by not doing this, and it is a mistake to think that a building can be plastered quicker by starting the work before the building is properly heated. On the contrary it is much quicker to delay starting the plastering until the heating apparatus is in working order, as the plaster dries out within a few days' time in this case, whereas it is liable to be weeks and months when this is not done.

With a temperature sufficiently high to evaporate the moisture, the plaster dries quickly, and the rest of the work can follow at once, but the usual method is not to wait until the heating apparatus is in order, but to enclose the building with muslin screens and use stoves, salamanders or open fires to dry out the building. Usually the fires are not kept going at night, and in consequence the building (which has probably been overheated in the day time, as is always the case of the ceilings in the rooms in which the stoves or salamanders are placed), is allowed to become cold at night. The chances are, too, that no precaution has been taken during the daytime to permit a draught of air to circulate through the rooms to carry off the moisture. What is the result? The heat of the day vaporizes the moisture and the cold of the night, after the fires are out, again condenses it and it settles on the plastered walls and is absorbed, or if the temperature is very low the moisture freezes on the face of the plaster, which is found covered with ice the next morning. In many cases this process of heating by day and cooling by night is kept up for weeks, with the moisture for the greater part still in the building at the end of that time, or possibly a sufficient amount of it has been gotten out to make the plaster appear sufficiently hard to finish, and the finish coat is applied. Each coat should be thoroughly dry before the next coat is applied.

Forty-eight-Foot Arch during Construction.

Forty-eight-Foot Arch Completed, Big Four Rectification.

After applying the finish coat of plaster all moisture from the under coats has to dry through the finish coat and as the finish coat is denser and more compact than the under coats it takes very much longer for the latter to become dry after the finish coat has been applied than if this drying had taken place before the application of the last coat. The results are usually as follows:

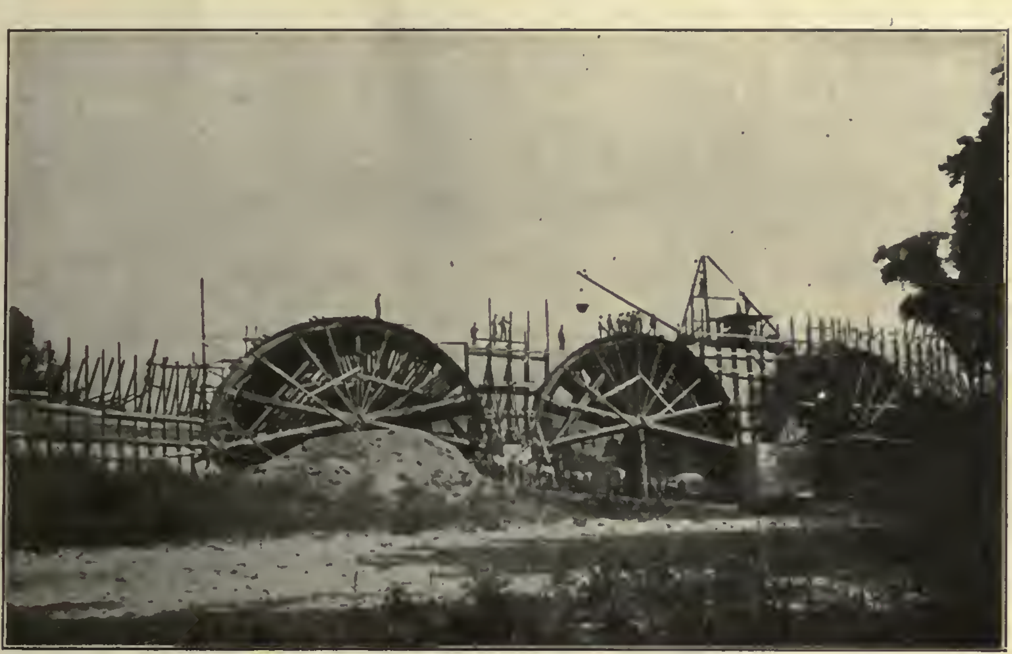
1. The Effect of Dampness Remaining in Plaster.—The most serious effect of plaster remaining damp and soggy and not drying out in proper time is to cause it to lose its set or strength, and in consequence it does not become hard. In other words the result is the same as if the plaster has been retempered. It is a well known fact that with plasters or Portland cements when they are retempered that their strength is lost. As time goes by, therefore, the plaster that has been allowed to remain wet and soggy dries out, but it is very apt to fall from the wall or crumble away like so much sand.

2. Staining Due to Dampness.—The scratch and browning coats of plaster should be perfectly dry before the finish coat is applied. If the finish coat is applied before the scratch and browning coats are dry, any staining from the wood lath (sap) or from brick or terra cotta walls will be carried by the dampness through to the surface of the finish coat, leaving a discoloration or stain. All moisture in the scratch and browning coats, and for that matter in the brick walls as well, dries out through the finish coat, with the result that the latter remains damp until all this moisture has entirely dried out. This seriously injures the finish coat and it is liable to remain soft. In large office buildings where the walls are massive, the dampness remains in the plaster for a long time, and beads of water are frequently seen standing on its surface. In case of brick walls when the water evaporates it leaves long, fine crystals of substances that have been brought to the surface in solution. Usually these substances are crystals of carbonate of soda, chloride of soda or other soluble salts. The use of dampproof paints on brick or terra cotta walls, before plaster is applied, prevents much dampness coming through the plaster and they should be used whenever possible.

3. Effect of Frost on Scratch and Browning Coats of Plaster.—The general effect of frost on plaster is to seriously injure its binding qualities or strength. The plaster becomes soft and does not set hard, and the plastered wall that

has been frozen, is liable to fall. If the frost has gotten into the first or scratch coat of plaster and causes it to lose its strength, it will not be strong enough to hold up the two succeeding coats (browning and finish), even though no frost has gotten into these last two coats; but should the scratch coat not be injured to such an extent as to cause it to fall, the frost will thaw out and in this process push off the browning and finish coats.

It is not an uncommon thing to see the browning coat separate from the scratch coat in large sheets where frost has affected the latter. In like manner, if frost gets into the second or browning coat, this will be damaged, as in the case of the scratch coat, and if the third or finish coat is applied while frost is still in the browning coat, the finish will be pushed off in sheets when the frost thaws out, just as was the case of frost in the scratch coat.



Centers for Three Sixty-Foot Spans.

4. Effect of Frost on the Finish Coat of Plaster.—Frost causes the finish coat of plaster to become soft and chalky and without strength or hardness. The finishing coat rubs off like whitewash and is a constant source of annoyance to the occupants of the house.

5. Plaster Appears Dry.—Scratch and browning coats of plaster appear to be dry on the surface when, in reality, underneath the surface they are still wet. This appearance is often misleading and the finish coat is applied too soon, with the result of having the finish coat remain damp until all the moisture has dried out from the under coats. As the finish coat is less porous than the scratch or browning coats, it naturally takes longer for a wall to dry that has had the finish coat applied while the under coats are still wet, than if the moisture in the under coats were allowed to dry out before applying the finish coat. This dampness in plaster is the cause of the disfigurement of decorations.

6. Staining and Cracking Due to Use of Salamanders and Coke Pots.—The sulphur and smoke from the coke or coal used in the salamander disfigure plaster. The smoke blackens the wall, but the sulphur of the coke unites with the lime in the finish of the plaster and forms sulphide of lime, which is yellow. These are the yellow spots or blotches that appear so often on the surface of plaster that has been applied in winter-time. As the sulphur only unites with lime when it is damp, these yellow stains appear in round spots, the moisture drying out in small circles, just as if water were dropped on blotting paper and were allowed to dry. These small damp spots absorb the sulphur of the coke and cause an unsightly wall. The small furnace used by the plumber also adds to this yellow staining. Coke pots, when placed too near the recently plastered wall are apt to dry it too quickly, and, in consequence, draw the wood lath, causing the lath to twist or buckle and the plaster to crack.

7. Decorating on Plaster That is Not Thoroughly Dry.—When plaster is damp, as shown above, the lime which is a constituent of the finish coat of all plasters (there is no exception to this rule), acts as a bleaching agent. Paper applied on damp plaster, therefore, will fade or discolor, and paint or kalsomine will be similarly affected. Naturally the more delicate the tints of paper or kalsomine the more liable they are to be affected. Often rooms are repapered and repainted, and even the second application of paper or paint is spoiled. If the dampness in the wall is excessive, the paint is pushed off from the plaster and peels off in spots several inches in diameter.

Forms for Three Sixty-Foot Skew Spans, Big Four Rectification.

Walls should be thoroughly dried before they are decorated and this takes time. If proper care has been taken in heating the building when the plaster was being applied, and this heat has been kept up until the trim is on and the walls are hard and dry, there is no reason why with proper precaution the walls cannot be decorated. Paint is very much less affected than kalsomine or paper. Delicate shades of either are more liable to damage, but if the walls are properly sized they can be decorated with satisfactory results. If very expensive decorations are to be made directly on the surface of the plastered walls it is best to allow the walls to become seasoned for at least one year. When decorations are on canvas or if burlap is used instead of wall paper little trouble is experienced. The trouble lies in the mistake that plaster that is hard and does not feel wet to the touch is considered by most persons to be dry, but this is far from the truth.

As poor drying conditions in winter are the cause of the troubles of plastering in winter, replace them with proper drying conditions and there will be no trouble. This can be easily brought about by observing the following simple precautions:

First, a building should be well enclosed. Nothing is gained in time by starting plastering before a building is properly ready to be plastered.

Second, a building should be well heated by furnace, steam or hot water heat. Salamanders, coke pots, stoves or open fires should not be used. They are not necessary and their use does not hasten the work. If, however, they are used their bad effects can be materially lessened if care be taken in their use. In case of coke pots or salamanders have them lighted out of doors, so that the first smoke will pass away and the coke become well ignited before they are placed in the house. Coke should always be used and not coal, as there is less sulphur in coke and less smoke than in coal.

Third, a building should be well ventilated. The windows should be opened from the top in the daytime and closed at night. This allows the current of air to circulate through the building and carry out the dampness. It is a great mistake to keep the building tightly closed during the time it is being plastered. Fresh air is a good dryer.

Fourth, if the precautions in regard to properly enclosing, heating and ventilating a building are looked after carefully, there will be little trouble with winter plastering. It is not well to paper or paint too soon on new plastering. Even under the best conditions, the plaster finish acts as a bleaching agent, and it should be well seasoned before it is decorated. When it is necessary to decorate quickly, the precaution should be taken of using canvas or an extra heavy coat of sizing before either papering or painting.

The Construction of the Texas & Oklahoma Railroad.

By Robert F. Powell, C. E.

The Texas & Oklahoma Railroad, technically known as the Texas Division of the Missouri, Kansas & Oklahoma Railroad, is a proprietary line of the Missouri, Kansas & Texas System comprising about 118 miles of main line and 12 miles of siding, extending from Oklahoma City, Okla. Ter., via Shawnee, to Coalgate, Ind. It is a connecting link between the recent extension work of this system in Oklahoma Territory and its coal fields in the region of Coalgate, and when completed it will be operated by and form a part of the Missouri, Kansas & Texas System. Most of the country traversed by this road is agricultural and has unlimited possibilities, though a small part of it is timber and grazing land. That portion of the road lying in the Indian Territory comprises both allotted and unallotted lands, and the difficulties in procuring right-of-way along this line from the migratory Indian allottees have no doubt caused the company's right-of-way agents many premature gray hairs.

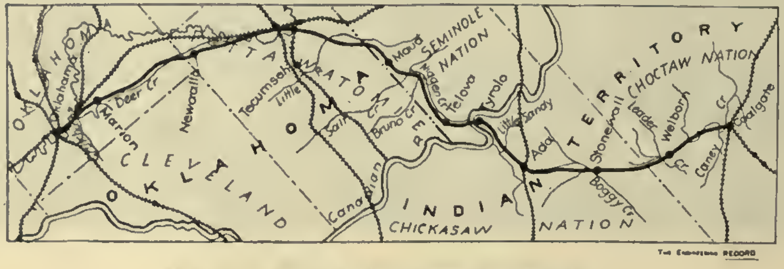
A thorough reconnoisance was made by the chief engineer, Mr. F. W. Fratt, who has had charge of the Missouri, Kansas & Texas construction work for many years, and locating parties were put into the field, the survey beginning at the Coalgate end of the line. From Coalgate to Shawnee, the line runs a little west of north, while the drainage is short and all toward the east, which necessarily makes a satisfactory and economical line rather difficult to find with the grade used, which was 1 per cent. south-bound and 0.7 per cent north-bound, there being many summits to cross and the divides are high. For the first 30 miles out of Coalgate a line was secured of remarkably long tangents for that country, easy grades and a small percentage of curvature, there being no curve sharper than 3 degrees. But this necessitated five steel bridges, four 60-foot deck plate girders and three 100-foot deck spans over the North Fork of Clear Boggy Creek, having 800 feet of trestle approach, and a height of 67 feet from ground to grade line. A special design of trestle was made for this long bridge in the office of Mr. Fratt, and as will be seen from the accompanying plant it has two cardinal points to commend it, "economy in its first cost," and "economy in maintenance," it being a simple matter to replace any timber in the structure.

From this point to Shawnee the location of a satisfactory line became even more difficult; the summits being more numerous, the divides higher and the drainage shorter. The first line adopted, while in some respects satisfactory, was entirely too expensive, which necessitated either a new location or the abandonment of the project; so another line was run which reduced the cost of construction but at the expense of alignment and grade. Rock being found along most of this portion of the line at a depth of 2 to 5 feet, the problem was to keep out of classified material as much as possible, and at the same time avoid broken and choppy grades, equalizing cuts and fills being no object on account of two-way specifications. The South Canadian River, 45 miles from Coalgate, is bridged with three 175-foot pin spans on three concrete piers sunk by pneumatic process, and one concrete abutment on the north side. Between this crossing and the two crossings of the North Canadian River at Shawnee, the line crosses two streams having a very large drainage area with practically no well defined channel, and in times of high water, overflowing their bottoms 8 or 9 feet; the bottoms are never less than three-quarters of a mile wide and both streams require a water way of from 900 to 1,200 feet; and in the case of one creek there are relief openings at the foot of the hills on each side.

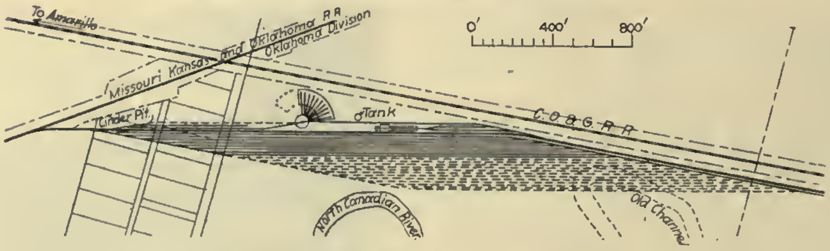
From Shawnee to Oklahoma City the line was run almost due west, crossing the Eastern Oklahoma Railroad just out of Shawnee on a 36-foot shallow plate girder. Only one summit of special height was encountered, at Deer Creek, but that one is the highest on the line, being about 600 feet above the elevation of grade at the South Canadian River. This part of the line is agricultural, fruit and truck country, and in season furnishes considerable traffic.

Our preliminary party consisted of the usual force with the addition of a topographer, assistant and draftsman, and the rate of progress was from 4½ to 5 miles per day. Topography was taken with 5-foot contours sketched in a book and afterwards platted on a 4-foot scale map. With the aid of this map and the preliminary profile, the located line could be laid very closely and the necessary notes taken to run it in on the ground, but deviation from these notes was made wherever the nature of the ground justified such change in order to get the best results.

On construction, the engineering force consisted of a chief engineer, two division and ten resident engineers with the usual duties of such positions. The contract for earth work for grading and bridging on the entire line was let to the McArthur Brothers Company, and there has been no friction between the engineers and contractors.



Map of the Texas & Oklahoma Railroad.



Layout of Oklahoma Terminal Yard.

The earthwork has averaged about 38,000 cubic yards per mile, and the weekly force employed on the work, except on some special excavation in the city of Shawnee, was about 1,425 men and 958 teams. The free-haul limit was 600 feet and within this limit there has been considerable dirt moved, but there has not been much overhaul, so the scraper plant has consisted almost entirely of wheel scrapers and slips. Below an average cut of 3 or 4 feet on about half the line, the material was classified, about two-thirds of the classification being solid rock.

One of the most interesting features of the work is the long cut within the city limits of Shawnee. It is necessary to haul the material from this cut about 2 miles east into an embankment at that point, there being no nearer place to waste the material and no place west in which it could be wasted. This is a cut about one mile long and contains about 140,000 cubic yards, the lower half of which is classified material. This material is handled on a double tramway of 63-pound rails, about two miles long, in cars pulled by teams; one track is used for empty and the other for loaded cars. Ten trains of about seven cars each are used, each train pulled by two mules, and each car containing about 2 cubic yards of material. The contractors have been able to handle on an average of about 700 cubic yards per day, some twenty-three or twenty-four teams in addition to those used for hauling the trains being necessary to do the work.

There are one hundred and sixty-five bridges on the entire line, comprising about four miles. In design the Missouri, Kansas & Texas standard plan of pile and frame trestle was adopted except at one crossing where a special design was made which would better meet the existing conditions. This standard plan calls for a pile bridge under a height of 24 feet, over that height either a combination pile and frame or a frame trestle is required. Bridging has been attended with considerable difficulty; all of the timber came from Texas and Louisiana, and all the piling came from Arkansas, with the exception of a few sticks used in falsework. It was particularly difficult to get piling; in the first place it was hard to find, then cars could not be obtained to haul it, and even after it was finally loaded for shipment it was often diverted. It was necessary for the Missouri, Kansas & Texas Railroad to furnish cars in this service for traffic which would never touch its line. After the timber and piling reached its destination it had to be hauled by wagon over very rough roads, in some cases for a distance of 16 or 17 miles, to get it on the work for which it was intended, the bridging all being done ahead of track. The company did not have an inspector at the mills, preferring to hold the contractors responsible for the quality of piling furnished, and it not infrequently happened that entire shipments were rejected at the receiving point.

With a few exceptions box culverts were used, being constructed in accordance with the accompanying plan, and where possible, preference was given to hewed native timber.

The water supply will be drawn from reservoirs and wells, preference being given to reservoirs where possible to obtain them. Two excellent basins have been built, one at Rock Creek, 21 miles from Coalgate, having a drainage area of 3,600 acres, a reservoir area of 24.6 acres, and a capacity of 35,107,000 gallons. The other one is near Maud, 64 miles from Coalgate and has a drainage area of 400 acres in addition to being spring fed; a reservoir area of 20 acres and a capacity of 80,000,000 gallons. When necessary to use wells, the Cook patent well points have been installed, so far with satisfactory results.

The company is laying its own track with 63 and 66-pound steel. The labor employed is principally American and Mexican with excellent commissary and sleeping provisions. In the beginning an effort was made to use negro labor wholly, but it was found unsatisfactory, as in this country a negro does not want to work as long as he has enough money to rattle, it matters not how little. So only a few of the most energetic ones have been retained, living in tents and drawing their supplies from the commissary, while the American and Mexican labor use dining and bunk cars. The Roberts track-laying machine is used, and about two miles of track is laid per day.

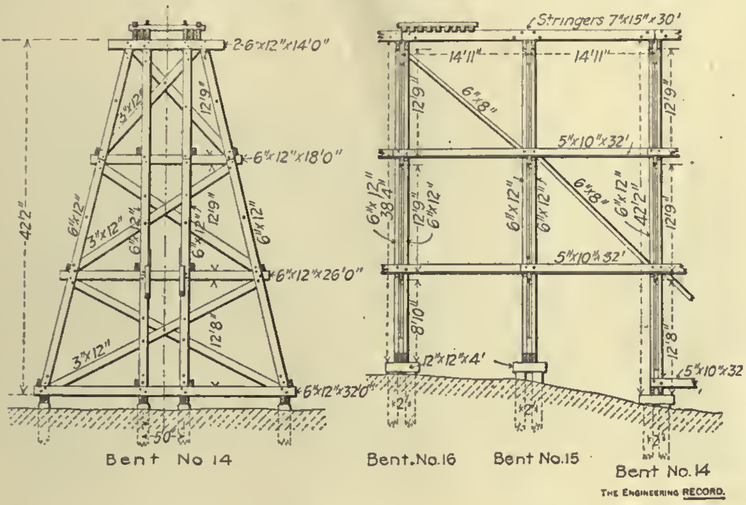
Most of the ties used are of hewed native timber, only about one-twelfth of the amount required being of Texas sawed pine, but as these ties of native timber are only obtainable south of the Seminole Nation, in the Indian Territory, it necessitates a special tie train to keep the front properly supplied, which materially adds to the cost of ties.

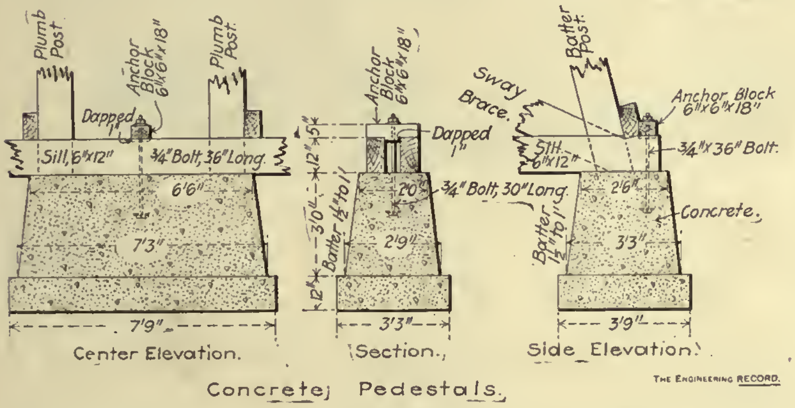
The location and arrangement of the Oklahoma terminal yard deserves special mention. It was designed by Chief Engineer Fratt, and while not of great capacity, it yet affords ample room and its arrangement is very convenient; also provision has been made for increasing its capacity from time to time as the needs of the company may demand. As will be seen from the accompanying plan, the roundhouse will accommodate ten engines, and the coal chute is fitted with six pockets on each side, the cars being hauled up the incline by a gasoline engine.

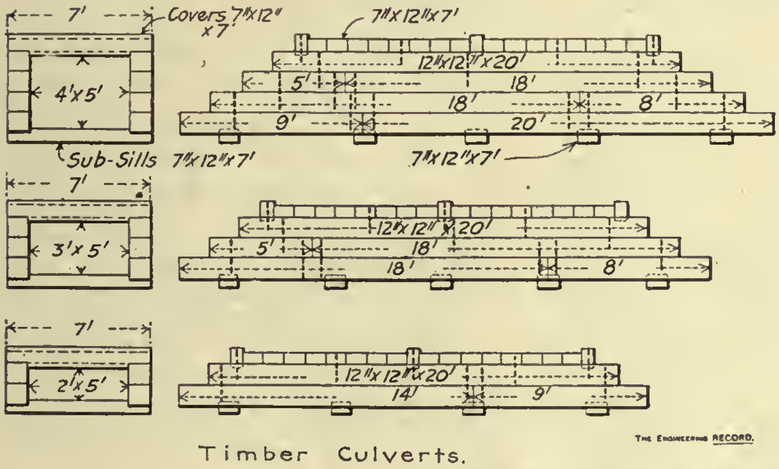
The cinder pit is 70 feet in length, of rubble concrete construction, has a retaining wall 300 feet in length and 10 feet in height. Paving of the pit is of vitrified brick set on edge and bedded in sand, with which the back fill is made. The rail is supported on cast-iron pedestals resting on concrete piers and carrying inverted rail to which the track rail is bolted. It has been found necessary, owing to the wide over-flow of the North Canadian River, to riprap the embankment, which is about seven feet high, between the two crossings of this river just west of the terminal yard for a distance of about a half mile.

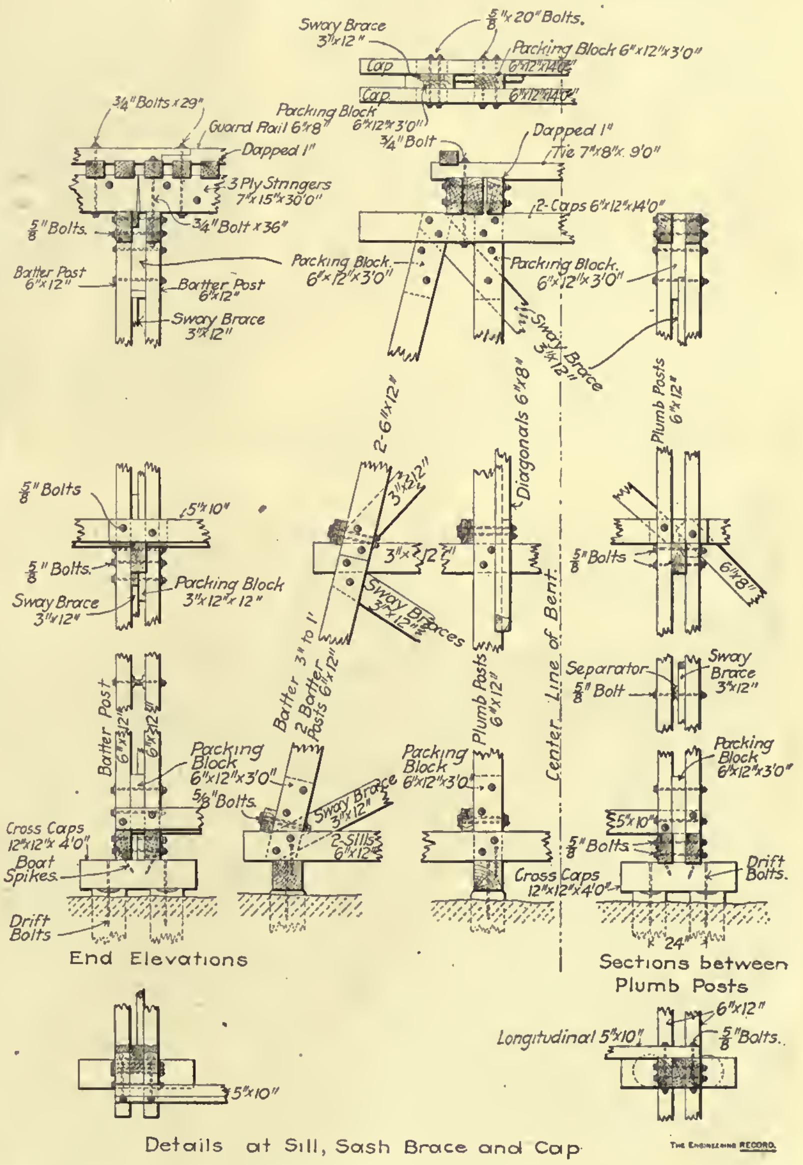
The water supply for the Oklahoma City terminal yard will be furnished by a patent screened well which is guaranteed to supply not less than 100,000 gallons daily during ten hours of continuous pumping. The first well sunk did not fulfill this guarantee, giving only about 6,500 gallons. The material removed from this well, however, gave splendid indications that an adequate supply was obtainable, the reason given for its failure being that the screen was in a pocket, so another well has been sunk and it is believed that the quantity of water it furnishes will fully meet the demand. Well water obtained at this point is very well suited for engine purposes.

One of the most vexatious problems which the construction of this road has presented has been in the matter of heavy classified cuts. Nearly all of the rock we have encountered in this country is badly decomposed and underlaid with clay, and it is necessary to shoot down the sides of cuts, as they will not stand at a slope of ¼ to 1. The town of Ada is on the top of a summit, and just south of the town on the slope of this summit a ridge about 1,000 feet wide and some 25 feet high rises almost perpendicular, through which it was necessary to cut in order to reach Ada. This ridge seemed to be a mass of earth and clay, underlaid with soapstone, and as fast as the cut was taken out this earth and clay moved into the cut something like an avalanche at the rate of 8 or 10 feet per day; it came in faster than the cut could be taken out with scrapers and teams, and adding to this difficulty a heavy rain fell which made the ground so wet and boggy that teams were unable to work. While waiting for the ground to dry out sufficiently to resume team work a force of shovelers were put in to keep the landslide under control and prevent it entirely filling the cut. For a time it looked as if it would be necessary to put a portable shovel in this cut, but by increasing the scraper plant sufficient headway was made to remove this troublesome sliding material after a short time.









Special Timber Trestle Details and Standard Box Culverts.

Works of the Smith Premier Typewriter Company, Syracuse.—I.

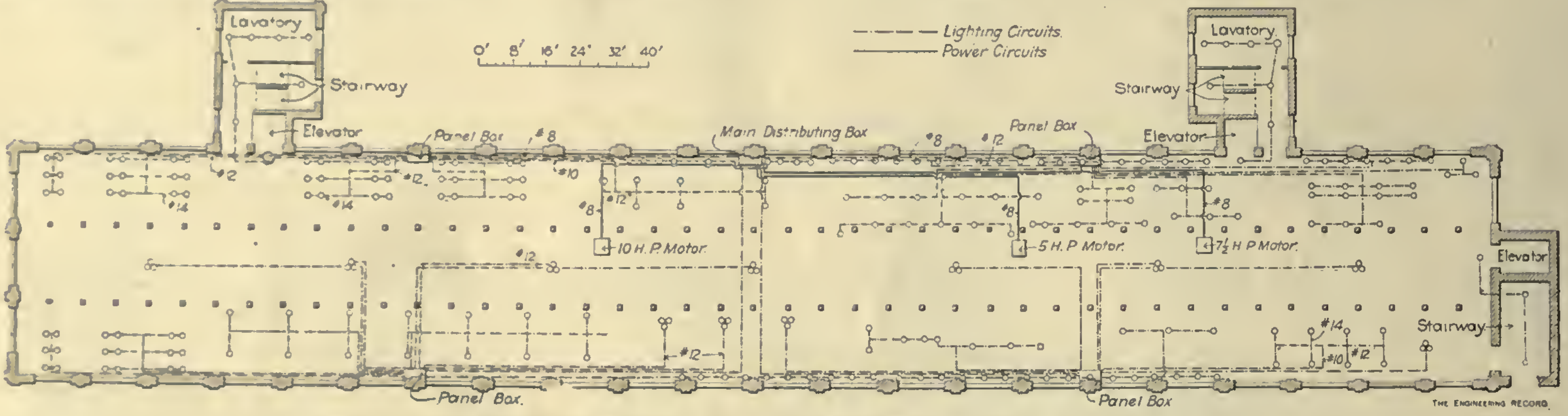
The Smith Premier Typewriter Company moved in January into a new plant in Syracuse, N. Y., located a few hundred feet from the old establishment which it had outgrown. Apart from the interest which attaches to a description of the works where the well-known typewriting machine of that company is produced, the new manufactory stands as an instructive example of modern practice in factory construction, equipment and power transmission. During the past year the machines have been built at the rate of 100 per day, but the factory was crowded to the utmost. While conditions might have been bettered by the erection of an adjacent and connected building, the best conditions for the most economical manufacture of the product, or for the greatest convenience and highest efficiency of the working force were found hardly possible. It was accordingly decided to establish an entirely new plant and in the new works now completed the output can quickly be raised to 150 machines per day and yet with far less crowding than in the old factory, while in addition much has been done for the promotion of the health, comfort and safety of the employes.

The new works occupy a site bounded by Gifford and Dickerson Streets, extending westward from Onondaga Creek. They consist of a seven-story, main building, the factory proper, 58½ by some 35,000 square feet of heating surface in pipe coils, equipment for 28 electric motors and 2,670 electric lights. In preparing the site a concrete retaining wall was built along Onondaga Creek, 22 feet in total height, with the water low on one side and the ground level at the top on the other side. The wall is 7 feet wide at the bottom and 2 feet at the top, with a batter on the fill side of 12 inches in 10 feet and on the water side of 18 inches in 10 feet.

The features of interest to be taken up in the succeeding account comprise the construction of the main building, the equipment of the power plant, the power and lighting system which is an alternating three-phase one, with 220-volt incandescent lamps for general illumination and 220-volt induction motors for power, and the heating system, which is a hot-water installation, circulating water warmed by exhaust steam in the power-house. The heating system is, however, quite unusual, as the generating engine is operated condensing by means of a jet condenser and the heaters are virtually surface condensers interposed between engine and jet condenser.

Main Building.—The factory building proper, as stated, is of mill construction having timber columns and beams and brick walls. These are set off with pilasters both inside and out, every 8 feet, or at every line of transverse beams, and the pilasters are noteworthy from the use of bull-nose brick at the outside edges or corners, which add much to the appearance

On the rear of the building, about 50 feet from each end, is an extension, the full height of the structure, in which, in each case, is an elevator well, a stairway and a lavatory on each floor. This arrangement is, of course, similar to that existing in lofty mill buildings where it is desired to minimize fire risks by avoiding the necessity of an opening between floors; and the advantage has been taken of locating the toilets in them where abundant light and natural ventilation is possible. The use of electricity for power has further made it unnecessary to leave any openings on this account between stories. The elevator well at each story and each stairway hall is guarded by a tin-covered door. At one end of the building is a third elevator and stairway hall, this elevator largely for shipping, while the others are for carrying parts from department to department in the process of manufacture; this extension is similarly cut off from the building proper by fire doors. A sprinkler system has been installed, in both the office building and in the upper story of the power-house as well as in the main building, and this having city connection with two streets, where a relatively high pressure is obtainable, did not require an elevated storage tank but only a fire pump, which is located in the power-house. The sprinkler distributing system includes a main along one outside wall at the ceiling of every story with lateral ceiling branches in the center of each section between the transverse beams.



Smith Premier Typewriter Works: Plan of the Fourth Floor, Showing the Wiring System.

nearly 380 feet in plan, a detached, fireproof power-house, two stories in height and 96x102 feet in plan, and a detached, frame building, two stories and an attic in height and 40x70 feet in plan. Though the main building is of slow-burning mill construction, the outside location of the power-house and the fireproofing of the latter were determined on to lessen fire risks. The second story of the power building is given up to the japanning department, which houses a number of baking ovens, and is on the level with the second story of the main building to which it is connected by a fireproof corridor-bridge some 50 feet long. The office building is also connected with the main building by a bridge, which is of frame under the protection of fire doors and a sprinkler system. The accompanying photograph, which is regarded as a rear view of the works, shows the office building in the foreground, the main building at the left, the power-house at the right and the connecting bridges from both the power-house and the office.

On March 5 of last year, ground was broken for the work, three months later the roof was placed on the main building and four months later, October 5, the boilers were fired. On January 4 the factory was opened for production, ten months after the actual beginning of the work of construction. This record is of interest when it is stated that the main building contains some 2,000,000 cubic feet of space, of the building besides actually giving a wider angle of vision for each window, or, in other words, more light. The building has two long, longitudinal rows of columns between outside walls, spaced on the 8-foot centers, and forming a central aisle 18 feet 8 inches wide on centers of columns, and two side aisles each 17 feet 11 inches wide inside. The columns are 12x12 inches through the first four stories, 10x10 inches through the fifth and sixth stories and 8x8 inches through the seventh. The beams are all 8x16 inches in cross-section. The outside walls are 2 feet thick through the first story, 16 inches through the second and 12 inches thick through the rest, except at pilasters, where the thickness is in steps from 3½ feet to 16 inches. The general height of the stories is 13 feet, but the first is 12 feet 8 inches, while the top is 12 feet plus the space under a saw-tooth roof which has there been provided. This is in three sections, corresponding to the three bays, and the glazed portions, facing the north as usual, are set in window frames operated by the Lovell device, by which a long line can be opened or closed simultaneously from a single controlling station. The rest of the roof is covered with rubberoid and the building walls are carried in parapets above the general roof level. The floors throughout are ⅞-inch maple on 3-inch pine planking and the beams and columns are all Georgia pine.

The proportion of window light is large. The windows extend from 3 feet above the floor to the ceiling and roughly there is about 1/5 square foot of glass surface per square foot of floor area, or 5.4 square feet of glass area per linear foot of wall. In the top story, this proportion is, of course, much larger owing to the use of the saw teeth. The effect of the natural illumination is enhanced by the painting, which is white on the brick walls and ceiling, a cold-water paint on the upper part of the walls and enamel on the lower where they are likely to become soiled. The timber columns for the lower 6 feet are a dark green.

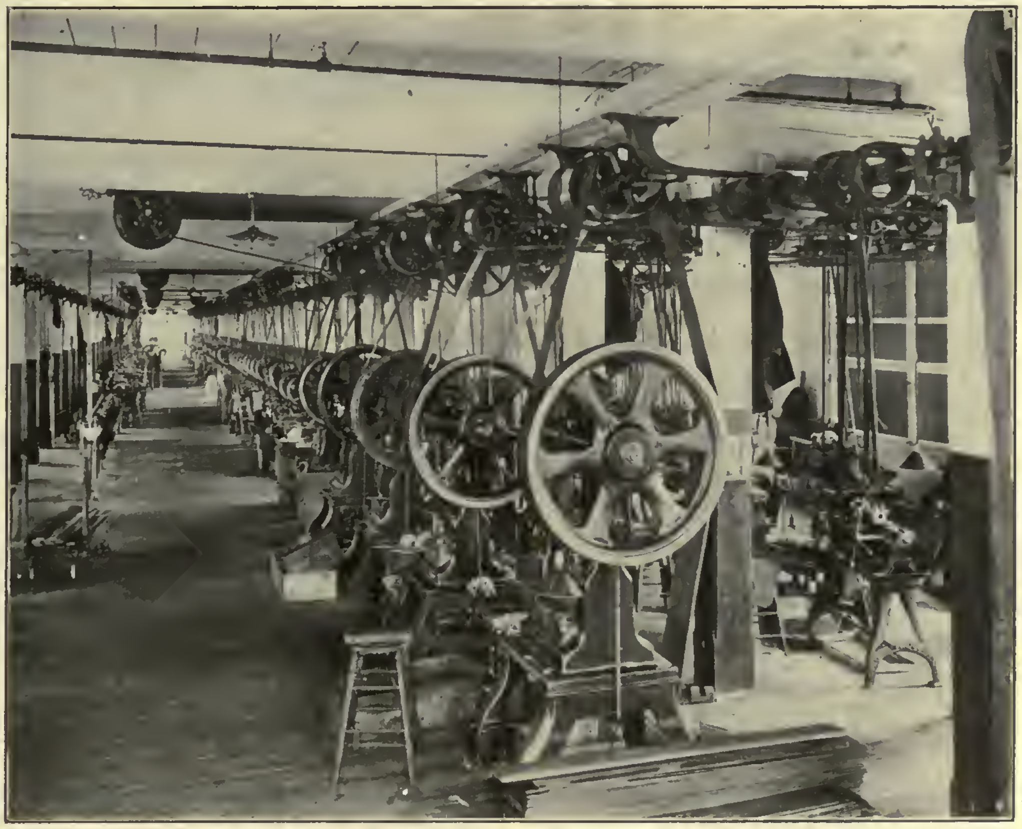
On each floor toward each end in the center aisle is a group of double cast-iron sinks for washing, and near this is a porcelain drinking fountain, this of the sanitary type common in public parks, where the water bubbles from the top of the drinking orifice. Temporarily, the water is allowed to flow constantly from the fountain, but a spring valve may be inserted so that water is only delivered when wanted, or the water may be piped from the fountains and collected for the various uses to which it can be put, as for flushing.

Factory Equipment.—It will not be possible in this connection to describe the processes of manufacture, which requires a considerable number of special machines for turning out in quantity the many small parts that go to make up a finished typewriting machine. Generally speaking the course of the material through the building is upward from floor to floor, the seventh floor finding the machines completed, but requiring testing for operation, correct alignment, etc., this department employing a surprisingly large force of men. On the first floor there is a group of Bradley cushion hammers for upsetting, bending and forming the small bars and rods in the machine, the table under each hammer having a special die or form for the work in hand. Small individual gas-fired furnaces, supplied by the American Gas Furnace Company, of Elizabeth, for working under an air blast, are used in this work. There is also on this floor a series of electroplating baths for nickeling various parts and a long line of polishing and grinding wheels, these equipped with exhaust hoods connected to an exhaust system of ducts which are led to a so-called dust house outside the building. This is a small brick structure in which is mounted a Sturtevant centrifugal exhauster driven from an induction motor by means of a Morse chain operating at a high linear speed.

On the second floor is the tool-making department which is an extensive equipment of machine tools with lathes, milling machines and the like largely for manufacturing dies for the special machinery. This apparatus is located mostly on the third floor, including automatic screw machines, for making the various lengths of threaded bars, and stamping machinery, under which head comes an ingenious machine, for making the small turnbuckles by which the type bar mechanisms are connected to the key bars. The fourth floor is devoted to finishing the castings for assembling, including filing, but the most interesting department here is the type making. The assembling is practically all done on the fifth floor, and the sixth is given up to shipping, to a department for the repair of typewriters sent to the works for that purpose, to store rooms for typewriter supplies and to a carpenter shop. Reference has already been made to the occupation of the seventh floor.

Smith Premier Typewriter Works, Syracuse, New York.

Most of the machines, both standard and special, were built outside of the works, but some were designed by the company. These include the turnbuckle machine, a rack machine for the racks for the escapement mechanism on the typewriters, the type-making machine and a group of so-called exercisers, which are automatic affairs in which the nest of the type bars and rods, as they are mounted in a typewriter, are subjected to the action of actual use. Each type-bar linkage is actuated 1,600 times, in very rapid succession, and each linkage is taken up in turn automatically, the exerciser serving to put the joints in desirable working order and to wear off burrs that might remain in the process of manufacture. The type-making machines are also automatic, receiving Norway iron 1/10 inch in diameter, heading it preparatory to forcing it against a hand-prepared type-die, cutting it and forming the shoulder for its emplacement in the type bar and blowing off oil and cuttings by compressed air after the die impression has been made. To secure the impression the die has to be given a kneeding action against the piece of iron. The type pieces are afterward tempered.



Third Floor of the Smith Premier Works.

The works are operated on the day, piece work and contract system, the latter applying largely to assembling work. A given contractor has to do with a certain part only of the assembling, and, of course, hires his own men and within limits employs his own methods for turning out his contract. This system has proved quite satisfactory. A system of tags has been developed by which a check is kept on the output. One tag, having a serial number, is given to each machine as soon as it begins to assume a distinct character. This tag carries a number of small pieces of cardboard which can be detached. Each of these is numbered to correspond with a definite operation in the process of assemblage, some for piece work and some for contract, and normally lie folded against the tag so that before removal from the tag, a punch perforation through any one of them by an inspector goes through the tag as well. A contractor or piece worker gets paid, of course, according to the number of the detached pieces he turns in.

Power Plant.—The power plant, occupying, as stated, the lower part of the detached fireproof power-house building, presents an unusual arrangement of rooms. The boilers, three in number, are grouped at one end of the boiler room, two in one battery and the third single, and the firing space is continued the full width of the building across the coal storage. Between the latter and the boilers is a pump room, walled off in brick, and both this and the coal store are in communication with the boiler room through large arched openings. The engine room, about 46x50 feet in size, is situated diagonally across the building from the boilers, while immediately back of the boilers is a room, with a separate outside entrance which is not given up to the power equipment. The engine room is distinctly apart from the boiler room while easily accessible, and the pumps have been afforded protection from the boiler room. The coal store is about 32x30 feet in plan.

The boilers are of the Babcock & Wilcox water-tube construction, each having 72 4-inch tubes 18 feet long, 8 tubes wide and 9 tubes high, and one 42-inch flowed-steel drum. They were built to carry 200 pounds pressure and a working pressure of 160 to 170 is maintained. They are hand fired with pea coal held in a 1-ton, open-sided, Hunt, coal car run on narrow-gauge tracking extending across the entrances to the coal pocket and over a weighing scale. The products of combustion are carried off by natural draft through a brick chimney 165 feet high and 6 feet in inside diameter. The peculiarity of this is the use of an inner shell of firebrick rising independently for 100 feet. The floors of the boiler and accessory rooms are paved with brick blocks. Extra strong piping is employed for the steam mains with Rainbow gaskets at joints. Each boiler feeds into the side of the steam header, with the usual pipe bend, and in this there are two valves, but none in the header. The latter before passing through the wall into the boiler room, is provided with a pocket to catch condensation, which is drained by means of a trap into the feed-water heater. This is of the Webster open type, located in the pump room. In this room are also a 18x10x12-inch 1,000-gallon feed pump and two 7½x5x6-inch Deane feed pumps.

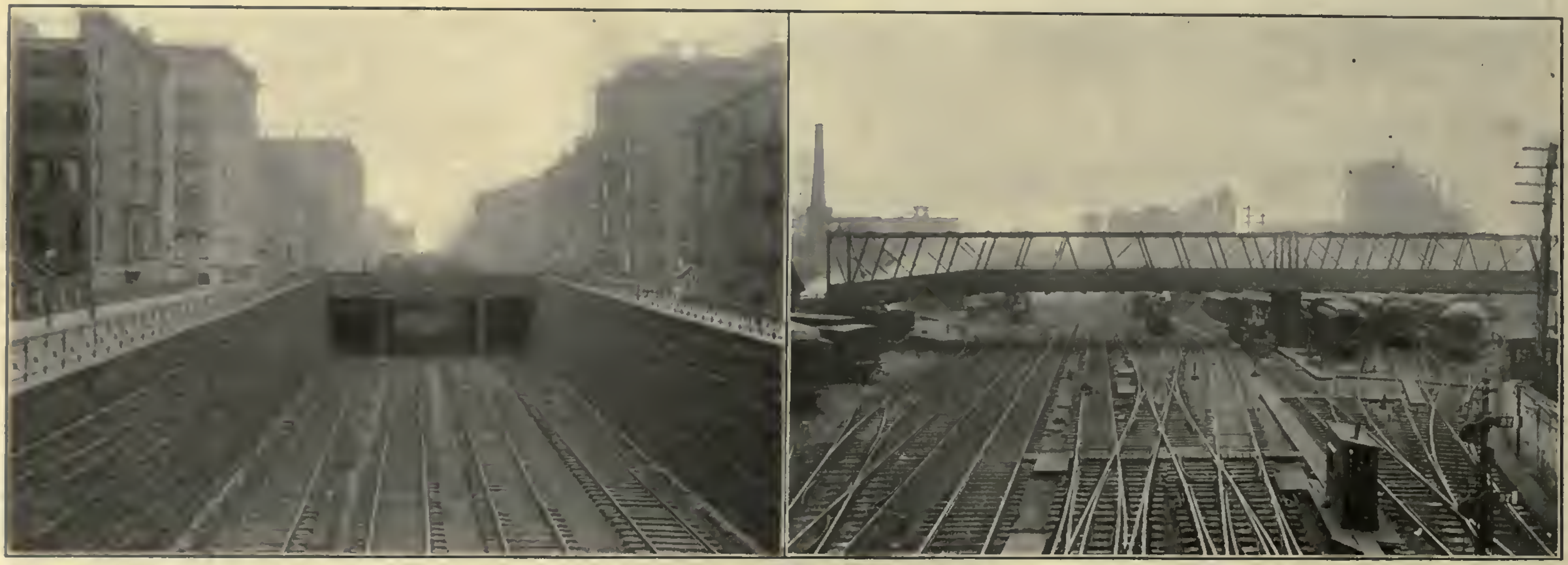
In the engine room is located a horizontal, cross-compound, condensing, direct-connected steam engine and generator, with space for a second unit, the switchboard and electrical apparatus and the condenser and hot-water heating equipment. The engine-room floor is somewhat higher than the general floor level, allowing the exhaust connections to be made readily under it. The engine, which was built by the Ball Engine Company, of Erie, Pa., has 15 and 25-inch cylinders with 18-inch stroke and runs at 200 revolutions per minute. The generator is a General Electric, 240-volt, alternating-current machine giving three-phase current at 60 cycles per second. The steam main overhead delivers to the high-pressure cylinder through a vertical Direct seperator.

The condensing equipment is, as stated, unusually interesting, owing to the utilization of the heat of the exhaust steam, though handled at a vacuum, for heating water for warming the entire establishment. As will be explained the exhaust steam is passed through two tubular heaters for this purpose, and the steam that is not turned into water in these is later condensed in a jet condenser.

(To be continued.)

The Grand Central Depot Yard Improvements, New York.

The four tracks of the New York Central & Hudson River Railroad and the New York, New Haven & Hartford Railroad enter the Grand Central Depot at Forty-second Street from a tunnel extending north under Park Avenue. They emerge from the tunnel at Fifty-sixth Street and from Fifty-sixth to Fiftieth Streets are run at a rising grade between heavy masonry retaining walls through a cut on the center line of Park Avenue. The intersecting cross streets are carried over the railroad tracks by steel foot-bridges. At Forty-ninth Street the tracks emerge at grade into the yard, which has a maximum width of three blocks, or about 950 feet, and contains turntables, storage, repair shops, express and freight houses, sheds, switch tower and other structures. At Forty-fifth Street the yards join the train shed, which, with the station building, occupies a full block in width and extends to Forty-second Street. The terminal thus covers an area from 375 to 950 feet wide and about 1,800 feet long between Madison and Lexington Avenues and Forty-second and Forty-ninth streets. Nineteen tracks enter the train shed at grade and extend a little beyond Forty-third Street. Outside the train shed there are fifty-three longitudinal tracks between Forty-fifth and Forty-seventh streets. Besides these there are many curved tracks, cross-overs and transverse spurs and radial tracks to the turntables and to the express houses and milk platforms, altogether making a very elaborate system of surface tracks.



Present Approach to Grand Central Depot, Park Avenue Roadways Each Side; Present Tracks and Foot-Bridge in Yard.

The terminal improvement is designed to depress all these tracks below the street level, and to carry eight lines in a subway from Fifty-second Street through a sub-station to Forty-second Street. By this plan the yard will be entirely re-arranged and considerably enlarged, and its whole area will be at a uniform level about 20 feet below the adjacent streets. The yard will be extended to occupy nearly all of the 950x1,250-foot rectangular area between Lexington and Madison avenues and and Forty-fifth and Fiftieth streets. Between Fiftieth and Fifty-seventh streets ten tracks will eventually occupy the full 140-foot width of Park Avenue and between Forty-fifth and Forty-third streets twenty tracks will accupy the full width of nearly 400 feet of the train shed. These areas will be entirely enclosed by retaining walls, and Park Avenue will be continued at present grade full width over the tracks from Fifty-seventh to Fiftieth streets, and from Fiftieth Street it will be extended to the depot at Forty-fifth Street by a plate girder viaduct 100 feet wide. From Fiftieth to Forty-fifth streets the cross streets will be carried across the yards on steel plate girder viaducts having solid floors. The deck carrying the yard tracks over the subway and the roof over the yards and the platform carrying Park Avenue over the tracks will be built of steel and concrete, of massive construction, and the result will be to abolish all surface tracks and restore the lower end of Park Avenue to the full width, besides affording a two-story system of express and local lines into the main depot and sub-station.

The steel structures consist of one and two-story platforms made with riveted columns and longitudinal and transverse plate-girders having web-connected ends and solid web knee-braces. Over the subway tracks the columns support longitudinal girders 5 feet deep, which carry on their upper flanges transverse girders for the solid floor of the yard tracks. The second tier of columns here carries a corresponding floor for the Park Avenue extension with a 30-foot roadway and two 10-foot cantilever sidewalks. The street floor is made with longitudinal steel troughs, and a lower system of troughs is secured to the under flanges of the transverse beams above the clearance for the yard tracks. Where the tracks emerge from the tunnel at Fifty-seventh Street their expansion covers the ground area with so many intersecting lines that it is impracticable to support the platform overhead on columns and it is carried on a pair of lattice-girder trusses 150 feet long and 26½ feet apart on centers. These trusses project above the surface of the street and carry on their lower chords transverse 24-inch I-beams which support the pavement. The trusses are enclosed in solid masses of concrete with moulded surfaces and ornamental finish which form parapet walls for the street.

Forty-sixth, Forty-seventh, Forty-eighth and Forty-ninth streets are carried across the yards on bridges which have heavy transverse plate-girders supported on two-column bents and carry ten lines of longitudinal plate-girders on their upper flanges. These have 30-foot paved roadways and two 10-foot cantilever sidewalks carried by very deep solid web knee-brace brackets. The columns are protected by solid walls of concrete about 5 feet high, which enclose their bases and are about 40 feet long so as to project several feet beyond each column and serve as buffers in case of derailment. The bridges from Fiftieth to Fifty-sixth Street, inclusive, are similar, except that the transverse girders are supported on four columns and are much shallower, and the roadway and sidewalk are carried by fifteen lines of longitudinal stringers. The two columns on each side of the center line have their bases protected by concrete walls, but these walls are built in two parts with an open space between them under the center of the bridge. Gas and water pipes are carried under the roadway pavement between the longitudinal girders, on slabs of reinforced concrete supported on the lower flanges of the girders. Electric mains are carried across Park Avenue at Fifty-fourth Street in 3½-inch iron pipes bedded in a solid mass of concrete 33 inches wide and 27 inches high in a trench just below the subway tracks.

Two-and-One-Half-Yard Steam Shovel Excavating Debris of Razed Buildings.

The subway is built chiefly in rock excavation and is lined with concrete on the bottom and sides. This concrete is built in two layers with waterproofing between them. The waterproofing is composed of several thicknesses of felt or burlap alternating with layers of coal tar pitch or asphalt. The steel track floor is covered with concrete deep enough to cover the inequalities due to rivet heads, and waterproofing, like that in the subway, is laid between the top of the concrete and the track ballast. Many different kinds of waterproofing are specified from which a few will be selected for use under different conditions.

In order to execute the work without interfering with the continuous traffic of the terminal, the yard is divided into three longitudinal portions in which the old structures are to be successively replaced by the new so that enough tracks will always remain undisturbed to accommodate the trains without serious inconvenience. The first section consists of the new area between the present tracks and Lexington Avenue and between Forty-fifth and Fiftieth streets. When this section is completed and the new tracks laid, a temporary station will be erected there and the eastern or adjacent half of the present tracks will be abandoned, thus clearing section 2, where the work will be carried on without interfering with train service. When section 2 is completed and the new tracks laid there, the remainder of the old tracks will be abandoned and section 3, extending to Madison Avenue, can in like manner be graded and built without interference with the traffic. By this system the entire work will be carried on rapidly without at any time being materially hindered by the great traffic of the railroads.

Grand Central Depot Improvements: Three-Yard Shovel Removing Foundation Walls.

The first operation was to remove the old structures in a part of the yard and on adjacent property acquired by the railroad company for its extension. This involved the razing of about 150 buildings, including a church, hospital, orphan asylum, express buildings, store houses and numerous dwelling houses most of them substantial brick buildings of two to six stories in height. These were principally located in the extension of the yard towards Lexington Avenue. Operations were commenced in August, 1903, and the walls, roofs and floors were demolished in the usual way and such materials as were deemed valuable were removed by the contractors. In November, after the walls were torn down to the first story or to the ground level, three large steam shovels were installed to load the debris into dump cars and to dig up the foundations and lower parts of the walls. They also continued the excavation to sub-grade in one or more lifts as convenient. This work was mostly confined to the first section and was arranged so as not to disturb any of the yard tracks except those leading to the old milk depot.

The west roadway in Park Avenue between Forty-ninth and Fifty-sixth streets has been closed and the west retaining wall of the cut removed; the excavation to sub-grade of existing tracks is being widened to the building line, so that two new tracks can be laid and permit the eastern to carry the railroad traffic and allow the eastern section to be relinquished wholly for the removal of the spoil cars and other requirements of the contractor. Steam shovels are being used in this excavation on Park Avenue and considerable rock is encountered, which is drilled and blasted in several places simultaneously. After the west side of the cut is widened, the same operation will be carried out for the east side, but to the grade of the permanent new tracks. The present excavation in this cut on the westerly side is through rock which required very little retaining, and a trench is being carried down to final sub-grade so as to build in it the face wall for the side of the subway and to permit the construction in its thickness of one of the new sewers, which it is necessary to complete before the subway on the eastern side can be begun.

In this manner the excavation and re-construction will be executed by ordinary methods and plant without involving unusual operations, but will necessitate extreme care and able management to perform it under the difficult conditions and the many restrictions imposed by the requirements of the high-grade residence locality and the great traffic on the congested tracks. These changes require some corresponding alterations in the systems of gas and water mains and conduits. The principal ones are the construction of new sewers and the moving of large pipes. The large sewers are egg-shaped brick conduits about 2 feet 8 inches by 4 feet 6 inches and are being built in Madison and Vanderbilt avenues, Forty-second and Fifty-fourth streets.

A 36-inch gas main crossed the yard at Forty-sixth Street and as it interfered with the operations of the steam shovels, it was taken up and carried under the Lexington Avenue sidewalk to Forty-fifth Street, and there carried across the yard on an elevated bridge to Madison Avenue. Here vaults prevented it being placed under the sidewalks and it was carried in a straight excavation back to Forty-sixth Street and there connected with the original line, thus making a U-shaped loop across the yards and allowing the straight line to be removed. A 16-

inch gas main at Forty-eighth Street was replaced by a 12-inch main, and it and a 20-inch main at Forty-ninth Street were carried under the sidewalks to Fiftieth Street, and there taken across the yards on a special temporary wooden bridge, then returned on the opposite side to connect with the original mains forming loops like the one above described and permitting the original mains to be removed where they obstructed the steam-shovel work. The cables from the Manhattan Elevated Railroad station and a sewer are to be carried across the tracks underneath the subway at Fifty-fourth Street. The excavation for this has been commenced and quicksand and difficult ground have been encountered which make it probable that the work will present some difficulty. Some of the street bridges across the yard have been removed and others have been built and either vehicular or pedestrian service or both will be maintained at Forty-fifth, Fiftieth, Fifty-first and Fifty-sixth streets.

All of the earth excavation is being made with steam shovels and by pick and shovel. That which is made by hand is shoveled into steel buckets which are emptied by traveling stiff-leg derricks into 30-yard steel dump cars which also receive the material from the steam shovels. These cars remove from 1,000 to 1,500 cubic yards of spoil daily. They are drawn by locomotives to points on the Hudson River Railroad or the Harlem Railroad and their contents are dumped alongside the tracks to make required fills. The average depth of the excavation in the yards and cut is about 20 feet, and the estimated quantities involved in the improvement include 1,000,000 cubic yards of earth excavation, 500,000 cubic yards of rock excavation, 100,000 cubic yards of concrete masonry, with a small amount of stone masonry face work, and about 30,000 tons of structural steel work. Many of the buildings on Park Avenue adjacent to the widened cut will require underpinning.

The plant now installed includes steam boilers and Rand air compressors at the foot of Forty-first Street, which were originally used on the construction of the Park Avenue tunnel for the Rapid Transit Railroad, and have been purchased by the contractors from the estate of Ira Shaler. These have a capacity of 5,000 cubic feet per minute and supply air at 100 pounds pressure through a 10-inch main with branches and flexible connections to the hoisting engines, drills and all other machinery except the steam shovels. There are one 3-yard Bucyrus shovel, one 2½-yard and one 3-yard Marion shovel now in operation, and a third Marion shovel with a 5½-yard bucket has been ordered for delivery May 1. The best efficiency attained by a steam shovel under the difficult conditions of this work has been forty 30-yard cars in 10 hours, which is estimated to be equivalent to about 1,000 cubic yards in place. Each shovel requires for its operation three men on the machine and six men on the ground. There are forty-five Rand rock drills and two stiff-leg movable derricks with 55-foot booms and Lidgerwood hoisting engines having improved attachments for revolving the derrick masts. There are sixty-nine 30-yard steel Goodwin dump cars, 50,000 feet of rails, switches, frogs, etc., supplied by the contractors and four locomotives used by the contractors and furnished by the New York Central Railroad. Two of these locomotives will be replaced by locomotives owned by the contractor. Very little water has so far been encountered in the excavations; it has been removed by two Cameron pumps and one Worthington pump operated by compressed air. The repair shop contains an 800-pound steam hammer, a drill press, pneumatic drills, pneumatic hammers and other tools operated by air pressure. A total force of about 300 men is now employed, most of whom work a single 10-hour shift. Both the number of the men and the amount of plant will be largely increased as the progress of the work permits.

The improvements were designed and are being conducted by the Engineering Department of the New York Central & Hudson River Railroad, under the direction of Mr. W. J. Wilgus, fifth vice-president; with Mr. A. B. Corthell, as terminal engineer, in direct charge of the work. The statements concerning them in this article are subject to many changes for the plans have not yet been finally approved. The entire contract for excavation, masonry, track laying and steel work here described was awarded to the O'Rourke Engineering Construction Company, of 26 Nassau Street, New York.

Traveling Derrick Loading Excavated Material into Thirty-Yard Steel Dump Car.

Silicate Stone.

Silicate stone is the name given in this country to an artificial stone manufactured according to a process patented by Mr. L. P. Ford, of Burton Tower, Gresford, Wales. It is a combination of sand and lime formed under the action of heat and heavy pressure, and judging from samples in the office of the Silicate Stone Company, at 39 Wall Street, New York, has a structure that would ordinarily be taken for a good, hard, natural stone, having a homogeneous texture on fracture without voids, cracks or veins. Several blocks trimmed by different stone cutters with various styles of surface finish had the appearance of fine white stone such as is used for decorative purposes in building construction, white sand having been employed in their manufacture, as the color depends largely on the color of the sand. A point regarding the production of the stone that is emphasized is that it is not made in block forms, but in a comparatively large mass, so that it may afterward be sawed into desired sizes.

It appears that the company mentioned intends erecting a plant in New York or the immediate vicinity to supply the building trade in the city and outlying districts. It may also erect other plants in promising centers or license local companies, so that there is no present desire to make public the details of the stone-making process. In general, however, 90 to 95 per cent. of silica sand is mixed with 5 to 10 per cent. of lime and the whole mass pressed into a mold into which steam is also admitted under pressure. The purpose of the steam besides contributing heat is to furnish moisture for slaking the lime. Further heat is supplied by the slaking action and the coincident expansion is counted on to create heavy pressure within the confining walls of the mold. On account of the strength required, the mold is cylindrical, and the initial pressure when the uncombined mixture is first inserted is obtained by pressing on the circular cover. Molds 6 feet in diameter have been used, giving a block of that diameter and 6 feet high, and, it is stated, no voids have been found, the air being removed in the process.

The degree of the hardness of the stone is largely dependent on the proportion of the constituents, but its limit is ordinarily that at which carving may easily be done. The oldest structure built of the silicate stone is a large porch in Wales, 3 years old, which, it is said, has not shown any deterioration. The composition of the stone is given as follows: silica sand, 78.65 per cent.; soluble silica and lime combined, 15.12 per cent.; lime uncombined, 2.29 per cent.; alumina, 0.98 per cent.; iron, 0.75 per cent.; combined water, 2.18 per cent.

As to its durability, it is stated that tests have been made with wetted samples, usually small cubes, subjected to freezing and others to atmospheres containing sulphurous, nitric and carbonic acids and the specimens were unaffected. Similar results were obtained with acid tests. Samples separately immersed in 1 to 2 per cent. solutions of sulphuric, hydrochloric and nitric acids were unaltered after a number of days submersion. In stronger solutions the stone was unaltered in both 5 and 10 per cent. solutions of sulphuric and hydrochloric acids, but was slightly attacked in the same strength solutions of nitric acid, and was also slightly attacked by 50 per cent. solutions of the sulphuric and hydrochloric acids. These tests are, of course, very severe as compared with the action of the usual exposure to atmospheric conditions. To show the strength of the stone the following figures have been taken from tests made at the Watertown arsenal: Tensile strength with pieces of stone cut to the dimensions and shape of a cement briquette, three specimens, 709 to 822 pounds per square inch, average 781 pounds. Crushing strength with three samples nominally 3 inches on an edge, first crack, 12,356, 10,470 and 9,920 pounds per square inch.

D. J. Whittemore, LL.D., Past-Pres. Am. Soc. C. E.

Among the living past-presidents of the American Society of Civil Engineers, there is none who has done more to develop the railways of the country than Mr. D. J. Whittemore, and it is particularly fitting that a sketch of his career should appear in an issue of The Engineering Record devoted mainly to construction problems and methods. The great railway system of which he has been chief engineer for forty years is so thoroughly expressive of his ideas regarding railway building, that an account of its development and a description of the methods of its engineering department ought, for some reasons, to be included in this note. Limitations of space unfortunately prevent the publication of such an article at this time, although it is to be hoped that before long the story of the development of not only the St. Paul but also the other large railway systems will be carefully written. When the importance of American railways is considered, the dearth of really useful information concerning other features of their development than the financial is surprising.

Mr. Whittemore was born in Milton, Vt., on December 6, 1830. He is a descendant of Thomas Whittemore, who came to this country about 1640 from England and eventually became owner of a farm in Chelsea, Mass., which remained in the possession of the family for 200 years. Mr. Whittemore's father was an unusually well-educated lawyer, who taught his son at home until the latter was old enough to attend the Bakersfield Academy. When he was seventeen years old, he joined the corps of engineers engaged on the location of the Vermont & Canada Railroad. The thoroughness of his education no less than his natural aptitude for his chosen profession are shown by the fact that in 1849, at the age of nineteen, he was appointed resident engineer in charge of the construction of the part of the road between Swanton, Vt., and Rouse Point, N. Y. On the completion of this work he was appointed resident engineer on the construction of a portion of the Great Western Railway of Canada where he remained until 1852. In that year his father, who was largely interested in the construction of the Central Ohio Railway between Zanesville and Wheeling, was accidentally killed while inspecting a bridge at the former city. The management of his interests fell upon the son and the latter was forced to resign his work in Canada. While attending to his business affairs he was nevertheless able to become the contractor's engineer on the Ohio Central work.

Although he was thus engaged in what was then western railway construction, in 1853 he went to the northwest of that date, as principal assistant engineer of the La Crosse & Milwaukee Railroad, then under construction. This line is now a part of the Chicago, Milwaukee & St. Paul Railway, so that it is proper to say that Mr. Whittemore's period of service with this system is about fifty years. In 1857 he was elected chief engineer and one of the directors of the Southern Minnesota Railway Company, now a part of the St. Paul system. For the next two years he was engaged in locating and constructing this road in what was then a primitive wilderness, and when work was suspended, his health had been so undermined by the hard life he had been compelled to lead, that he sought a change of climate. While visiting Cuba, he served for a few months as assistant chief engineer of the Western Railway on that island, but in 1860 he returned to Wisconsin as principal assistant engineer of the La Crosse & Milwaukee Railroad for a second time. In 1863 this line was merged into the Chicago, Milwaukee & St. Paul Railway, and shortly afterward he was appointed its chief engineer, an office he has held continuously until the present time.

One of the most interesting characteristics of his methods of work is to be found in the attention he has always paid to unsuccessful enterprises. To use his own words: "The scrap heap—that inarticulate witness of our blunders and the sepulchre of our blasted hopes, the best but most humiliating legacy we are forced to leave to our successors—has always to me been brim full of instruction." This is shown in his discussions and papers before engineering societies, and one of these on the form of railway excavations and embankments is here reprinted, not only as proving the value of a keen observation of unsuccessful work, but also as an unusual example of brevity. It is paper No. 730 of the "Transactions" of the American Society of Civil Engineers and reads as follows:

D. J. Whittemore.

"Nowhere in quiescent Nature do we find earth surfaces in right line planes, or changes in direction of same made by abrupt angles, yet it is the general practice in laying out and constructing railway excavations and embankments to establish slopes on such planes intersecting the natural surface of the ground and the formation level of the roadway in a well-defined line.

"These conditions are never, or rarely ever, maintained. Storm water breaks over the crest thus formed, seeking and making channels of least resistance down the unprotected slopes, bringing with it earth from the crest and from immediately below it, filling the ditches in excavations. Embankments suffer change of form from similar cause; and immediately after the line of railway is opened for traffic the ditching train is called into service to remove the slush from ditches and to widen embankments, at a cost of $1 to $2 per cubic yard; and this expense is continued year after year, and charged to operation. Often this expense during the first year of operation will exceed the cost of forming and protecting the slopes of excavation on the plan shown by the diagram herewith, which, with the above remarks, the writer submits without further comment to the consideration and criticism of the members."

The diagrams showed a roadbed in excavation, having the crest of the slope rounded to a 15-foot radius. The slope is sodded during construction and is tangent to a ditch having a radius of 2 feet. This ditch is paved when the ballast is placed, and tile is placed below it in wet localities. For a roadbed on embankment the slope ends below in a curve of 10 feet radius and above in one of 6 feet radius.

This brief paper brought out a discussion which is one of the most important and valuable in the "Transactions" of the Society. Although many engineers had observed the same facts before, none had apparently reasoned so clearly from the defective results of the usual cross-sections to the remedy for them. The importance of the subject was well stated in the discussion of the paper by Mr. J. F. Wallace, who said that "if the ideas advanced by Mr. Whittemore had been put into practice years ago, the result would have been a saving of hundreds of thousands of dollars to railroads in the central and western portions of the United States. The past and present practice of making the cross-section of railroad excavation and embankment conform to the theoretical lines laid down by the earlier engineers has so far given expensive and unsatisfactory results." He went on to say that he knew cases where it required as great an expenditure to maintain a good roadbed through excavations as it originally cost to make the cuts, due to the sloughing-in of the sides of the excavations, the filling up of the ditches, and the imperfect drainage caused thereby.

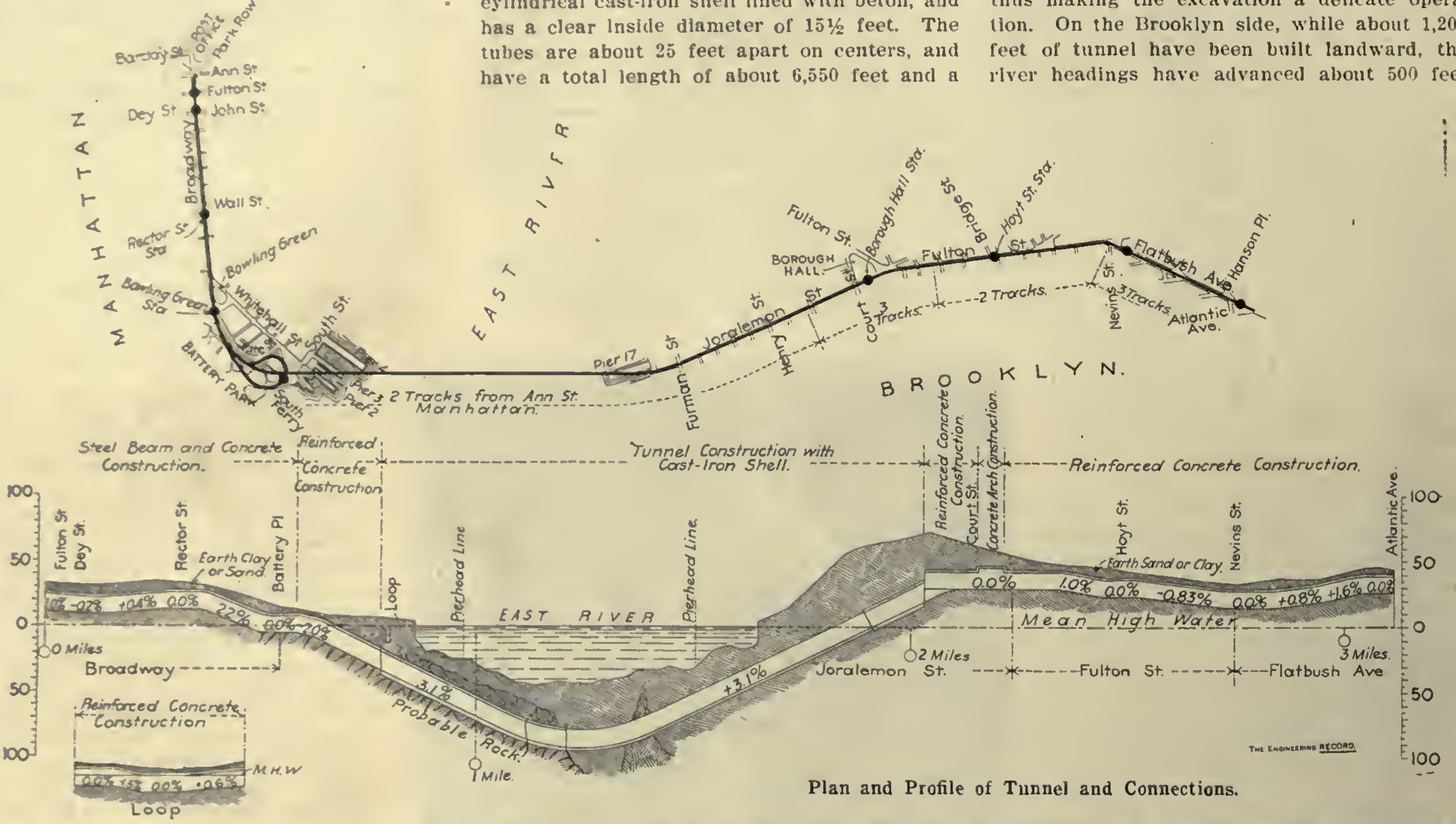
Mr. Whittemore occupies a leading place among the pioneers of the American cement industry as well as in engineering. About 1874 his attention was called to the hydraulic properties of the water-lime rock at Milwaukee, which closely resembles the rock in the Rosendale district in Ulster County, N. Y. He conducted a series of experiments which proved that an excellent hydraulic cement could be made from this rock, and the Milwaukee Cement Company, in which he took an interest, was formed to do this. The original works were built in 1876 and rebuilt in 1893, while a second plant was put in operation in 1889. This was fully described in The Engineering Record of April 2, 1898. Mr. Whittemore was a director of the company until 1891 when he resigned to become one of the founders of the Western Portland Cement Company, of which he is now the vice-president. This company's plant is located a few miles west of Yankton, S. D., and is one of the most interesting of the wet-process type in the country from a technical point of view. Chalk and clay are the raw materials used, and the works resemble in a general way the English plants on the Thames and Medway, except that labor-saving apparatus has been adopted extensively, and new methods of working the slurry and securing uniform mixtures are employed. The burning was originally done in six Johnson kilns, with drying chambers and a central chimney, but rotary kilns are now being installed. The works were fully described in this journal on November 19, 1898.

Mr. Whittemore became a member of the American Society of Civil Engineers in 1872; in 1881 he was elected a director and in 1884 was elected president. He has presented five papers before the Society and has taken part in many important discussions. He was a member of the committee which prepared the Society's famous report on a uniform system of cement tests and has taken an active part in various international engineering functions. He joined the American Society of Mechanical Engineers in 1889 and the Institution of Civil Engineers in 1885. The University of Vermont has conferred on him the degree of Civil Engineer and the University of Wisconsin has recognized the scientific character of much of his work by conferring the degrees of Doctor of Philosophy and Doctor of Laws. His success he attributes largely to the able and considerate presidents and managers of the corporations with which he has been connected and the loyal assistants under him. Another explanation may be the fact that his prime ambition has always been to be esteemed a worthy member of the civil engineering profession, whose aim he recently defined as the consideration and determination of the economic use of time, power and matter for the uses of mankind.

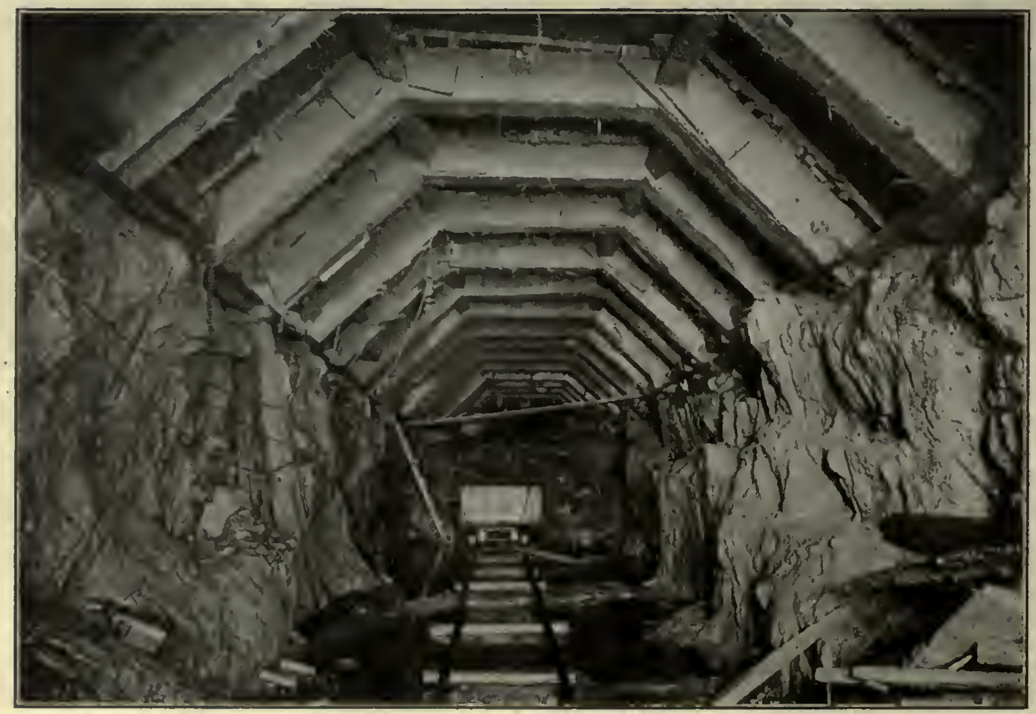
THE BOILER ROOM of the Manchester street power station of the Rhode Island Company, in Providence, R. I., is so utilized by the arrangement of plant that there is about 1.5 square feet ground area per horse-power of boiler capacity. The statement in this paper on February 20 that only 2/3 square foot per horse-power was needed was an evident error. The importance of this relation is so great, however, that attention is drawn particularly to the correct ratio. An instructive paper might be written on the utilization of space in important central stations.

The New York and Brooklyn Tunnel for the Rapid Transit Railroad.—I.

The subway of the Broadway extension of the Rapid Transit Railroad is to be connected with the Brooklyn subway by two parallel single-track tunnels crossing the East River from the Battery Park loop to Pier 17, Brooklyn, and thence under Joralemon Street to a connection with the Fulton Street line. Each tunnel has a cylindrical cast-iron shell lined with beton, and has a clear inside diameter of 15½ feet. The tubes are about 25 feet apart on centers, and have a total length of about 6,550 feet and a maximum depth of about 94 feet from mean high-water level to base of rail. The maximum depth of water is about 50 feet and the thickness of the roof above the tubes varies from about 6 to 30 feet. The maximum grades are 3.1 per cent. and are connected by a vertical curve under the middle of the river. The location and character of the materials encountered differ essentially from the indications afforded by the preliminary exploration.



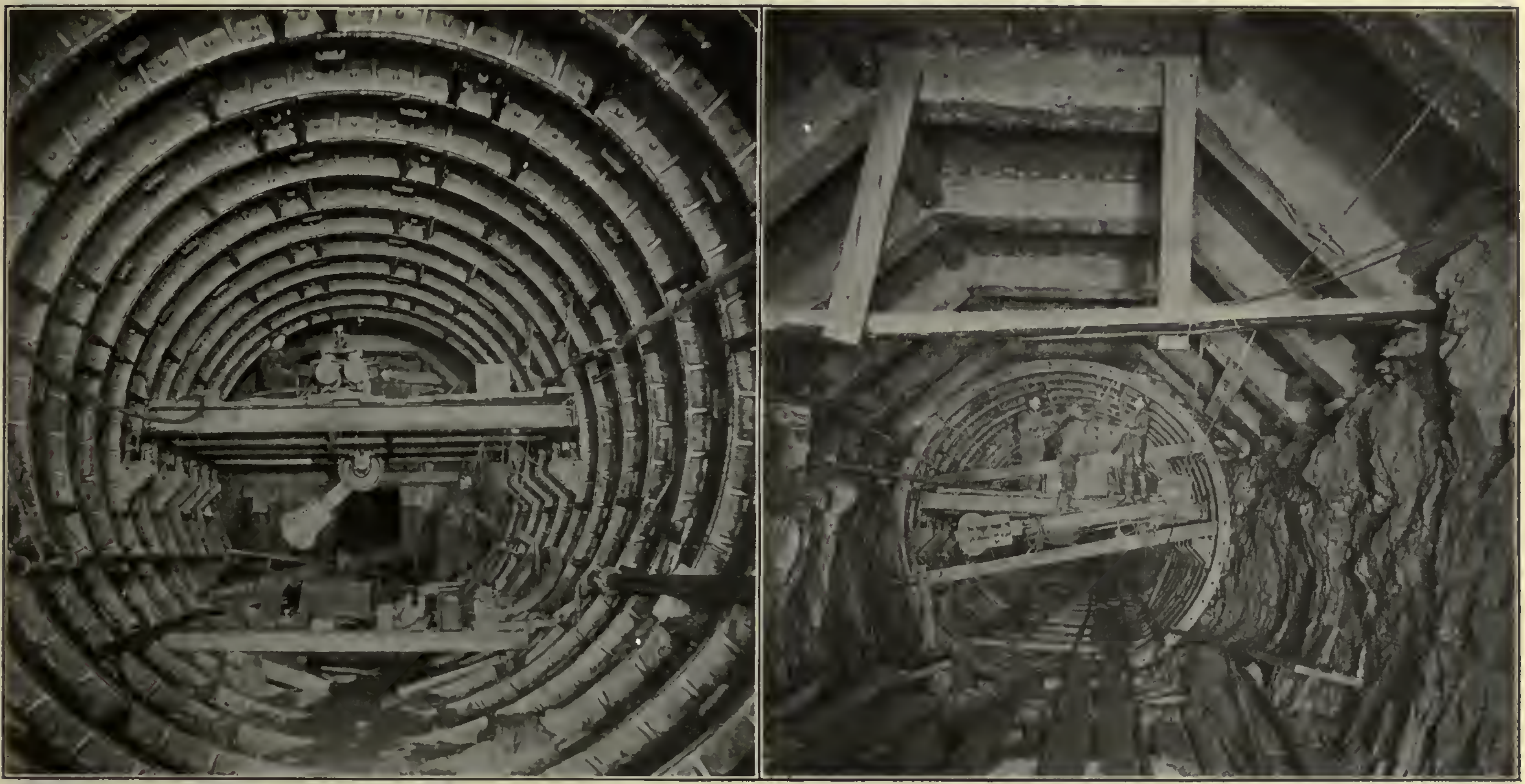
Plan and Profile of Tunnel and Connections.



New York and Brooklyn Tunnel: Timbering in New York Heading.

On the New York side the excavation has progressed for about 500 feet, all of it through solid rock of variable character, some being hard and some soft or decomposed, with numerous irregularities, fissures and open seams. The surface undulates within limits of about 10 feet vertically. At present the New York headings have only about 2 feet of shaky rock over them, and above the rock there is only 6 feet of clay, boulders and other loose material, thus making the excavation a delicate operation. On the Brooklyn side, while about 1,200 feet of tunnel have been built landward, the river headings have advanced about 500 feet from the shaft in one tube and 200 feet in the other, neither of which have yet reached the shore line. Here the excavation has been wholly in sand and gravel, and at present is being accomplished with special steel shields and without air pressure. On the New York side no shields are used, but the work is being executed under a pressure of about 10 pounds, equivalent to the hydrostatic head, due to the depth of the river at the headings.

The New York headings are being driven from a 53x15-foot shaft about 42 feet deep, braced and sheeted with timber in the ordinary manner. It contains two separate elevator shafts and is surrounded by an enclosure which reserves a portion of the east end of Battery Park, under the elevated railroad tracks, for the installation of the surface plant, storage of materials, repair shops, offices, derricks and spoil tracks. Both drifts are being made with ordinary upper headings about 8 feet high and of the full width of the excavation. The rock is so treacherous that the roof is supported, as fast as the excavation is made, with 3-inch poling boards and bents of arch timbering 5 feet apart on centers. Each bent consists of a horizontal center piece and two inclined end posts with miter joints. Each piece is a 12x14-inch timber 8 feet long. Four Ingersoll-Sergeant and Rand rock drills are used in each heading to bore holes about 6 feet deep by means of which the rock is blasted by light charges of dynamite carefully proportioned to avoid lifting the thin roof. The upper holes for the center cut are drilled but not fired before the center arch timber is set, because they are so near the roof that the timber would otherwise interfere with the drills. After these holes are finished, the center timber is temporarily supported on the horizontal arms of the drill columns, and the remainder of the holes are drilled. Afterwards the sides of the drift are taken out and the inclined side posts of the bent are inserted. A bench about 12 feet high is taken out in the usual way and is kept from 20 to 30 feet distant from the heading. Where the roof is very thin, special care is taken to pack hay tightly in the cavities over the forward ends of the poling boards as fast as they are advanced so as to prevent the flow of sand and earth which crumbles very easily. The finished iron shell is kept as close as possible to the end of the finished excavation, usually being not more than 20 feet behind it. As fast as the shell is assembled, all the spaces between it and the rock are carefully packed with dry stone laid as closely and solidly as possible. The interstices among these stones are afterwards thoroughly filled with grout at a pressure of 90 pounds per square inch, thus making a concrete sleeve for the shell, which would have considerable strength if the shell were entirely removed and through which there is even now scarcely any leakage.



Iron Lining, Erector and Bulkhead Protection against Blasts in Heading; Assembling Section of Lining with Erector,—Looking from Heading.

The shell is of the ordinary construction with eight main segments about 6½ feet long and a crown segment or key about 1 foot long. Each segment is 22 inches in width and is made of 1⅛-inch metal with flanges on all sides 7 inches deep over all. The flanges are bored for three 1-inch bolts in each end and six on each side; they are 1⅛ inches thick at the edges and are stiffened by knee-brace webs. The segments are put together without gaskets and have bearings on planed surfaces 5 inches wide. The outer 2 inches of each flange are recessed so as to make calking spaces ¼ inch wide. Each segment is made with a short inside longitudinal web in the center, having two bolt holes to facilitate handling it during assembling. There is also a 1½-inch hole tapped through the web which is normally closed by a screw plug and affords connection for the 1¼-inch grouting pipe. The segments are delivered by boat to the cars on a double-track trestle which crosses Battery Park from the water's edge to the shaft. There they are unloaded by a stiff-leg derrick and lowered by the elevator car in the shaft. From the foot of the shaft they are sent to the heading on small platform cars, which deliver them to a special machine called an erector. The erector has a horizontal platform about 14 feet wide on the center line of the tunnel which is movably supported on the flanges of the shell. This platform carries a radial arm which is revolved by an air motor about a horizontal pivot in the axis of the tunnel. The extremity of the arm is bolted to the 900-pound segment of the shell and revolved into the required position. An hydraulic piston in the arm then pushes the segment out to place, and it is bolted through two flanges; another segment is added and so on until the ring is complete. The erector weighs only about 3 tons, is simple in its operation and is considered very efficient and satisfactory. With it four men can assemble one ring of the shell in about 1 hour.

The assembling gang is followed at a distance of from 50 to 100 feet by the grouting gang of three men. The grout machine is operated by an Ingersoll-Sergeant three-cylinder air engine. It consists of a small air-tight cylinder in which six bags of cement and crusher dust are mixed by revolving paddles, and from which the mixture is expelled by air pressure.

About 100 feet from the foot of the shaft each tube is closed by a solid mass of brickwork about 6 feet thick apart. Built into them are the two air locks, the lower one 6½ feet in diameter and 20 feet long is chiefly for the passage of cars and materials. The upper one, 3 feet in diameter and 32 feet long, is for the passage of men and to admit long timbers, rails, pipes, etc., without excessive loss of air. It is also designed to be always available as an emergency lock. The spoil is loaded at the heading into 1-yard steel cars having special trucks of 30-inch gauge. Each axle is keyed to one wheel and loose in the other wheel, and is enclosed by a sleeve, the space between the axle and sleeve being filled with oil for automatic lubrication. Both these cars and the platform cars run from the foot of the shaft to the heading by gravity and are pulled back by a steel wire cable operated by a single-drum Lidgerwood hoisting engine seated on the overhead platform. Each tube is lighted by groups of three incandescent lamps at intervals of about 50 feet, besides additional lamps at the different machines and in the heading and shaft. These lamps are connected to a three-wire system arranged with a loop so that all lamps may have the same potential. A 110-volt current is used so as to avoid all danger of accident and insure safety even in handling the naked wires.

There is not much water in the heading, and it is easily expelled through a blow-out tube by the air pressure, thus avoiding any necessity for pumping there. The blow-off delivers to a sump at the foot of the shaft, whence the water is raised to the surface by steam pumps. With the exception of these pumps, all machinery in the tunnels is operated by air at 90 pounds pressure.

The principal quantities per linear foot of each tube which are involved in the construction of the tunnel include 9 cubic yards of excavation in rock and 8¼ yards of earth in shield work, 120 feet board measure of timber for rock excavation, 4,000 pounds of cast-iron in the shell and about 21 cubic feet of 1:3:4 Giant Portland cement concrete made with ¾-inch stone, which is used to fill between the flanges of the segments. From 9 to 12 men are required in each heading; about 225 men in all are employed on the New York side and 100 on the Brooklyn side in the tunnels. The work is done with three eight-hour shifts daily, and a maximum progress of 12 feet in 24 hours has been made in the shield tunnels and 3 feet in the rock tunnels.

The contractors' plant in the tunnels on both sides of the river includes fourteen Rand and Ingersoll-Sergeant rock drills, fifty 1-yard mine cars, four Lidgerwood hoisting engines, ten Cameron pumps, four shields, made by Alexander Miller & Bro., of Jersey City, six erectors, two grout machines, four material locks and four emergency locks made by the Cockburn Barrow & Machine Company, of Jersey City, and six hydraulic pressure pumps operating the erectors, besides the hydraulic machinery for the shields, which was made by the Watson-Stillman Company, of New York.

Blackwell's Island Bridge: Dock, Elevated Materials Track and Derrick at Manhattan End; Concrete Mixers, Storage Bins and Footing of Pier I.

The surface plant at the New York end includes a 650-horse-power battery of Hogan boilers; one Bacon hoisting engine, driven by compressed air, operating the balanced cages in the shaft; one 500-horse-power Ingersoll-Sergeant air compressor with a capacity of 3,000 cubic feet of free air per minute, fitted with an intercooler and a 6x15-foot receiver, supplying air to the heading under a present pressure of about 10 pounds; two Ingersoll-Sergeant straight line compressors with a capacity of 1,200 cubic feet of free air per minute which supply air at 100 pounds pressure to operate the machinery in the tunnel; one General Electric Company's and one Keystone direct-connected 17-kilowatt 110-volt dynamo; one direct-connected Westinghouse 40-kilowatt 100-volt dynamo; one 16x10-inch Farrell 50-yard stone crusher, driven by a 9x10-inch Vim engine, and a 10-inch bucket elevator 40 feet long on centers which delivers the crushed stone and dust to 10x10x11-foot elevated bins. There is also a buzz-saw for cutting the arch timbers and some machine shop tools for repair work, which are driven by a 10-horse-power Ames steam engine. On the Brooklyn side power is furnished by five Gem City 125-horse-power horizontal tubular boilers and by a battery of 500-horse-power Heine boilers. There are one large and two small compressors like those on the New York side; two Keystone direct-connected 32-kilowatt 110-volt dynamos; two separate Bacon hoisting engines for the shaft elevators; and small tools for the repair work similar to those installed on the New York side.

The Brooklyn headings have been driven from two 24x20-foot shafts about 65 feet deep and 50 feet apart on centers sunk and timbered as described in The Engineering Record of October 31, 1903. The soil at this point was found to be sand and gravel with small boulders, and as it could not be depended on to stand up for the sides of the excavation, shields were installed as soon as the shafts were sunk. These shields are of riveted steel about 17 feet in diameter and 9½ feet long, including the tailpiece and exclusive of detachable hood and central platform extension. They differ in several respects from shields previously used for tunneling and were especially designed by Chief Engineer Aims to meet the conditions which were expected to prevail in this work. Patents on the novel features have been applied for and include the removable hood, special working platforms and bracing in the front of the shield and horizontal sliding doors in the transverse diaphragm, which are operated by hydraulic cylinders.

The cylindrical iron shells were delivered in four sections each and assembled with the girders and diaphragms at the bottoms of the two shafts. When they were completed, special bracing was built in the shaft lining and the lower portion of the sheeting and timber work was cut out to allow the shields to be driven through the walls. The first two shields were driven away from the river to the shore end of this section of the subway, where they now remain and may either be utilized by the contractors for the adjacent section or may be removed. After these shields had been driven clear of the shafts, two more shields, duplicates of the first, were assembled in the bottoms of the shafts and were driven in the opposite direction on the line of the tunnel under the river. These shields have now been advanced about 500 feet from the shafts, and air locks similar to those described for the New York side have been built behind them about 100 feet from the shafts. The shields are driven in the usual manner by hydraulic jacks operated by pumps carried on the erector platforms and worked by air at 100 pounds pressure.

The water encountered in the headings is pumped to a sump at the foot of the shaft and then repumped to the surface. The lining and grouting is carried on in a manner similar to that described for the New York side.

The design and construction of the tunnel is under the supervision of Mr. William Barclay Parsons, chief engineer of the Rapid Transit Railroad Commissioners for the city of New York; Mr. George S. Rice, deputy chief engineer, and Mr. Robert Ridgway, division engineer. The contract for this section of the subway was awarded to the Rapid Transit Subway Construction Company, Mr. J. B. McDonald, president; Mr. S. L. F. Deyo, chief engineer; and Mr. Harry B. Reed, division engineer. A sub-contract for the tunnel construction was let to the New York Tunnel Company, Mr. Andrew Onderdonk, contractor; Mr. Walton I. Aims, chief engineer; Mr. John Kergan, superintendent. Mr. Bernt Berger has assisted Mr. Aims in the preparation of some of the detail plans for the structural work.

(To be continued.)

Masonry Construction for the Blackwell's Island Bridge.

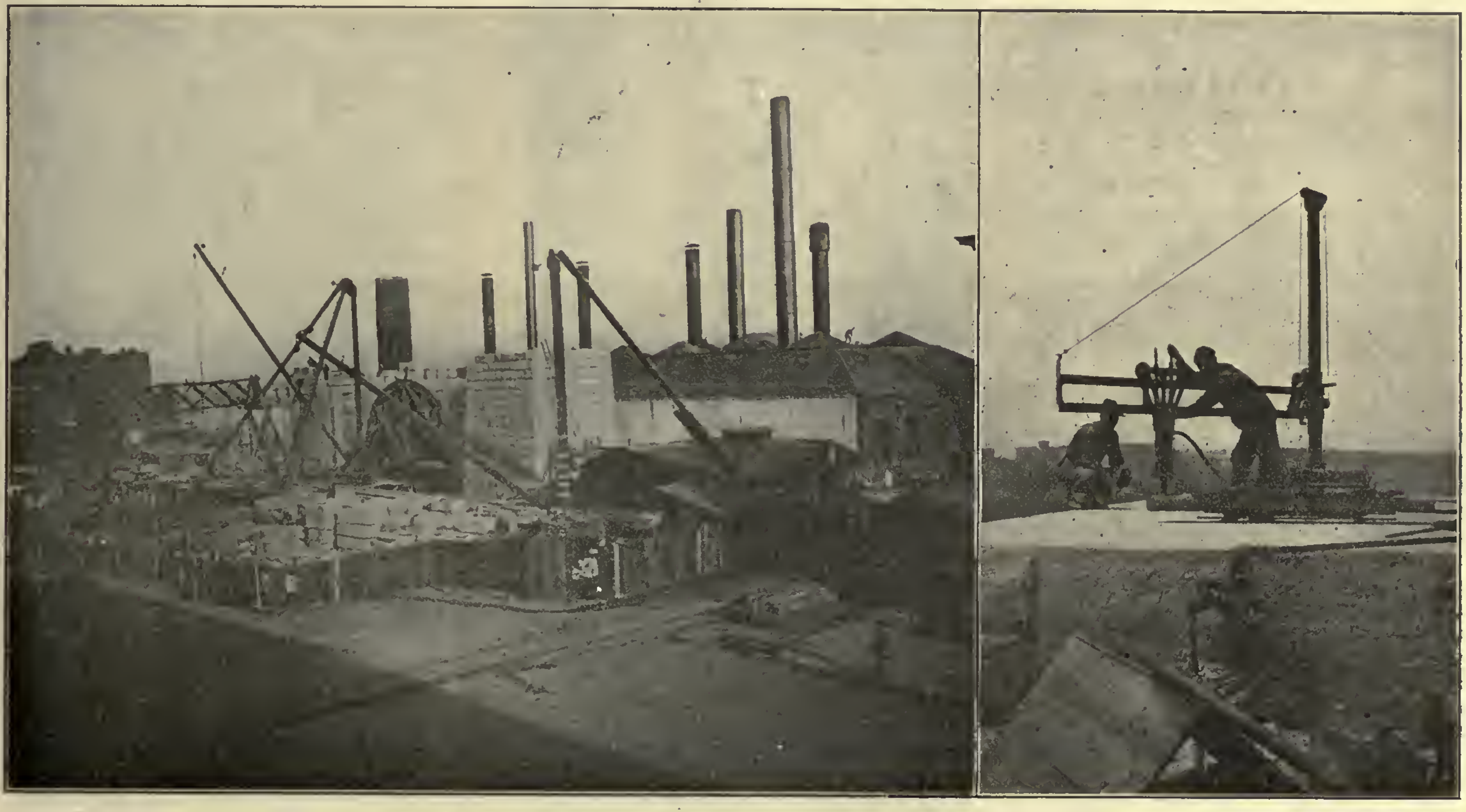
The bridge which will be third in order of completion across the East River, New York, is officially called Bridge No. 4, and will have a total length of about 7,636 feet, reaching from Sixtieth Street, Borough of Manhattan, to Ravenswood, Borough of Queens. It will have long steel viaduct approaches and will cross Blackwell's Island and both channels of the river with five cantilever spans of from 459 to 1,182 feet, aggregating 3,724½ feet between anchorages. The minimum clear height will be 118 feet above mean high water, and there will be a height of 135 feet over the main channel. The bridge will have a capacity of two elevated railroad and four electric car tracks, two carriageways and two sidewalks. The trusses, to be the second longest of their type and much the heaviest ever built, are notable for special features of design and for the use of nickel steel eyebars of very large dimensions. The estimated cost of the bridge is about $12,500,000. The original designs were made by the Department of Bridges of the City of New York when Mr. John L. Shea was commissioner, Mr. S. R. Probasco, chief engineer, and Mr. R. S. Buck, engineer of the bridge. Mr. Shea was succeeded by Mr. Gustav Lindenthal and Mr. Buck by Mr. H. A. Lachicotte, and a commission of engineers and architects was appointed to report on changes in the design proposed by Mr. Lindenthal after work on the substructure was well advanced. The new design was adopted, and after considerable delay the work was resumed and is now nearly completed on the substructure under the direction of Mr. George E. Best, Commissioner; Mr. O. F. Nichols, chief engineer; Mr. R. S. Back, consulting engineer; Mr. H. A. Lachicotte, assistant engineer, and Mr. Oscar Erlandsen, assistant engineer at the site.

The substructure for the main spans consists of four piers and two anchorages, all with concrete foundations on solid rock at moderate depth, those of the piers being close to the water line on the shores of both channels. All the piers and anchorages are of similar design and each consists of two square battered shafts with their upper parts connected by an arch of about 50 feet span carrying a transverse curtain wall. They are all built of massive rock-faced granite ashlar, backed with limestone masonry and concrete and trimmed with cut stone courses, quoins and deep mouldings. The design was fully described in The Engineering Record March 16, 1901; December 13, 1902 and August 22, 1903. The principal quantities are estimated to be about 86,000,000 pounds of steel, 22,800 cubic yards of granite, 14,000 yards of limestone, 17,000 yards of concrete, 14,000 yards of earth excavation and 6,500 yards of rock excavation for the five main spans. The contract price for the six piers and anchorages was $846,000 and only about $26,000 worth of work now remains to be done to complete them. Piers 2 and 4 and the east anchorage are finished; all the stone is cut for, and only a few hundred yards of masonry remain to be laid on, piers 1 and 3, and about 2,000 yards on the west anchorage.

The substructure contract was let in June, 1901, to Messrs. Ryan & Parker, and work was immediately commenced on piers 2 and 3, on Blackwell's Island, and afterwards on pier 4 and the east anchorage, at Ravenswood, pier 1 and the Manhattan anchorage being delayed on account of obstructions on the site. The location and conditions made it necessary to establish three complete construction plants, one on the island, one at Ravenswood and one in Manhattan. These were all of different design with special equipment for mixing and handling the large quantities of concrete, and those on the island and at Ravenswood were illustrated in this journal December 13, 1902.

The Blackwell's Island plant consisted essentially of a receiving dock, concrete machinery, power plant, falsework tower, derricks and stone yard, where all cut stone was dressed and stored. The spawls and refuse from the stone yard were crushed and screened and delivered automatically by elevators to storage bins under an extension of the dock platform. Sand was unloaded from boats and stored in adjacent bins, and sand, stone and cement were placed on a long Robins belt and conveyed to the concrete mixer in the tower, which had a capacity of 150 cubic yards of concrete in eight hours. The concrete buckets were delivered on cars to the boom-derricks which handled the tower masonry. The towers were built with stiff-leg derricks seated on the ground and on the masonry, and on a 36x36-foot tower 100 feet high, which was moved across the island from one pier to the other.

All the stone was delivered from the contractors' quarries by schooners of from 600 to 800 tons burden, which made the trip from Maine in from 48 hours to 48 days. The granite quarry, described December 13, 1902, was equipped with men and plant that quarried and loaded the stone for nine schooners in nine days. The stone is of beautiful quality and large dimensions up to pieces of 12 tons each. All the stone was dressed on the island by a maximum force of 125 stone cutters. There were about 5,000 cubic yards of fine cut work and it was all dressed by Kotten pneumatic machines operated by air from a Norwich compressor supplied with steam by a 60-horse-power boiler. Small stones were dressed by this machine as they lay on the ground, but it was not high enough to clear the ends of coping stones 9 feet long and special provision was made for them. A pit 5 feet wide, 5 feet deep and 16 feet long was dug and lined with concrete. Tracks were laid on the surface of the ground alongside the pit and the machines traveled on them to dress the upper ends of the long stones set vertically in the pit. The most interesting use of these machines was to dress the 21½x21½-foot beds on top of the pedestal stones in position at a height of 125 feet above the water. These stones were set ½ inch high and were required to be faced with great precision, although the truss shoes are to be seated on them with ¾-inch rust joints. The machines were set up on the pier tops and dressed the beds



Shore Side of Pier I, Storage Bins and Concrete Plant at Left; Pneumatic Machine Dressing Pedestal on Pier Top.

to within 1/50 inch, going over the surface until it was so perfect that there were no variations greater than the thickness of a sheet of thick paper, and no hollows could be detected by a leveling rod or by the moisture remaining after a shower. This work took about ten days for each pedestal.

At Ravenswood the plant consisted of a dock, a long inclined platform in the bridge axis, reaching from it to the pier and anchorage; storage bins and delivery tracks at a low level, under the platform; a concrete mixing tower on the platform, ordinary boom-derricks for unloading boats, serving the concrete mixer and handling the masonry; a hoisting engine and cable for hauling cars up the incline, and a 200-horse-power boiler plant. Here the storage bins discharged to cars underneath which delivered to measuring boxes hoisted by a derrick and emptied into the mixer. The mixer discharged to buckets on cars on the incline, and these ran by gravity or were hauled by the cable to the pier and anchorage, where the contents of the buckets were emptied by the derricks. When work was in progress on both pier and anchorage about 350 cubic yards of concrete was mixed and laid in one eight-hour day.

The plant at the Manhattan end of the bridge is installed on the steep bank of the river about 50 feet above high water. The coal dock of one of the power houses of the New York Steam Company extends in a sharp point into the river at Fifty-ninth Street, and the privilege was obtained of setting on it the mast and one stiff-leg of the special unloading derrick, which was arranged so that its platform was about 20 feet above the dock floor and only a very few square feet of the floor surface was occupied, causing practically no obstruction on the dock. The derrick delivered stone, sand, cement and other materials from boats to cars on an elevated platform trestled out from the top of the bank. Its two tracks were carried to street level and thence ascended about 10 feet and continued across the shore side of pier 1, where they terminated on the deck or roof below which were built rectangular storage bins having an aggregate width and length of 32 and 46 feet and a depth of 18 feet. About 6 feet above the ground they had flat bottoms with holes closed by horizontal sliding steel plate gates through which the sand and stone, dumped from the tracks above, were discharged into cars which were run over a shallow pit. The cars were of a special pattern designed by Mr. Parker, and had A-shaped bottoms and flap doors, opening outwards in the lower part of the sides so that they would discharge the contents when unlatched. They were made of the exact size required to hold the proportions of sand and stone for one 2-yard batch of concrete, and discharged their contents to scale boxes in pits between the tracks on which sand and stone cars were brought opposite each other.

With the sand and stone nine bags of Lehigh Portland cement was delivered to the scale box through a chute from the deck above for each batch of 1:2:5 concrete. The bucket was raised by a trolley hoist on an overhead track between two combination Howe trusses, 8 feet deep, 75 feet long and 3 feet apart on centers, which are supported on timber trestles about 50 feet high. At the end of the trolley track the charging box is discharged into the hopper of a 3-yard Carlin's cubical mixing machine. The mixer is revolved a minute or more until a bucket is set under it and the concrete or mortar is discharged into it. The bucket is either delivered by the derrick directly to pier 1, or the mixer is emptied into a wagon in the street, which is drawn by a two-horse team up the light grade to the anchorage 600 feet away and there dumped wherever required. The concrete may be put on cars and run out on the trestle and back to surface track in a parallel street, which also goes to the anchorage, but at a grade so much steeper that it was not easy to haul over. The trolley track is inclined downwards, away from the concrete mixer just enough so that the slope would partly keep the trolley stationary against the stress of winding up the hoisting rope and would return the car by gravity from the mixer to the scale-pan pit. It was, however, provided with an endless rope led around pulleys at both ends of the truss and to the drum of the hoisting engine, by which the trolley could be held against the hoisting rope or moved independently of the latter. The wooden charging boxes have double flap bottoms, opening downwards, held up by bridle chains from the hoisting rope. The tension on these chains keeps the flaps closed while the charging box is suspended, and when it is delivered to the charging hopper its ends only are seated on supports which clear the flaps. Then when the hoist rope is slacked off it allows the flaps to open and empty the contents. With this plant a force of ten men have made and laid 300 cubic yards of concrete and the mortar for 150 yards of stone masonry in one eight-hour day for the anchorage and pier 1, respectively. The efficiency of the plant was secured by making all the operations as nearly continuous as possible and might have been still greater if it had been practicable to take the concrete from the machine and put it in place more rapidly. One charging box was in the track pit being filled while another was being emptied into the charging hopper. The charging box was kept filled over the concrete mixer while the mixer was in operation, so that it was ready to deliver its contents the moment the mixer discharged a batch of concrete, and an empty bucket was kept waiting under the concrete mixer while the full one was being delivered to the pier or anchorage, but as this last operation took more time than it did to run a batch through the mixer, it limited the output of the latter below its capacity.

A Philadelphia Fire Protection Stream.

The foundation excavations were all made in open pits which were carried down to a maximum depth of about 40 feet. The sides were retained by ordinary sheeting, and at piers 2 and 3, where the rock bottom was only a few feet below low tide, the water was kept out with sand-bag coffer dams. Very little pumping was required except at pier 1, where a 6-inch centrifugal and a 4-inch duplex pump were installed. All excavating was done with pick and shovel and the spoil was handled by scale boxes and boom derricks and used for fill.

At the Ravenswood anchorage test pits were not driven to rock and the position of the rock surface as indicated by the profiles was wrong. The contractor was therefore obliged to excavate about 12 feet deeper than was expected; difficult and expensive work in the quicksand was encountered there. After the footings of this pier were finished and the masonry had been carried up to a considerable height above the surface, it was decided to lengthen the anchorage in accordance with the revised design and the contractor was obliged to repeat the difficult excavation at one end of the pier.

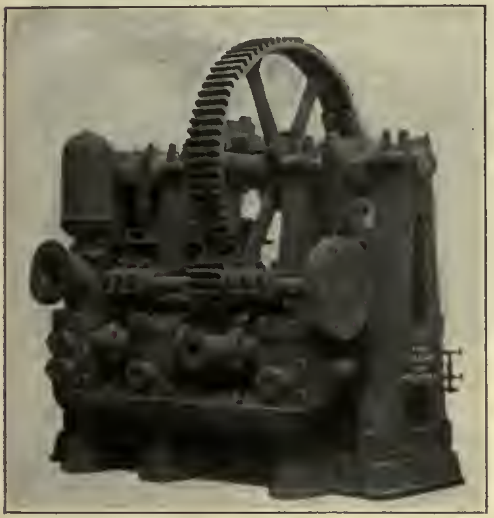
The stiff-leg derrick on the coal pier at the Manhattan end of the bridge had a 60-foot boom and a 40-foot mast braced by two stiff-legs making an angle of about 60 degrees with each other. The mast was supported on a single trestle bent about 20 feet high, seated on the string piece bolted to the fender piles on the face of the dock and therefore occupied none of the dock floor. One of the stiff-legs was nearly in the plane of the trestle bent and had its lower end seated on shore, where it was secured with a heavy load of riprap. The foot of the other stiff-leg was secured to the end of a horizontal sill about 18 feet in the clear above the dock floor. One end of the sill was supported on the trestle and the other end was shouldered into the tops of two vertical posts and braced laterally by a timber strut to the shore. A heavy platform 7 feet square was built on the floor of the dock and connected to the feet of the vertical posts and on it was piled 34 tons of pig-iron, enclosed in a strong box to prevent it from being stolen. All the stiff-leg connections and those at the feet of the vertical posts were made with 3-inch pins engaging the ends of eyebars which had been saved from a roof truss and were drilled and bolted to the ends of the timbers to make jaws. The contractor had a large number of these short bars in stock which make admirable tension connections for timber and serve instead of expensive special forgings. Two more 10x14-inch timbers were set parallel to the sill and with it acted as beams to support the hoisting engine platform with plenty of clearance below it over the dock floor, so that only 49 square feet of the dock was required for the derrick. The trestle under the mast was thoroughly braced and bolted to the string piece and piles so that it resisted any displacement of the derrick in its plane, and as the two stiff-legs resisted any kick in either direction at right angles to the trestle the mast was secure on all sides and safely handled heavy loads through an arc of 270 degrees, although the base was a narrow one. A stiff-leg derrick with a 78-foot boom was set in the bridge axis at pier 1 and commanded both its shafts and the concrete mixer and handled all materials for the pier up to a height of about 10 feet above the crown of the arch, when a guyed derrick with a 78-foot boom and an 85-foot mast was set in the center of the pier and finished the work there, being occasionally shifted and raised to allow the masonry under it to be built up. This was accomplished by unshipping the boom and using it as a gin-pole to set the mast in the new position and then using the latter to put the boom back in its seat, the whole operation throwing the derrick out of service only about three hours. At pier 1 and the Manhattan anchorage the contractors did not install any power plant, but operated all hoisting engines, pumps, and concrete machinery by steam purchased by meter from the New York Steam Company.

The contractors had in all twenty-two large derricks on this work, all of them having booms from 60 to 87 feet long with a capacity of at least 12 tons. Four teams were required to haul the concrete from the mixer at pier 1 to the Manhattan anchorage and a tug with a capacity of 100 passengers was employed constantly to transport the men at work on the island and handle scows, etc., other towing being done by the towing companies, as needed. The maximum force employed was about 250 men and the largest amount of masonry laid in one month was 5,400 cubic yards, including 2,750 yards of concrete. The special features of the contractors plant were designed, the plant was installed by Mr. A. McC. Parker.

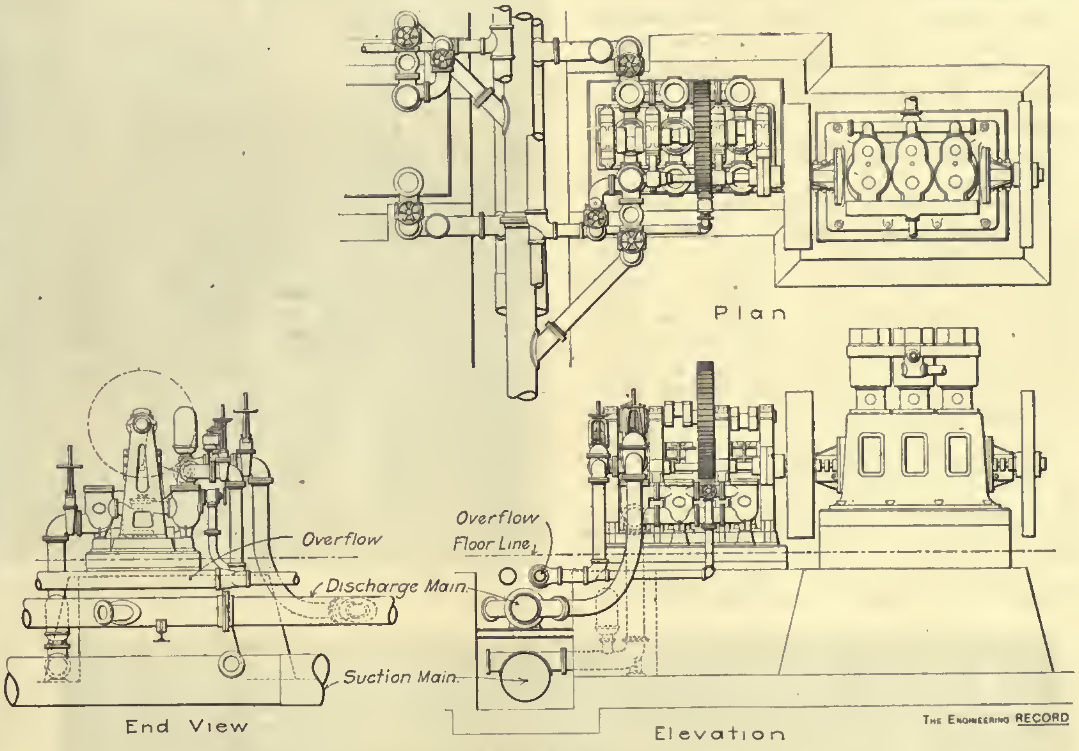
The Philadelphia Gas Engine Pumping Station for Fire Service.

An important development in the application of gas power is marked by the establishment of the Philadelphia high-pressure pumping station. This station supplies water at necessary pressure up to 300 pounds per square inch to a high-pressure pipe network covering the downtown business district, which has been designated by the insurance companies the "congested" or "danger" district. The ultimate capacity of the station is approximately 3,000 brake horsepower or 12,700 gallons of water per minute. Up to the present time, 2,200 horse power in engine capacity has been installed and the plant will be extended in the future when required. The establishment of the Philadelphia station was directly brought about by the action of the insurance companies in raising rates throughout the so-called "danger" district. This movement was necessitated by the severe losses which have been sustained as a result of lack of adequate fire apparatus.

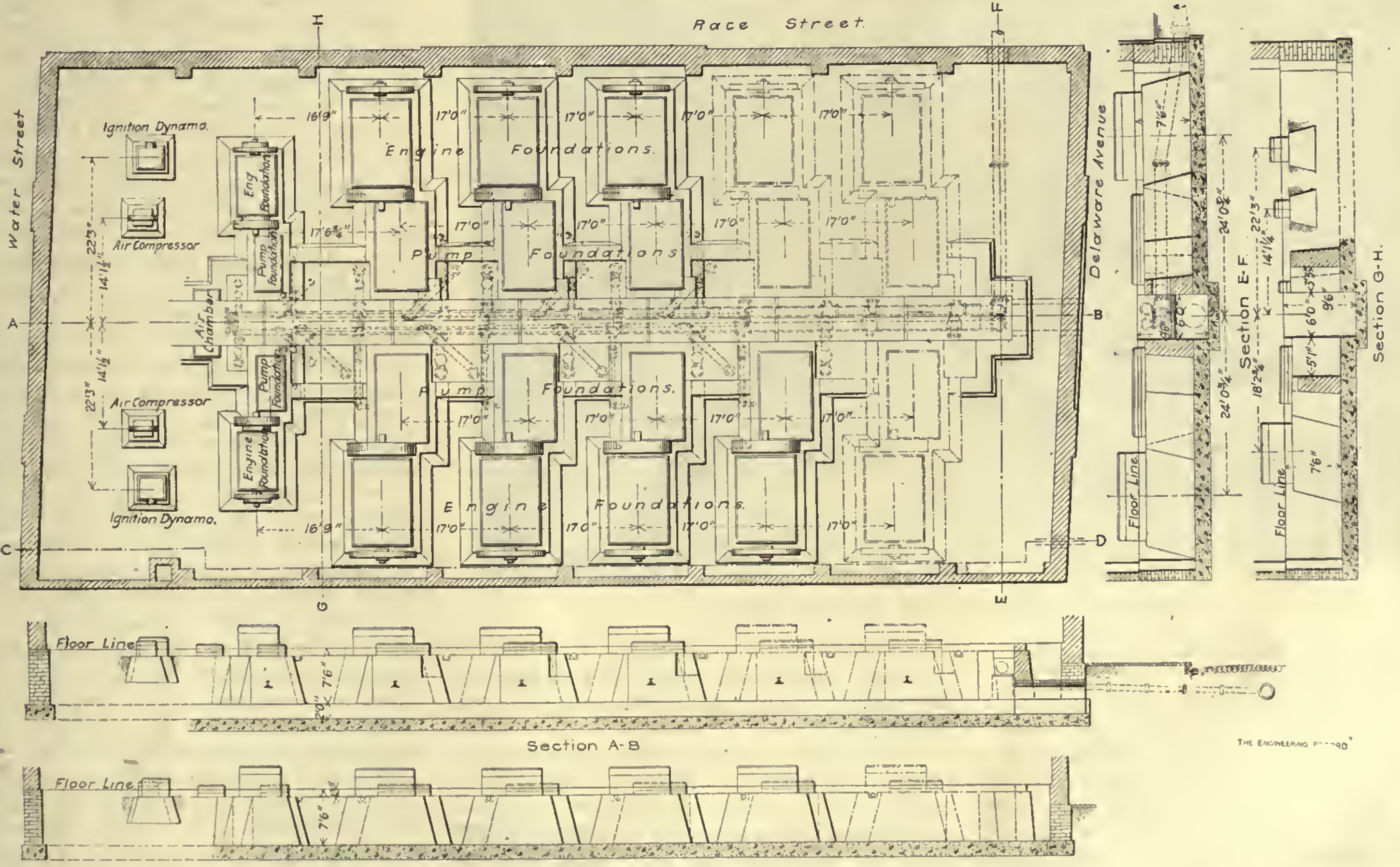
The high-pressure piping system has been installed about two years and was served by three fire boats, plying along the Delaware river front pending the completion of the central pumping station. With these fire boats, a pressure of 225 pounds per square inch has been obtained upon the system at the most distant point, and results secured far superior to any possible with present portable fire fighting apparatus. The aggregate capacity of the fire boat pumps is 9,000 gallons per minute, and the three boats with an average pressure of 180



One of the High-Pressure Pumps.



General Arrangement of a Gas Engine and Pump Unit.



THE GENERAL ARRANGEMENT OF THE PHILADELPHIA FIRE PROTECTION PUMPING STATION.

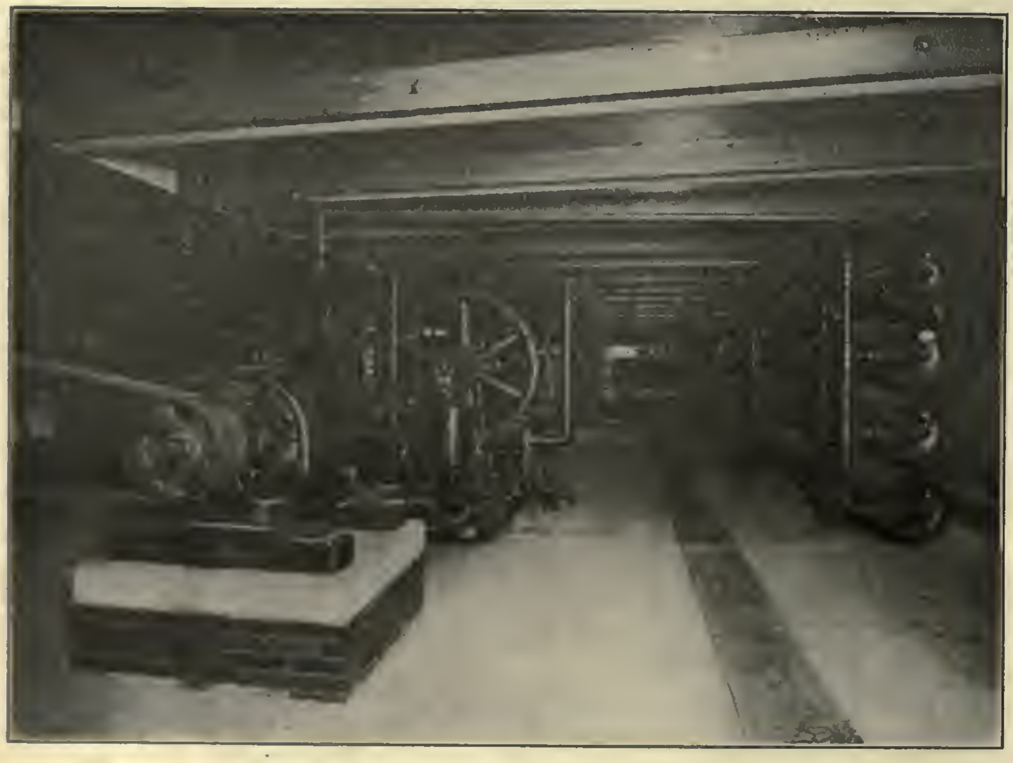
pounds at the pumps, have maintained twelve 1¼-inch streams, covering a horizontal distance of 150 feet. Four 2-inch streams were thrown 190 feet with a pressure of 237 pounds at the pumps, and a single 2-inch stream was thrown 315 feet horizontal and 230 feet vertical distance with a pressure of 230 pounds at the pumps. A loss of pressure of 47 per cent. with twelve streams and 34 per cent. with four streams was observed between fire boat and hydrant, this loss occurring over a network of piping 1¼ miles from end to end. With the higher pressure available at the pumping station, a corresponding increase in pressure at the hydrants will be available, thus enabling a much greater number of streams to be maintained than before. The fire boat service will not be discontinued but will be maintained as an auxiliary to the gas pumping station.

The comparative cost between a steam and a gas plant is well shown by the following excerpt from a report by the chief of the Bureau of Water, Mr. F. L. Hand:

Items.	Steam.	Gas.
Number of engines	3	8
Capacity, million gallons per 24 hours	15	16
Number boilers	8	none
Cost—engines, boilers and stack	$140,000.00	......
Cost—engines	......	$150,000.00
Wages, per month	$650.00	$450.00
Cost coal, at $2.00 per ton.-	500.00	......
Cost gas, at $1.00 per M...	......	392.00
Cost fuel, per hour	(50.00)	(39.20)
Oil, water, etc.	48.00	48.00
Repairs	85.00	85.00
Running expenses per month	$1,283.00	$975.00
Cost per year	$15,396.00	$11,700.00
Saving gas over steam plant................		24%
Saving, basis equal capacity...............		29%

In the above figures, no fixed charges upon the station have been considered. Assuming an interest rate of 5 per cent. and an average depreciation of 7½ per cent., a further saving of 21 per cent. on this item alone is realized. Thus a total saving of 50 per cent. in aggregate operating cost is secured by utilizing gas power instead of steam power.

The Philadelphia Fire Protection Pumping Station.


Apparatus in Basement of the Pumping Station.

Gas engines were chosen for service in the pumping station for a number of reasons; primarily, the question of expense involved in the maintenance of a steam station is effectively solved by the use of gas power; secondly, the operation of the pumping station is simplified to the extent that a complete boiler plant has been dispensed with; thirdly, engines of comparatively small capacity may be employed with the same economy and reliability as larger ones, thus enabling the entire capacity of the station to be sub-divided among many power units. Electric motors supplied from the local electricity distributing system were at first considered for operating the pumping units in the station. This arrangement would obviously provide the greatest convenience of operation, but in the present instance the liability of accident to power house and transmission line, and the fact that the entire fire situation would then be in the hands of independent corporations, prohibited the use of the motor.

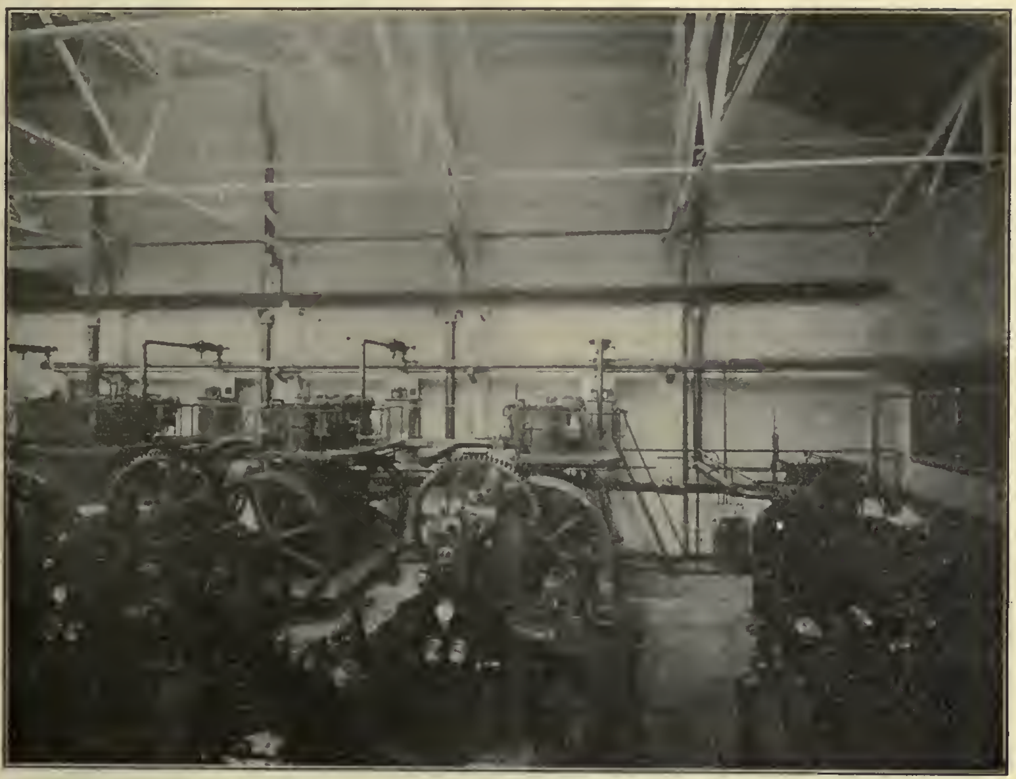
In locating the pumping station, the site selected was considered most desirable even at increased cost, on account of the loss in pressure which is avoided in the pipe main connecting the station and the distributing network. The station is located at the corner of Race Street and Delaware Avenue, facing the river front. It is thus within the area covered by the network and by means of a trunk main the five feeders extending west into the business district are directly supplied. Unexpected difficulties were encountered in the preparation of the foundation, by reason of the unsubstantial character of the sub-soil, which proved to be little better than river-bed muck. The sub-foundation is a monolithic concrete bed 5 feet thick on which rests the building and engine piers. The maximum concentrated load upon the sub-foundation is about 4,000 pounds per square foot, and the concrete was therefore reinforced by a steel mat of one inch round rods assembled in layers near the upper and lower surfaces.

The building is approximately 130x68 feet in interior dimensions, of which about 115 feet are devoted to the engine room, which is entirely clear of columns or other obstructions, and is served by a hand-operated traveling crane. Offices and lavatories occupy the western end of the building, a gallery being constructed for this purpose on a level with Water Street. In a basement beneath this gallery are located the air compressors, air storage tanks, igniter generators and building heating apparatus.

The general arrangement of the power units is shown in the accompanying plan. The engine room accommodates ten 300-horse-power units, of which seven are at present installed, also two 125-horse-power units which form part of the present equipment. The two-foot concrete footings in the original design for the foundations had to be changed when the character of the sub-soil was discovered. The foundations of the engines are of brick extending to within 12 inches of the floor level. At this point, a ledge is formed supporting cross beams between which concrete arches are sprung for the floor construction.

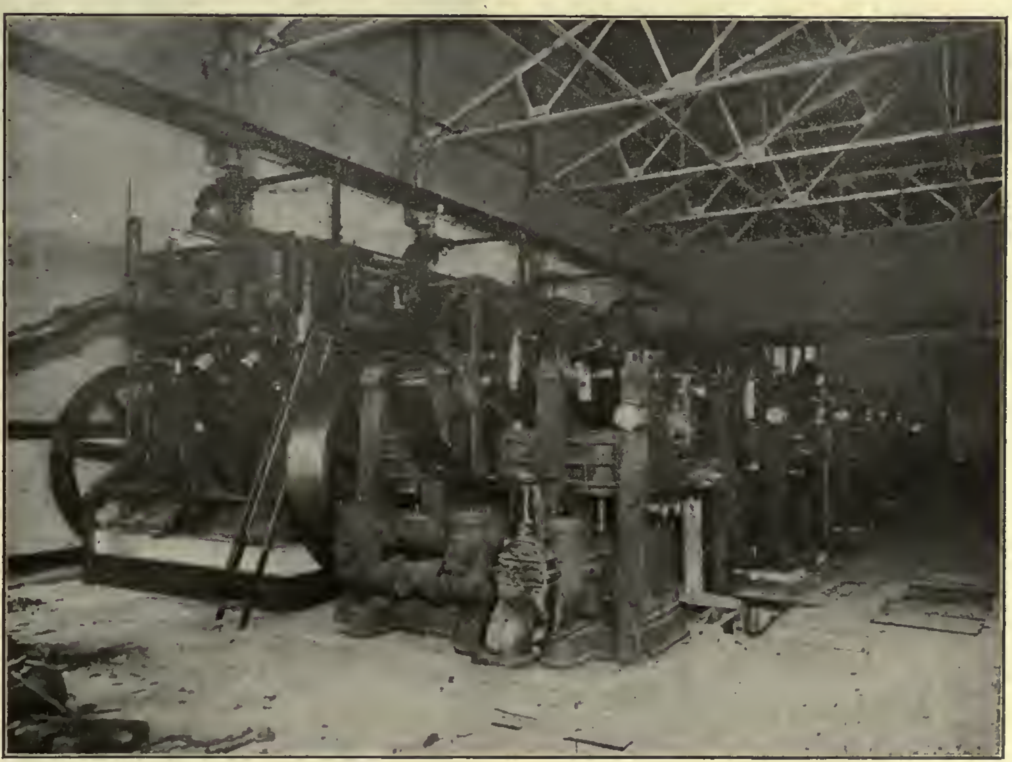
On account of the necessity of placing the pumps entirely above the floor level, the engines are mounted upon an extension to the pier, 28 inches above the floor level. Dressed stone caps 12 inches in thickness are used and that part of the piers extending above the floor level is finished in glazed brick. A tunnel 6 feet wide and 9½ feet in depth extends the entire length of the engine room and contains the suction, discharge and over-flow piping.

The main pumping unit consists of an 18x22-inch 300 horse-power Westinghouse, three-cylinder gas engine, direct-connected to a 11½x12-inch Deane, single-reduction, double acting, triplex pump. The pumps are located on the main aisle in order to minimize piping and so that the control valves and indicating gauges may be more readily accessible and kept in constant view of the operators. After the engines are started the entire manipulation of the plant is taken care of at the pump end by means of these valves. The main engines on each side of the station are connected by an iron gallery from which all the valves, regulators, igniter cabinets and upper works of the engines are accessible.


View Showing Gauge Board on Pumps.

The uncertainty concerning the reliability of gas engines for such service, at least in the Bureau of Water, led to the following stringent requirements in the specifications: "The Director of Public Works desires it to be understood that he will not try or accept anything experimentally nor use the first engine of its kind built by any manufacturer. No bids will be considered on engines or pumps which have not demonstrated their capacity to operate in the size herein contemplated in regular every day service, and each bidder is required to submit with his proposal a list of the plants in which such size units are in operation."

The pumps are connected to the engines by steel flanged couplings and through a gear reduction of 5 to 1, giving relative-normal speeds of 200 and 40 revolutions per minute respectively. A gear casing surrounds the gear mesh in order to protect workmen. An especially massive construction is employed in the pumps in order that the high pressure may be carried with a sufficient factor of safety. All interior fittings are of composition bronze, thus conforming to underwriters' pump construction. The triplex design affords a uniform rate of discharge desirable for distributing water under high pressure, and, as an extra precaution, a large air chamber has been installed at the end of the pressure main. A further important aid in securing uniform discharge is the principle of speed regulation employed in the engines. The valve mechanism regularly admits a charge of explosive mixture, of uniform quality, to each cylinder, at every other downward stroke, which mixture is in turn ignited at each succeeding stroke. This secures an extremely uniform effort upon the crank shaft.


View down Center Aisle Showing Air Chamber at the End.

A striking feature of the equipment is the provision of a motor-driven bypass or overflow valve, controlling the output of the pump. This valve is located in a branch from the main pump discharge and connects with the overflow piping. It is operated by a simple series motor through a large gear reduction, so that about one minute is required for closing or opening the valve, so that sudden shock upon the pipe system due to the quick closing of the valve is automatically avoided. Current for the motor is taken from the station mains, with a duplicate supply from the city lighting system if necessary.

The main pump discharge is controlled by a 12-inch outside screw and yoke valve protected from back pressure by a check. When this valve is closed and the bypass valve opened, water drawn from the suction main is delivered into the discharge main at no pressure. If the bypass valve be then closed, the pressure in the pump gradually rises to 300 pounds, when if the main valve is not opened a relief valve upon the rear water box opens, again turning the pump discharge into the overflow.

The method of operation is as follows: While the engine is starting, both valves are opened. As the work done upon the pump is then simply that of mechanical and fluid friction, practically no load is imposed upon the engine in starting. When the normal speed is reached, however, the switch controlling the bypass valve is closed and the bypass discharge is gradually throttled until the pressure upon the pump rises to 80 pounds, at which pressure the check valve in the discharge main opens against the city pressure, which is always kept upon the distributing system. At the opening of this check, the pumps then begin to deliver water to the city system, and if no hose connections have been made the pressure rises rapidly to 300 pounds. At this pressure the relief valve comes into action and the entire pump discharge is turned into the overflow until fire apparatus at some part of the system is put into service. As soon as the demand for water exceeds the capacity of a single pump, the operator notices the pressure on the system falling and another unit, which has in the meantime been starterd, is immediately thrown into service, this operation being repeated until the demand for water is met. In the daily tests upon the station equipment the starting operations are regularly performed on each unit in order that the equipment may be kept constantly in serviceable condition.

Each pumping unit is fitted with a gauge board, comprising a direct reading pressure gauge and a direct reading suction gauge for indicating the condition of the suction piping. A stoppage of the intake or the unsealing of a pump valve by foreign matter is readily indicated by this suction gauge. Daily records of the operation of each unit in the station, the time of daily tests, and, in case of fire, the duration of the high pressure service, are kept on file for reference. These records are obtained by 24-hour Bristol recording pressure gauges at the top of the gauge boards. The output of the pumping units is determined by speed counters mounted on the pump frame. This instrument gives the plunger displacement which, with the average discharge pressure shown by the recording gauges, furnishes data from which the output of the engine may be estimated and the gas consumption approximately determined. At present no meters are installed for measuring the gas consumption, as a considerable amount of valuable space would be taken up by them, and, on account of the intermittent service, the consumption can be approximated with sufficient exactness. In order to facilitate the computation of gas input a chart is used, based upon the results of tests of the engines at the works of the builders, representing the average gas consumption.

The gas supply of the plant is drawn from a 20-inch trunk main one block distant, which connects two large gas holders located respectively on the north and south sides of the city. The gas is furnished by the United Gas Improvement Company of Philadelphia, from their local distributing system, and is the ordinary illuminating gas. The average analysis is given by the chief inspector of meters in the report for 1902 of the Bureau of Gas as follows: Carbon dioxide, 2.89 per cent.; oxygen, 0.60; hydrogen, 32.7; carbon monoxide, 21.2; methane, 26.3; nitrogen, 4.7; illuminants, 11.61. The average calorific value of the gas is 675 British thermal units per cubic foot, as determined by both chemical and calorimetric tests at the United Gas Improvement Company's laboratory.

A valve located in the 16-inch street main outside of the station controls the entire supply to the station. The supply line to each engine is similarly controlled by a valve located at the junction of branch and station main, and readily accessible from the platform. Gas is supplied to the engines at approximately atmospheric pressure, through automatic regulators inserted in each supply line. A throttle valve at the engine is ordinarily used to control its operations, while the above-mentioned valve in the supply line is left open in order to reduce the duties of the operator in starting. A mixing valve behind the engine throttle controls the proportion of gas and air, and at the same time the quantity of mixture admitted to the engine cylinders. The definite proportion of the mixture may be permanently adjusted by hand levers, the best mixture being actually determined by shifting the levers back and forth when the engine is running, when it becomes a simple matter to determine the relative position that gives an explosion of maximum power.

The speed of the engine is controlled a sensitive centrifugal governor, driven through gearing from the main shaft. This governor directly controls the quantity of mixture admitted to the cylinder by the mixing valve. Clause 53 in the specifications indicates the degree of regulation required: "The regulation and governing of the engines shall be such that in the event of the load being suddenly thrown off, such as would be caused by the bursting of a water pipe, the speed of the engine shall not increase more than two per cent. from its speed at full load."

A duplicate set of igniters is supplied on engine cylinders, so that if one fails the other may be thrown into service. Three sources of ignition current are available, viz.: 220-volt current from a duplicate set of 7½-kilowatt generators belted to the smaller engines; 220-volt current from the Edison mains; and, finally, current at 8 volts from primary cells. In order to reduce the voltage to that suitable for igniters, a small motor-generator is mounted on each igniter cabinet and controlled by automatic starting boxes. No arrangement of the switches will result in interference between the various sources of supply, and a hasty closing of one switch will always result in current at the igniters.

The engines are started by compressed air, at pressures ranging from 150 to 200 pounds, by means of a very complete system of storage tanks located in the basement. With the tanks full, at 200 pounds pressure, sufficient air is available for starting up the entire station independently of the compressors. Air is supplied to the tanks by a duplicate set of Rand two-stage compressors, each provided with an automatic relief valve which unloads the compressor when a discharge pressure of 200 pounds is reached. After the valve operates, the compressor cylinders are bypassed, so that the load falls to that of friction. As soon as the pressure falls below 200 pounds, however, the valve again automatically places the pump in action. Ordinarily one of the small engines is started after the first or second main unit, during the wait for increased demand upon the fire system. Part of the storage system is kept in reserve in case of accidental loss of pressure from the remainder of the system. Starting one main unit reduces the pressure in two tanks about 50 pounds, or in one battery of four tanks about 25 pounds, so that the necessity for the starting of the compressors simultaneously with that of the first unit is not for the time being imperative.

Ballast Spreading Car Built by McArthur Brothers Company.

The water suction and discharge mains were specially designed for this plant. As no pressure is carried on the suction main, it consists simply of a 36-inch steel pipe riveted and calked. The connections to the pumps are cast steel nozzles riveted to the top of the pipe, to prevent sediment and foreign matter accumulating in the bottom of the suction main from entering the pump cylinders. On each branch to the pumps there is located a small air chamber. The 36-inch suction main extends to the river bulkhead, where it is water-sealed several feet below low tide. An automatic check valve located in a large manhole prevents the main from being drained.

The high-pressure line consists of 21-inch special extra strong rolled steel pipe approximately ⅜ inch in thickness, with rolled steel flanges. The flanges are recessed and the ends of the pipe expand into this recess, the flange being machined after bending. The two sections are then joined by bolts with corrugated copper gaskets. Special cast-steel nozzles are also employed on the discharge main, the pump discharges being introduced at an angle of 45 degrees in order to avoid eddies at the junction. For the purpose of absorbing possible shock, a large air chamber is mounted above a T in the discharge piping.

Through the six weeks prior to the placing of the station in operation, systematic training of attendants was carried on in three shifts of three hours per day, Sundays excepted. During each shift the alarm was sounded without warning and several units gotten under way. The regular station operating force during any shift consists of two men—the engineer and his assistant, the entire station being under the direct charge of a superintendent. The total number of distinct operations required in starting each unit is seven, of which five are performed by the engineer and two by his assistant, as follows:

Engineer:
Upper platform—{Close ignition switch,
Open engine throttle.
Lower platform—{Throw compression air valves.
Throw exhaust valves,
Turn on cooling water.
Assistant:
Main aisle—{Open suction valve,
Close motor switch on "bypass" valve.

When it is considered, however, that each group may be performed without either attendant moving more than three feet, the operations are in reality reduced to three in number.

The superintendent's record of the six weeks' trial show the following results:

1. Not more than 25 seconds required to obtain full speed at each unit.

2. Not more than 45 seconds required to obtain full 300 pounds pressure.

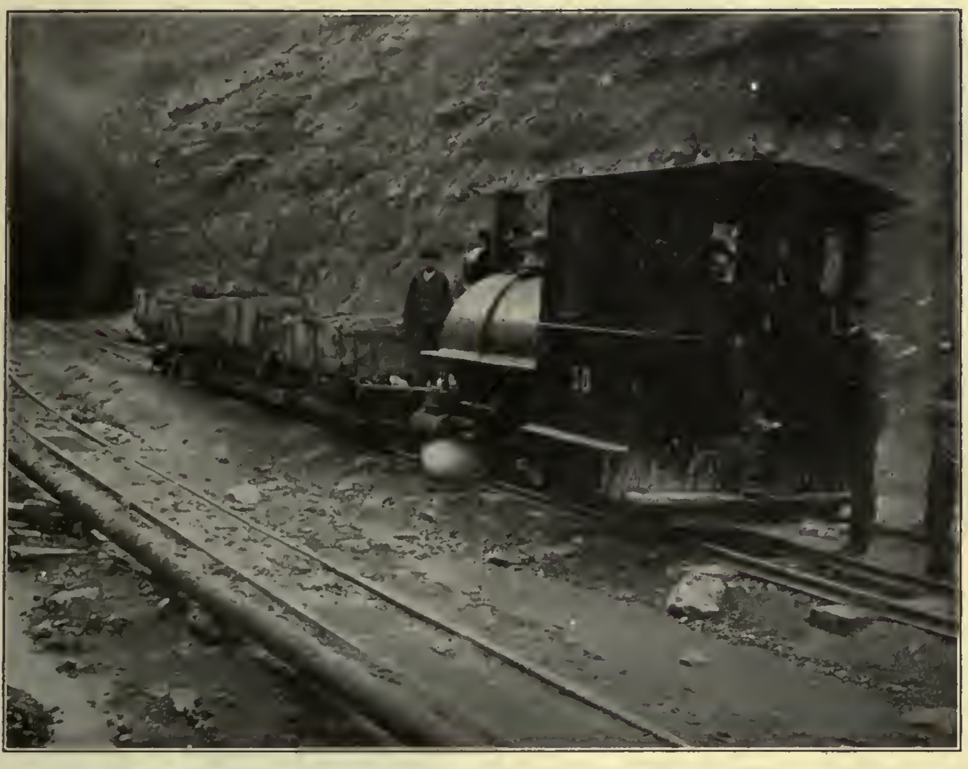
3. Seven minutes required for placing entire seven units in service.

4. During the 36 days' trial, out of a total of over 100 alarms, not more than four misses have been made in getting a single unit started. In these four cases the engineer neglected to open the engine throttle or turn on the ignition current.

These results indicate that even in the extreme case of a sudden demand for the total capacity of the station, the average time required for placing the station in service is 60 seconds per unit, from the time of signal from fire headquarters, and it is thus evident that one minute after the alarm full pressure is available at any part of the system or buildings connected to the system.

No complete trials of the station and system have been up to the present time carried out, as the pipe system has already been tested before representatives of the Board of Underwriters, and the pumping station has been so constantly under the observations of the city officials as to require no official test. At a preliminary test on December 11, 1903, four streams from 2½-inch nozzles, through 50-foot lengths of 3½-inch hose were easily maintained over a horizontal distance of approximately 250 feet, with a pressure at the station of 225 pounds.

The pumping station was officially accepted by the Bureau of Water at the close of 1903 from M. R. Muckle, Jr. & Company, engineers of Philadelphia, who designed and installed the entire power equipment of the station. The engineering details and design of the building were executed by Mr. John E. Codman, chief draughtsman of the Bureau of Water, and carried out by Mr. John W. Weaver, superintendent of construction. The execution of the important work of establishing the high pressure fire system has been accomplished by the Bureau of Water, a bureau of the Department of Public Works, under the efficient management of the chief of the Bureau, Mr. F. L. Hand; while the operation of the pumping station and the service system is conducted by the Bureau of Fire, a bureau of the Department of Public Safety. Throughout the entire work, the closest co-operation between chief engineer, his assistants, and contracting engineers was maintained, with such fortunate results as to have already insured success to an enterprise possessing some of the most novel features in the modern application of modern power apparatus.



Narrow-Gauge Contractor's Locomotive Used in Greentree Tunnel, Pittsburg.

The Repair Shops of a Large Contracting Company.

A company carrying on a large contracting business all over the country accumulates a quantity of plant that requires central repair shops to keep it in order. Ordinary repairs can be made at the working site, but extensive reconstruction is not only beyond the capacity of such facilities as usually exist there, but would also prove very expensive even if it could be carried out. Few people realize the amount of reconstruction which can be profitably done in a well-equipped shop like the establishment of the McArthur Brothers Company, at McCook, Ill. McCook is a station which has apparently been put on the map for the business of this company and of two large crushing plants where the limestone underlying the region is broken up for contractors' use. These three establishments and one house are the only buildings visible in the place, but the railway's business done at the station during the building season is very heavy.

The McArthur shops include a wood-working shop, machine shop, blacksmith shop, storage sheds, office and a large amount of open storage space for carts, cars, track material and the like. A spur track from the Santa Fe road runs into the yard and a crane is provided by which carts, small cars and other equipment are quickly handled off and on the standard railroad cars. The saving in labor and time which this crane effects in the course of a busy season is surprising. The old cars and wagons received in the shops are burned on receipt if the cost of repairing them is greater than the expense of new equipment, but it generally happens that the running gear is in pretty fair condition. In such cases the woodwork is knocked off and the frames sent to the woodworking shops, where new bodies are put on and other repairs made. One very handy tool in this shop is a square boring machine, which is used to advantage in much of the framing of the car bodies.

Much of the equipment returned to McCook is not immediately repaired, but is sent to the storage sheds. Standard equipment is kept up as completely as possible, while the rest is repaired as opportunity occurs or a demand arises. The sheds contain many interesting supplies from notable works, among which may be mentioned the 2½-inch cables employed on the suspension bridge employed in making fills on the Union Pacific Railway in the manner described in The Engineering Record of February 2, 1901. The sheds are an interesting museum of contractors' plant, for the company requires a great variety of equipment for the different classes of work it carries on, and sooner or later a large part of it reaches the McCook shops. Steam shovels, traction engines, small cars of many types, carts of all sorts, scrapers, derrick fittings, locomotives and standard gauge cars all come to this place for their repairs, and it may be of interest to state that in repairing the shovels it is generally found desirable to strengthen them very materially as compared with their original design.

The machine shop is a very interesting place, and the work done in it is surprising to the visitor acquainted only with large works where every stage of manufacture of the product is carried on by special tools. At McCook anything is undertaken. Two locomotives were under repair at the time of a recent visit. One of them had come in with its frames badly twisted, and these were straightened out by heating the bends with gasoline torches and pressing them back into place. On the other the cylinders were out of order, and were rebored without taking them off the frames by means of a home-made tool built from parts of machinery on storage in the sheds. The star feed, for example, was furnished by remodeling one of the parts of a small gas engine.

McArthur Brothers have always been noted for the special equipment they made for their work, and the accompanying illustration shows one of the ballast-spreading cars built at their shops from the designs of Mr. J. C. Depew, the company's master mechanic. This car has a wing or plow which folds flat against the side of the car when out of service. When it is to be used, the tackle suspended from the cap of the gallows frame is loosened. This lowers the board somewhat and allows it to swing out into the position shown, where it is braced by timber struts. These struts are hinged to the sill and fit into pockets in the back of the board when the latter is swung out. This spreader is low in first cost, durable and easily repaired and has proved very successful. In use it is sometimes necessary to weight the front of the car to keep the forward truck on the rails when spreading large quantities of ballast.

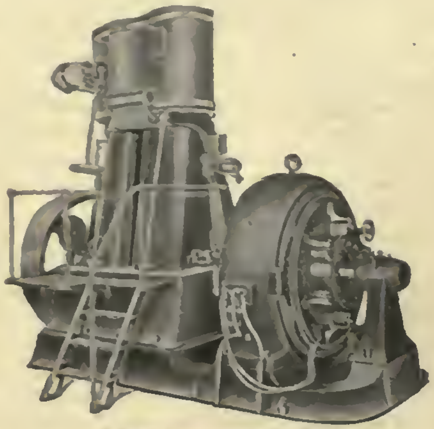
A Twenty-four-Inch Gauge Contractor's Locomotive.

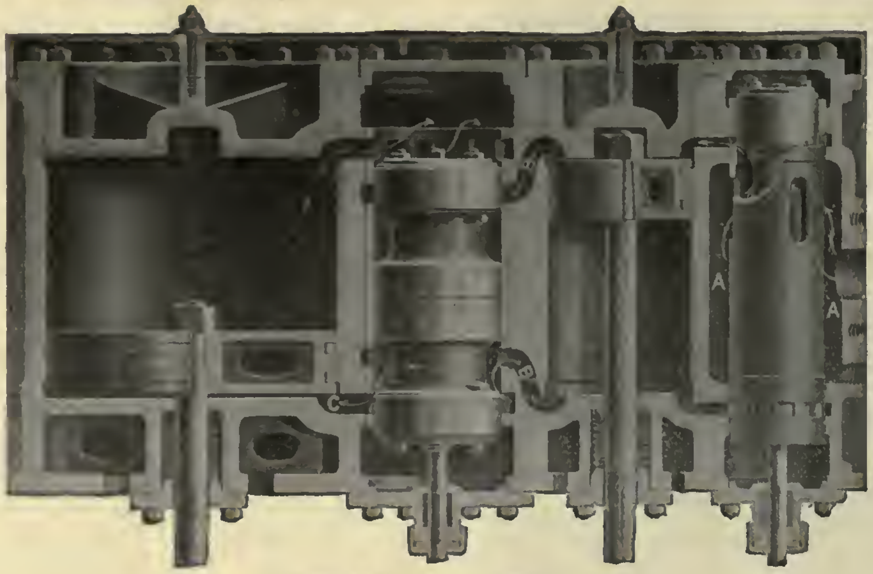
For some time the Wabash Railroad has been engaged in the construction of several connecting links and extensions of its lines which will give it access to important industrial centers not reached heretofore. Particularly persistent efforts have been made to enter Pittsburg, this extension being known as the Pittsburg, Carnegie & Western Railroad. The large cantilever bridge on which this road crosses the Monongahela River has already been described in these pages. Other interesting features of the work are the Mount Washington and Greentree tunnels, the former 3,300 feet long and the latter 4,600.

In the construction of the Greentree tunnel the contractors, Messrs. William Kenefick & Company, of Pittsburg, made use of an unusually narrow-gauge working railway, the gauge being only 24 inches. The locomotive and some of the material cars run on these tracks are shown in the accompanying cut. The locomotive has 7x12-inch cylinders, and is equipped with hand brake, shaking grates and a stack suitable for burning coke. This locomotive is of somewhat unusual interest owing to the narrow gauge, the usual contractors' gauge being 36 inches. Although this locomotive is but 24-inch gauge, the general dimensions are much the same as for the 36-inch gauge, and the cab, as can be seen in the illustration, is very roomy. The Vulcan Iron Works, of Wilkesbarre, Pennsylvania, the makers of this locomotive, are building a number of contractors' locomotives at the present time of this gauge, and there is apparently a great deal of work that can be done as well by using the narrow gauge equipment as that for the 36-inch gauge. The narrower gauge makes lighter equipment for handling in transportation and in making shifts of the working track.

Some New Details of the Reeves Steam Engine.

An improvement in the admission valve of the Reeves steam engine and the Reeves automatic revolving governor bearing are the subject of the accompanying illustrations, one of which allows also of examining the features of the cylinder construction of the compound engine built by the Reeves Engine Company. The addition to the valve comprises a sleeve in which the valve itself works and its advantages are discussed in the explanation of the engraving mentioned.


Reeves Compound Engine.



Cylinder and Valve Construction.

This view is a vertical cross-section through cylinders and valves and shows the high-pressure piston about to start on its downward stroke, the low pressure on its upward. The admission valve is moving upward, admitting steam on top of the high-pressure piston and across through the connecting port B, and around the head of the main or center valve. At the same time the main valve is moving downward, admitting steam under the low-pressure piston. This is the exhaust steam from the previous stroke of the high-pressure piston and it passes through the port B around the neck of the main valve and through port C into the bottom of the low-pressure cylinder.

When the pistons have moved about three-eighths of their stroke, the admission port has been opened and admission valve returned to point of cut-off. The main, or center, valve is now moving upward and finally closes port C. At this point compression commences in the high-pressure cylinder and continues until the main valve opens port C again; meanwhile the main valve closed the upper port and compression took place in the low-pressure cylinder.

The steam distribution is designed to give practically an equal division of work in the high and low-pressure cylinders, and there being no receiver employed, losses from free expansion and condensation on that account are obviated. The engines are designed so that either cylinder can be used, independently of the other, should necessity require. The chamber A, around the sleeve in which the admission valve works, acts as a separator and is drained, as can be seen, at the extreme lower end. The sleeve receives the direct impact of the steam instead of the valve and the valve is balanced, as all its exposed surfaces are under constant uniform pressure. Each one of the three openings in the sleeve are larger than the steam pipe, and the steam is therefore not wire drawn by them in passing to the cavity inside the sleeve.

The cubical capacity of chamber A together with space inside of sleeve is greater than the amount of steam the high-pressure cylinder can take, up to three-quarter cut-off, and, as a result, the actual difference between the initial cylinder pressure and pipe pressure is small. The space formed by the separator acts as a storage from which the engine draws its supply of steam. The lower cylinder heads are cast integral with the cylinders which reduces the number of joints to keep tight. The piston valves can be easily adjusted, each end independently of the other, and made steam tight without removing them from their seats and while steam is on the engine.

Another of the illustrations shows the hub of the governor wheel with the automatic revolving bearing partly assembled. The holes for the shaft and governor pin are bored at the same setting, to ensure perfect alignment, then a hard cast-iron bushing, which has been carefully reamed and ground, is pressed into the cavity that is to carry the pin. Into this bushing is introduced a carefully finished gun metal sleeve, constructed with connected lubricating grooves, on inside and outside, around and lengthwise of same, and by means of the grooves the lubricant, which is supplied by force-feed grease cups, is carried to all the bearing surfaces.

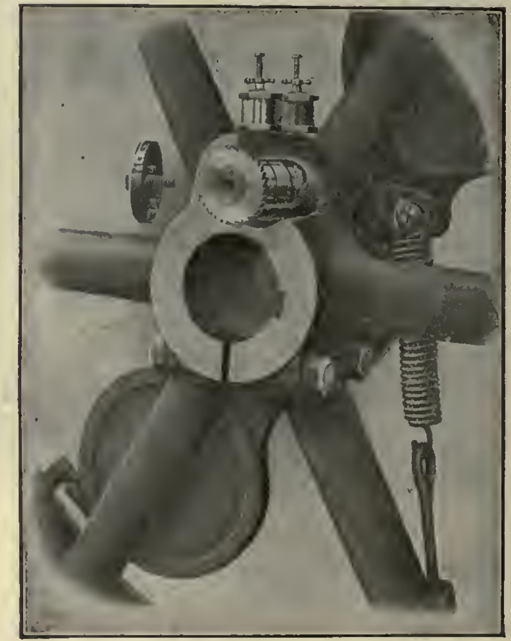
The governor is now attached to the wheel by inserting the pin, through the gun metal sleeve. The shoulder, on the bar, will face the finished surface on back of wheel and the end of the pin will come flush with the face of the sleeve on the front and be held in place by the cap, shown in the cut. There is a pawl on the cap, and the teeth cut into the rim of the sleeve. When the cap is in place it must move with the pin since it is securely held by a dowel and stud bolt. When the governor arm moves away from the stop on the rim of the wheel, as it is sure to do when the engine is started, or whenever there is any material change in load, the pawl on the cap will pick up a tooth and turn the sleeve a short distance (always in the same direction), and when the arm moves back another tooth will be engaged and the operation repeated, thereby presenting continuously to the pin a freshly lubricated bearing surface.

The direct-connected unit shown illustrates the general appearance and characteristics of the engine and the accessibility of parts. This engine has cylinders 10½ and 24 inches in diameter by 14 inches stroke; the shaft is 6½ inches in diameter and is provided with three bearings, the outside ones being 11 and the center one 10 inches long.

A Controller for Regulating and Reversing Motors.

Any design of controller for motors used on cranes or in other places where frequent stops and reversals necessitate sturdiness, in order to withstand the strain and wear of constant motion, is apt to be of interest. Accordingly reference is made in this connection to a type of motor controller built by the Westinghouse Electric & Manufacturing Company, in which the effort has been made to produce a device that is simple and positive in action, in order to secure control of both the speed and direction of rotation of the motor, with the fewest possible movements of the controller handle.

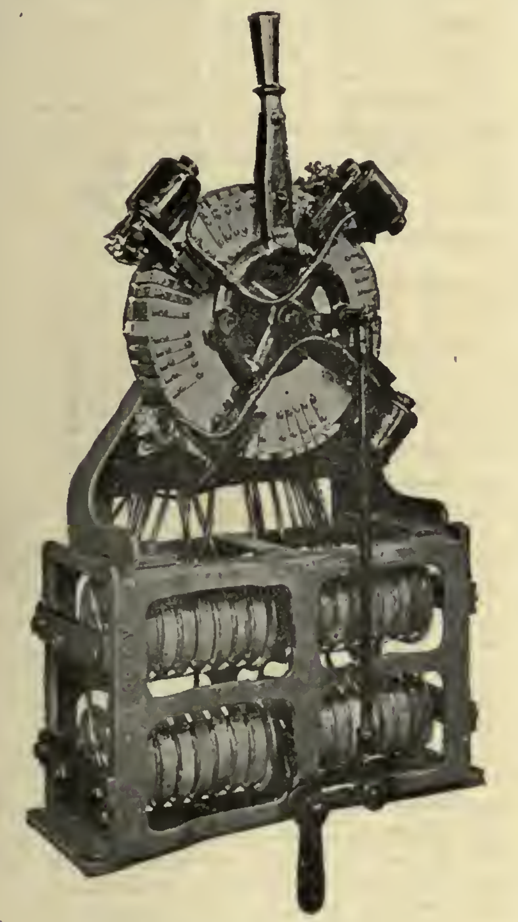
The controller, as shown in the accompanying illustration, is of the commutator type, and is adapted for use with direct-current series, shunt and compound motors. For convenience in installation, it is made in two forms. In one type the controlling mechanism is mounted on the side of the frame containing the resistance, while in the type shown it is mounted above the resistance. The space available for installing controllers for motors used with cranes and other machinery is usually greatly restricted, and this provision for adapting the device to the place in which it is to be used is of corresponding value.


Revolving Governor Bearing.

The controlling mechanism is mounted upon a circular slab or base of insulating material, which provides insulation between adjacent contacts and between the contacts and ground. Both the contact and finger tips can be removed easily and renewed without disturbing the connections. The contacts are arranged in parallel rows around the periphery of the disk, the relative position of the contacts and the finger tips being the same as that of the brushes and commutator in a generator or motor, a form which has been found desirable for this particular service. The same contacts are used for application of the current in either direction thus lessening the number required, while a magnetic blow-out is employed to break an arc and prevent burning of the contacts.

Each controller has four brush holders mounted upon a rocker arm to which the handle is attached directly, working without gears or pinions. A single movement to right or left applies or reverses the current, and the distance the handle is moved determines the motor speed by varying the amount of resistance in series with the motor armature. There are 16 steps in each direction and a close regulation of the speed is thus obtained. When the controller is placed in the rear of a crane cage, it is operated by a crank and lever directly attached to the spider which carries the brushes. The controller mounted above the resistance is generally employed for this purpose. All parts are exposed to view, facilitating making connections.

The resistance used with controllers of large capacity is of the grid type. For small capacities with large ohmic resistance a cell resistance is employed with ventilating spaces between the cells, which are separated by non-combustible insulating spreading blocks. This form has been found to provide good ventilation, insulation and durability. The resistance is varied for the different capacities and uses of the motor which the controller governs, a different resistance being used for crane controllers where a close regulation is required than is provided for roll tables and soaking pits where sudden and repeated starting and reversing is the prime requisite.

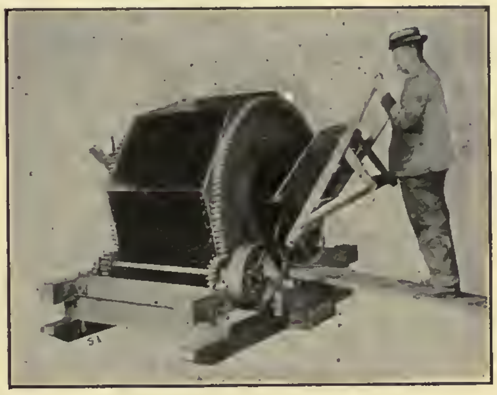


Motor Reversing Controller.

Controllers of the commutator type are made regularly in capacities from 2 to 75 horse-power, and can be furnished especially of any capacity desired. For less than 10 horse-power, the Westinghouse Company makes a face-plate type of controller which contains many of the features of the device described.

A New Concrete Mixer.

The Stanley prismatic concrete mixer shown in the accompanying illustration is particularly noteworthy for the arrangement of deflectors within the drum. These have been designed so that the material lifted to the top of the drum does not fall in a mass directly to the bottom, but is thrown from side to side. This action increases the thoroughness of the mixing with a given number of revolutions. The machine runs continuously and is discharged by simply throwing a lever. This lever actuates the discharge chute, which, when the mixing is complete, is simply thrust into the opening of the drum to catch the concrete as it drops from the upper deflectors. The drum is mounted on rollers after the fashion of tube mills, and is driven by belt or directly by a steam or gasoline engine or electric motor. The supporting wheels run on roller bearings which are designed particularly to exclude dust. Both rims of the drum are provided with a rack driven by a pinion as shown in the cut; the object of this unusual arrangement is to avoid any unequal pressure on the supporting wheels. Special attention has been paid to reducing the weight of the mixer so far as durability will permit. This machine has just been brought out in four sizes by the Contractors Plant Company, 37 Pittsburgh Street, Boston, and is intended for uses to which the company's gravity mixer is not adapted.



A New Drum Concrete Mixer.

Variable Speed Motor Driving from Single Voltage Supply.

A system of electric tool driving that allows for a wide variation of speed with any standard two-wire or three-wire direct-current system, has been brought out by the Commercial Electric Company, of Indianapolis. By means of an electric motor having two commutators and two different windings and a speed controller for making different combinations of the armature windings and variations of the field strength, a range in speed of four to one in twelve uniformly graded steps that do not overlap has been obtained. From a number of curves which the company has prepared, the following information has been drawn on the characteristics of the system, including the noteworthy efficiencies obtained throughout the speed range.

A 5-horse-power 220-volt motor when developing 5 horse-power showed an efficiency of 80 to about 82 per cent. from 400 to 675 revolutions per minute, 74 to 77 per cent. from 800 to 1,065 revolutions and 66 to 78 per cent. from 1,200 to 1,600 revolutions, showing high efficiencies on both slow and medium ranges. At lowest speed and variable load the efficiencies shown by a motor were 80, 79, 77, 74 and 70 per cent. for 6,5, 4, 3 and 2 horse-power, respectively. The variation between no load and full load on each of the 12 speed steps appears slight. On the eighth step, for instance, the speed of the 5-horse-power motor at no load is 1,110 revolutions and at full load is 1,060, while on the first step the speed at no load is 500 revolutions and at full load is 450 and on the second step the speed at no load is 520 and at full load is 570. A 15-horse-power motor showed efficiencies of 82.5 to 85 per cent. throughout a range from 275 to 1,100 revolutions.

The system has been designed to secure greatest torque, or pulling, power, at slowest speed, so that with direct attachment to a lathe pieces of large diameter may be turned with as heavy cuts as smaller pieces, to develop constant maximum horse-power at all speeds and to have practically constant speed at all loads when the controller is set at a given point, as referred to in the foregoing paragraph. The motor is run, as stated, from the same wires to which a constant-speed motor or lights may be connected.

Controller.

The two windings of the motor armature are of the same size conductor or same ampere capacity. The controller contains a rotary starting and reversing switch by means of which the motor is started, stopped and reversed while the speed control is set at any desired point. The speed controller and starting switch are combined into one piece of apparatus, enclosed in a compact case which can be placed at any desired point on a driven tool or which can be mounted on a stand conveniently located by the side of the tool. The stand pattern of controller having the main switch included in the equipment is shown in the accompanying illustration.

Letters to the Editor.

Light Steel Work.

Sir:—We have read with much interest the editorial in your paper of February 6 regarding the design of light steel work, and while we agree with the argument in some respects, still we do not think that the advice is exactly correct, and while we do not wish to get into a newspaper discussion, we think that the impression given should be modified.

In our opinion the design of such construction should be in the hands of a competent consulting engineer and by this we mean an engineer who has had experience in the draughting room or engineering department of one or more bridge shops and in the office of consulting engineers who do this class of work. A number of engineering firms have just such men in their employ, and the results obtained are very satisfactory. A few of the arguments which we advance are as follows:

First.—The only way to get true competition is to have all the bridge companies bid upon one correct set of detailed plans. If the plans are made showing details then each bidder can estimate exactly the weight, and it is then a question of individual costs and profits desired which regulate the bids. The lowest responsible bidder secures the contract (in all our arguments we consider that there is no collusion or favoritism on the part of the bidders). If each bidder submits his own design, then there is no method of comparison, and it is often the agent who can bring the most influence to bear that secures the contract. It is almost as difficult to check over a set of plans submitted by the different bridge companies and determine the one which is the most advantageous to accept, as it is to prepare correct plans in the first place.

Second.—An engineer who is experienced in making such detailed plans will get a design which exactly meets the requirements and at the same time will be the most economical. If general information only is given, then the bridge company has to prepare plans which will be in competition with every other plan. In order to get a satisfactory plan and bid he must either have some especially attractive design or have one of the lowest possible weight. Strength is often sacrificed, and it is often the man who has the most confidence in the material he sells who gets the contract. Very rarely do the bidder's plans show the details, but merely the size of the members, and if he gets the job then it is a question of skinning the details to a minimum in order to make the profits a maximum. When it is considered that the details of such construction sometimes amount to as much as 50 per cent. of the main members it is easily seen how a profit can be made by skinning the details. In our experience this is the greatest trouble, and we have found that the strength of a building is often reduced 50 per cent. or more by the details not being equal to the main members.

Third.—The best and most economical design is not always obtained by having each bridge company prepare its own plan. Of course the cheapest design may be obtained but rarely is it the best. Suppose there are ten bidders upon a piece of work, everything else being equal; each bidder has one chance in ten of getting the contract, or he has to make ten different designs in order to get one contract. Can he devote as much care to preparing this one plan as an experienced engineer who has in mind getting the design which best suits the requirements and at the same time being the most economical? The bridge man cannot go into the fine points as closely as the engineer, and the result is that while the building may be good enough, still it is not the best for the particular case.

We have in mind one instance where the contract was about to be awarded on a plan submitted by a bridge company. In some respects it did not exactly suit the purchaser, and before awarding the contract he submitted it to an experienced consulting engineer for examination. The defects were pointed out and the engineer was requested to prepare new designs which exactly suited the case and get new bids. The result was a building better in all respects as to arrangement, strength, rigidity, etc., and at the same time resulted in a saving of $10,000 to the purchaser. Such instances are numerous.

Fourth.—Again did you ever stop to consider that it costs each of the ten bidders something to prepare his plan and that someone has to pay for them? Each bidder has to add to his bid a price to include not only the cost he is put to on this one design, but the cost of the nine other plans on which he was unsuccessful. Why not save this expense to the bridge companies and at the same time to the owners by having plans prepared by an experienced and disinterested engineer, disinterested except in getting the best possible designs for the place. We know that the bridge companies would prefer to bid upon good detailed plans prepared by consulting engineers, and we feel confident that if such a plan was adopted by all cities, railroads and corporations, that much lower prices would be obtained for such construction. Those cities and corporations which follow out this plan do secure the best prices.

Yours very truly, Contracting Engineer.

[This letter emphasizes the point made in the editorial referred to, which reads: "The work is routine designing . . . best done . . . in the offices of bridge companies or engineers making a specialty of mill architecture and employing designers trained in bridge shops." This latter part of the article has evidently been overlooked by the writer of the above letter. The point made in the editorial is that it is better to have light steelwork designed in bridge shops than by people not acquainted with such design, where it is not considered possible to retain an independent experienced engineer for the purpose.]

Tin Roofs in the Baltimore Fire.

Sir:—A number of witnesses of the recent fire at Baltimore have called our attention to the fact that tin roofs were instrumental in preventing the still further spread of the flames, and that, even in the fire belt, the buildings roofed with tin held out much longer than those covered by other kinds of roofing material. Composition tar and gravel roofs literally burst into flames from the intense heat before the fire reached them, and in distant parts of the city the greatest trouble from the sparks carried by the wind was with roofs of this character, those covered with tin requiring almost no attention. It is significant that, profiting by this experience, the architects in charge of new construction at Baltimore are, in the majority of instances, calling for tin to be used on the roofs.

Very truly yours, N. & G. Taylor Company.
Philadelphia, February 23.

Estimating Weights of Rails.

Sir:—Referring to Mr. Du Mazuel's letter in the Record of Feb. 20 giving factors for the total weight of rails in a given length of track, the old-fashioned method used by many trackmen and by some engineers may be cited to advantage, as follows: To find tons per mile of track multiply pounds per yard of rail by 11/7. Thus it is seen at a glance that 56-pound rails weigh 88 tons per mile; and, with a little more effort, that 100-pound rails weigh 157 1/7 tons. This one fraction applies to all weights of rails, is easily memorized, and then enables an engineer to answer almost instantly a question frequently asked him by railway officials on inspection trips and at other times when he is away from his office data.

Yours truly, John W. Burke.
New York, February 23.

Steel-Core Dams.

Sir:—My friend, Mr. A. McL. Hawks, has asked me to corroborate the statement in his letter, which you published in your issue of the 6th inst., to the effect that as long ago as May, 1891, he evolved the "steel-core dam," and consulted me about it. I have looked up Mr. Hawks' letter, dated May 26th, 1891, and beg to quote you therefrom as follows:

"While I was down in Arizona building my new form of curved crib dam I had a good opportunity to study, and there I completed the evolution in my own mind of what I wanted to make a perfect, quickly erected, and substantial structure. The foundations have always been my bugbear, but now I see how to accomplish that portion of the work with considerable ease, and wish you to give me your opinion on the metal portion of the structure. It consists essentially of a curved framed structure of steel I or deck-beams, divided by the braces into rectangles of say eight or ten feet square. This shell is the arch that carries the total load and delivers it to the rock abutments at each end. And the squares are filled with 6x6-inch, or 8x 8-inch timbers and then cross-sheathed with 2-inch plank to make it water-tight. In appearance it would then not differ from the bottom of a vessel and would have all of the inherent qualities of strength that a ship's side possesses. The resemblance would perhaps be more of a shield planted point down in the river channel and curving slightly in both directions so that the strain would always be transmitted to the cliffs and in a slightly downward direction."

Mr. Hawks is correct in his statement that I discouraged his project mainly because of the high price of steel at that time.

Very respectfully yours, J. A. L. Waddell.
Kansas City, February 26.

The Proportions of Concrete.

Sir:—In the article in your issue of February 6 entitled "More Light on the Theory of Concrete," there is a misleading statement in the following lines: "The lowest proportion of voids obtained with the gravel and sand used in the above experiments was 19.1 per cent. Addition of this proportion of cement would give a very rich and expensive concrete, about 1 to 5, far beyond anything that could be required for any use except watertight work." The customary meaning of the ratios 1:5, 1:7, 1:9, etc., in describing concrete is, I think, the volume of cement divided by the sum of the volumes of sand and gravel, measured separately. The writer of the above article, however, measures his sand and gravel together; and the resulting volume is probably very little greater than the volume of the gravel alone. His 1:5 concrete is not by any means 1:2:3 concrete, but perhaps about 1:2:5, which is not excessively "rich and expensive."

Yours truly, Henry H. Fox.
Cambridge, Mass., February 8.

Sir:—Replying to the comment of Mr. Henry H. Fox in reference to the statement of the proportions of concrete in my paper printed in your issue of February 6, I would say that the full text of my article shows that in the experiment mentioned the materials used were: Coarse gravel, weighing 101.2 pounds per cubic foot, with 38.7 per cent. voids, and sand, 20 to 40 mesh, weighing 105.8 pounds per cubic foot, and containing 35.9 per cent. voids, a mixture of two volumes gravel with one volume sand weighed 133.7 pounds per cubic foot and contained 19.1 per cent. voids. Addition of the volume of cement theoretically required to fill these voids would give a mixture of nearly 1 cement to 5 of mixed sand and gravel. By calculation we find that to produce these five parts there would be required 2.18 parts sand and 4.35 parts gravel, or a total of 6.53. Mr. Fox is, therefore, quite correct in pointing out that a "1 to 5 concrete" is by no means so rich as a "1:2:3 mixture." It seems, however, that a concrete composed of one part cement to five parts mixed sand and gravel would be considered more "rich and expensive" than is necessary for ordinary purposes, especially if the mixed materials showed a low proportion of voids. The chief purpose of my paper was to show, by practical examples, that it is impossible to judge of the richness or poverty of a concrete from the proportions used, unless the amount of voids in the mixture is determined.

Very truly yours, S. B. Newberry.
Sandusky, Ohio, February 13.

The Fall of the Steelwork of an eleven story hotel under construction in New York, which occurred on Wednesday, remains unexplainable up to the time of going to press. Some details of the steel and cast-iron work as planned were condemned by the Building Department.

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Cast-Iron Columns in Buildings.

The Darlington Hotel disaster on West Forty-sixth Street, New York City, described elsewhere in this issue, is one more of a long list of building wrecks whose precise origin will probably never be known. This wreck, like others, has its peculiar features, no two of such a class being identical in all respects; the common characteristic is the absence of well defined evidence regarding the weak or defective point of construction which first failed and then caused the destruction of the entire framework. Whether the detail or the main features are like, or different from, those of previous building disasters, there are certain fundamental and valuably instructive facts that should be most carefully borne in mind.

Tall iron and steel frame buildings have now been constructed in considerable numbers annually for a period of 15 or 20 years. During this period there has not occurred one instance, within the limits of the information possessed by this journal, in which a wrought-iron or steel frame has collapsed either before or after completion, excluding those cases, if there be any, in which defective foundations have produced failure. On the other hand, whether the fact is with or without significance, a number of buildings with cast-iron columns have failed and have produced building disasters of no ordinary magnitude, involving not only loss of property but large loss of life. It is not the purpose of this comment upon building failures to make any sweeping condemnation of properly designed cast-iron columns, but the facts as they stand should be recognized. Whether those facts are of such a character as to teach a lesson in the design of iron buildings must rest largely with the individual judgment of parties in interest, but an engineering consideration of such a question compels a recognition of the situation as it is.

There is a practice in building construction, altogether too common, of running up tier upon tier of floors of high buildings loaded more or less, supported by vertical series of columns, whether of steel or cast-iron, without any lateral bracing whatever. A little stiffness of exceedingly uncertain value is given to such an incomplete skeleton by bolted joints between the floorbeams and the columns at each story. Immunity from many serious accidents in such cases has appeared to justify hazards which prudent engineers do not care to take. In case of riveted joints between steel columns and steel floorbeams with heavy gussets or brackets the lateral stability is entirely satisfactory; it is capable of closely approximate computation with the highest wind pressures which have been observed, and no criticism can justly be made of such structural features. Where, however, the joints between columns and floorbeams are made by resting the ends of the latter upon brackets on the former and loosely bolting them to the columns, the stiffening effect is so small that it cannot be even roughly approximated by computation. This latter class of joints is that which characterizes all cast-iron column construction, and it was used in the frame of the Darlington Hotel.

Again, a vertical series of cast-iron columns has only the continuity at each story possessed by an abutting flanged joint held together by a few loosely fitting bolts. Even if the ends of such columns are carefully faced, the series will not constitute a truly continuous member as in the case of steel columns with riveted splice joints and with the solidly riveted floor connections at every story. The details of such steel joints can be made perfectly satisfactory in every respect, and in all first-class designs they are so made. No failure is possible except by gradual distortion of members, which usually gives ample warning and affords abundant time for the execution of protective measures if they are needed. In the case of cast-iron columns and corresponding details of shelf brackets and bolts, no degree of true continuity can be attained, and the treacherous character of the material always exists as a menace to the safety of the work. The details are invariably such as to cause the load applied to the columns at each story to act with a considerable lever arm, thus producing heavy bending in the columns in addition to the disturbing influence of abutting joints. Under such circumstances it is simply impossible to avoid a constantly increasing bending effect upon cast-iron columns in passing downward from the top of the building to its foundation, so that even if there were no defects in the material there would be a strong tendency to throw the columns out of line, and it would not be a matter of surprise if that tendency were at times sufficient to throw them out of place and wreck the structure.

Besides these considerations, which exist independently of the quality of the material, it is one of the great merits of the production of steel members that the quality of metal is under complete control in all stages of manufacture from the furnace up to the shipment of completed members. On the other hand, the unreliable character of cast-iron as a structural metal has been so well known that engineers have excluded cast-iron columns from all bridge construction whatever for more than 25 years. It has been perfectly well known that castings from the grades of cast-iron ordinarily used for engineering purposes are liable to be affected in all parts by blow holes, cinder spots and other defects, seriously impairing their carrying capacity and safety. It matters little how many drill holes may be made in a cast-iron column to determine the thickness of the metal or its character. Such holes may show satisfactory results in every particular, while alongside of any one of them there may be such a defect as to make the column unfit for use, and that sort of a feature may be found at almost any number of points. When these defects are liable to take place not only in the body of the column but also in the brackets and other details, the hazardous character of cast-iron members of this class may easily be realized.

It will be observed, of course, that there are many buildings with cast-iron columns that have stood with an apparently satisfactory performance of duties for many years, and no intelligent person will attempt to controvert that observation. At the same time there is no reasonable ground for supposing that even such cast-iron columns are carrying their loads with anything like the factor of safety that nominally belongs to them. Indeed the last and most extensive series of full-size column tests shows that the formula commonly used has greatly over-estimated the carrying capacity of cast-iron columns. When this fact is coupled with the certainty of defective and weakened spots in columns and their details, there can be little satisfaction in contemplating what margin of safety may exist.

Such wrecks as that of the Darlington Hotel, in which cast-iron columns have been used, should bring home to building owners and to the building departments of cities the question of permitting cast-iron columns to be used at all. Extended experience with wrought-iron and steel columns indicates with reasonable certainty that under ordinarily good design such wrecks would be impossible with them, as the defects characterizing a brittle metal like cast-iron would be entirely avoided. It is a fact, moreover, that in tall buildings at least, cast-iron columns of equal strength with those of steel yield no economy whatever over a well designed steel frame. While some economy is claimed for cast-iron in low buildings, it can at most amount to but little and may be imaginary. The question arises then whether the time has not come for cast-iron columns to be relegated to disuse in buildings precisely as they have been excluded from bridge work for a quarter of a century. However much may be said in their favor, the broad question still asserts itself: Is it worth while to imperil life and property by the use of a class of members that have failed repeatedly and are likely to fail at any time in the future, when all such danger may be eliminated by the use of a stronger and more ductile material possessing better qualities of every kind without exception, and which can be used with equal economy? Good business and a proper regard for past experience indicates that municipal building departments should take the position which engineers assumed so many years ago, and have never regretted.

The Association of Portland Cement Manufacturers.

To anyone having much acquaintance with the national associations of men in the steel industry, the manufacture of engines, the pulp and paper making business, the foundry interests and other manufacturing branches of an important character, the quarterly meeting of the Association of Portland Cement Manufacturers at Philadelphia this week was particularly interesting. A report of the proceedings is printed on page 342 of this issue. It is pretty well shown by experience that if a strong initial meeting is held for organization purposes, such a society will run along for a year before there is much flagging in the interest. But little weakness will develop until the second year. The cement makers' organization held the first quarterly meeting of its second year this week, and it was so successful that the future of the society seems assured. The American Portland cement industry is so new, in comparison with others of the same financial importance, that the idea of an association of its competing members is probably a little novel to many, although it is an old idea with manufacturers in many other industries. Nevertheless an association so young and undeveloped which will bring together for a two-days' meeting representatives from the Pacific Coast, Michigan, Illinois, Virginia, Ohio and the North Atlantic States, certainly has the elements of great strength. It already represents a manufacturing capacity about the same as that of the members of the famous Society of German Portland Cement Manufacturers, and its representatives are associated with those of national engineering societies on joint committees investigating uniform tests of cement and the design and execution of concrete-steel works. In a business way it is understood that the Association has proved of considerable service to its members.

It is not probable that all the members of the organization appreciate the attitude of the engineering profession toward the Association or recognize the satisfaction that is felt among engineers over its continuous success. Within a very few years the average engineer, even though he might be a large consumer, could only enter many American cement plants by means of a dark lantern and a jimmy. A cloak of mystery hung over the works and a high board fence enclosed them. To-day the conditions are very different. The processes of manufacture are well known and very few plants refuse admittance to a properly accredited visitor. All this is very pleasing to the engineer, whose training renders him curious about the methods of producing the materials he employs. He recognizes that as soon as manufacturers show their works to each other they will show them to him, and he is correspondingly gratified at all indications of harmony in the industry. His experience with cement manufacturers in the past has not been wholly satisfactory largely because he was kept in ignorance of the difficulties of the manufacturers in producing a sound uniform product. It has not been wholly his fault that the varieties of cement specifications have been legion and their quality correspondingly diverse. This has not been the case with steel specifications largely because the structural steel makers have made no secret of their methods. Cement is assuming a position in engineering construction of almost equal importance with steel, and the more information the engineer can secure concerning its properties, the less liable he is to run after false ideals in his specifications. It really makes no difference to him whether the cement is made in a rotary kiln or a cook stove, so long as it will answer his requirements, but there are many features of manufacture which are directly influenced by his specifications and about these he has reason for showing curiosity. Until a short time ago, this curiosity could only be satisfied by a study of the publications of the Society of German Portland Cement Manufacturers. It was to satisfy this curiosity that The Engineering Record secured from Mr. F. H. Lewis, the valuable series of papers on foreign and American cement plants which was published six years ago. Now that the manufacturers of Portland cement are interchanging data, the engineer has every reason to expect them to co-operate with him more completely than in the past, a procedure which he knows will result in better results in the structures under his charge.

For another reason, also, the engineer is following with interest the development of this Association. It is acknowledged openly by cement manufacturers that improvements in plant and in methods are coming along rapidly. These mean both a lower average price of cement and an improvement in its quality. So far as cost is concerned, every experienced engineer expects the manufacturers to make a reasonable profit. History shows, however, that no important improvement in manufacture has ever been made which has not been followed eventually by a lower price for the product. The raising of the quality of the cement by better manufacturing plant and methods is likewise a subject in which the engineer is vitally interested, and the value of a society of manufacturers which will speedily circulate the news of such improvements throughout the country is perfectly recognized by him. It is self-evident that the developments in the cement industry must be followed by changes in the cost and quality of the product. In short, the Association of Portland Cement Manufacturers represents to the engineer who buys cement a definite organization for assisting him in an indirect but by no means unimportant manner.

The Pitot Tube.

In 1732 Pitot described before the French Academy of Sciences the tube for gauging the velocity of fluids which has since borne his name. The apparatus he employed was a small piece of wood behind which two tubes were attached. One of these was vertical; the other was vertical at its upper end while its lower portion was bent around the block and brought to its face. In the hands of the inventor this device yielded surprisingly accurate results. Evidently he made a thorough study of the influences affecting its accuracy, so far as the facilities at his command permitted. The men who took up its use after him were far less painstaking for a time. In their hands it gave results of a very imperfect character. Little by little the favor in which the instrument was held during Pitot's lifetime lapsed into disfavor. The device came to be regarded as an extremely inaccurate one, although in the work of a few of Pitot's countrymen it found favor and regained in a measure its good name. Dupré conducted some ingenious experiments nearly half a century ago, using the tubes to measure the velocity of air currents. At a later date Darcy took up the subject in a thorough manner. He investigated its best form, showed how the change in this form affected its reliability, and pointed out the importance of keeping the current to be measured free from disturbance.

Unfortunately, a very large part of the really valuable work done with Pitot tubes is described in French papers inaccessible to all but a few investigators. This is particularly true with respect to descriptions of accurate work. Most of the early investigations concerning the accuracy of the instrument were conducted with water, and it is largely to American experiments that the public rehabilitation of the tube as an accurate water-gauging device is due. Mr. Hiram F. Mills conducted some very important experiments of this nature a number of years ago, but these are, unfortunately, unknown to most engineers. The same is true of the less extensive work of a few other hydraulic specialists. It unquestionably remained for Professor Gardner S. Williams and his former associates on the Detroit water works to demonstrate the value of the Pitot tube in the hands of experimenters acquainted with the sensitiveness of the device and the best methods of employing it. Mr. Cole has since proved by his experiments in many cities that it is an instrument of large practical value in the commercial operation of water works. As before stated, all this work has been done to a large extent in gauging the flow of water, and it is only recently that the value of the Pitot tube for similar work with gases has been fully established. It is necessary to look to Great Britain for the most important papers on this subject.

Messrs. Heenan and Gilbert have shown in a paper published in the "Proceedings" of the Institution of Civil Engineers that in gauging the flow of gases certain simple arrangements of the apparatus will satisfy some of the conditions of accuracy. Dr. Stanton has given some results in a paper before the same society on the resistance of plane surfaces in a uniform current of air, which were obtained by Pitot tube experiments at the National Physical Laboratory under the direction of Dr. Glazebrook. Last month a still more elaborate contribution to the literature of the gauging of gases with the device was made by Mr. Richard Threlfall, F. R. S., in a paper on the motion of gases in pipes read before the Institution of Mechanical Engineers. It is interesting to notice in this paper as well as in the discussion it elicited that the same uncertainty arose respecting the true theory of the instrument that has been a source of controversy in this country. It may be recalled that at a meeting of the American Society of Mechanical Engineers a few years ago the accuracy of the apparatus in gauging water was relegated to a minor position as compared with its theory, and this controversy led to a number of short papers on the subject. Fortunately, as Professor Williams has pointed out in this country and several of the members of the Institution of Mechanical Engineers in Great Britain, the value of the instrument, the best form to give it for a definite purpose, and the proper methods of using it, can all be studied without reference to the theory of its action, while the two theories which are advanced to explain this action lead eventually to similar formulas.

The paper presented last month by Mr. Threlfall is altogether too voluminous to be reprinted in this journal. It takes up in turn the construction of a suitable manometer for observing the small differences of pressure which are dealt with in gauging the flow of gases and render the use of the instrument for such purposes far more delicate than with water, the influence of the shape of the tip of the Pitot tube on the pressure, the reliability of side gauges in indicating the pressure of the gas, the relation between the velocity of the air currents and the pressures developed in the tubes, and the distribution of velocity of gas streams in the pipes. These divisions of the subject are discussed in an unusually interesting manner, but the result which outweighs in importance all others given in the paper is the proof of the reliability of the instrument for measuring the velocity of gases. The work during the last eighteen months in the National Physical Laboratory furnishes an excellent check on that of Mr. Threlfall. The two sets of experiments were made with different gases, one with dry clean air and the other with blast furnace gas. They agree within about 5 per cent., which is within the limits of accuracy it is reasonable to expect in such investigations, and they prove that the method of measuring velocities of gases up to about 3,000 feet per minute by the Pitot tube is one which may be safely adopted.

The return to good standing which is given the Pitot tube by experiments on both sides of the Atlantic should be a matter of congratulation among engineers. Not only is it important in itself that this simple apparatus should be proved an accurate one when properly made and employed, but it is equally important as indicating the possible value of other simple instruments known for many years but still under the ban of the scientific experimenter. It is an interesting fact that many important investigations are conducted in which use is made of some of these little-esteemed instruments or methods, but because of their lack of reputation the men in charge of the experiments often prefer to remain silent concerning the successful use of such apparatus or procedures. They prefer to avoid criticism by giving no opportunity for it. This is to be regretted because it is now a fairly well accepted fact that considerable improvement can be made in the conduct of experimental work by a thorough investigation of the capabilities of methods which received the unmerited stamp of disapproval many years ago when the facilities for such work were not so great as at present.

Fire-Protection Water Supplies for Mills.

It may be of interest to the readers of The Engineering Record to know that in the Baltimore fire two manufacturing plants, which had been equipped in accordance with the standards of the Associated Factory Mutual Fire Insurance Companies, held their own against a fierce attack of flames and gave such support to the fire department that the conflagration went no further in their direction. They were equipped with sprinklers, shutters, private fire pumps and hose, and their loss was almost solely from water damage and the destruction of the shutters. The financial loss in these two factories is less than one-third of one per cent. of the valuation of the properties. In the great fire at Paterson, N. J., a little more than two years ago, a number of buildings equipped in the same manner passed the test in a striking way. Moreover, at Paterson these well-protected mills were able to assist the fire department to a considerable extent and not only saved their own property but also aided materially in reducing the damage in their vicinity. It has been thoroughly well established by these two fires that city mills should be provided with powerful pumps independently supplied with ample water, if possible, in order that they may take the place of public apparatus when it is unavailable from any cause. This is particularly true in cities where the street-main pressure is weak or the pipes themselves are small. At Paterson it is understood that the mill pumps did a large part of the work of checking the spread of the flames and without them many of these factories would have been destroyed.

A second lesson which is shown by these fires and others is the necessity of providing a liberal water supply for such independent pumps. The small fires in such mills are taken care of by sprinklers or small streams supplied from the public service. When the pump-protection is called into use, it may be required for hours instead of minutes and a very liberal supply for these mill pumps in cities is therefore essential. Most cisterns are filled from public mains through a small pipe, often not larger than 2 inches in diameter. It is manifestly impracticable for such a little pipe to furnish the large quantity of water which is necessary for the pumps when they are run for any length of time.

Particular attention is drawn to this matter because in some large mills lately constructed there seems to be a tendency to neglect the matter of fire protection. The desirability of good fire-resisting construction is fully recognized, attention is paid to the exposure of the buildings to outside risks, inflammable materials are isolated so far as possible, but the water supply seems to be neglected. Of course in the factories which are insured by the associated factory underwriting companies this neglect of water does not exist to any serious extent. Other companies are not so strict and occasionally even yard hydrants are not used on account of the charge made for them by the local water works, and reliance is placed on fire hose connected with the piping in the buildings. This piping is metered and the meter is a small one compared with the demand for water in case of a conflagration. Naturally enough the water department refuses to put on a large meter in such a case, on account of its lack of sensitiveness in registration at the usual rate of supply to the buildings. When a large fire breaks out and the demand for water in a few minutes may become many times that called for in the establishment in a day under usual conditions, the meter simply acts as a plug to check the flow in the pipes. A fire-protection water supply of this nature is very largely a useless ornament.

If the cost of the public water is so great as to be a serious matter, it is often possible to secure an ample supply for fire protection purposes from wells or a neighboring body of water. It is unnecessary, of course, to use water of the highest character for extinguishing fires, and this makes the problem of securing a supply for fire protection a much easier one than is usually the case. But if no such supply is possible, it is difficult to understand the reasoning which leads the owners of large establishments to risk their investment in buildings and a possible disastrous loss of business through a shut-down made necessary by rebuilding after a fire, in order to save the comparatively few thousand dollars needed to install a thoroughly good pumping plant. One or more large connections from the street mains, pipes of ample size to feed water to all parts of the plant, good underwriters' pumps and an ample supply of hose are not very costly. While they may not be needed very often, when they are required they are needed so badly that in less than an hour their cost may well have been saved many times over by the good work accomplished with their aid in extinguishing what would otherwise be a serious fire.

Notes and Comments.

The Hudson River Tunnel of the Pennsylvania Railroad's terminal improvements in New York is to be built by the O'Rourke Engineering Construction Company, according to a statement made by President Cassatt on Thursday. This announcement will gratify the wide circle of friends of Mr. John F. O'Rourke, M. Am. Soc. C. E., whose engineering and executive ability in carrying on difficult construction, for others in former years and for himself of late, has received signal recognition in the award of this contract.

The James Watt Memorial to be erected in Greenock, Scotland, on the site of the cottage where the famous inventor was born, deserves the hearty support of Americans. A committee has been appointed to attend to the work of handling the subscriptions from this country, and the presidents of the four national engineering societies are acting on it in company with eminent manufacturers and representatives of trade unions. Only small subscriptions are desired, which should be addressed to Theodore Dwight, Treasurer, James Watt Memorial Fund, 99 John Street, New York. The number of subscriptions from this country should be in excess of those of other lands, for it owes its present advanced condition almost wholly to what Mr. Morison has called the manufacture of power.

Commercial Motor Wagons will be subjected to practical tests early in April under the direction of the Automobile Club of America. Six classes of wagons have been established, the rating depending on the dead load each is capable of carrying. The wagons will be placed in regular service by two of the New York express companies and employed in transferring merchandise, produce and baggage between the various depots of these companies. Awards will be made in each class for the best performance based on economy of operation in time and fuel, ratio of paying to non-paying load and general reliability. Further information can be obtained from the Secretary of the Club, Mr. S. M. Butler, 755 Fifth Avenue, New York. Makers of motor wagons should take advantage of this opportunity to bring their cars to the attention of the large number of people who have been thinking seriously of placing delivery automobiles in service. It would surprise a good many of these makers to know what a large field still remains open to them. Manufacturers of heavy machinery in many parts of the country are almost ready to adopt such wagons, while their value for express service in connection with interurban railways is just becoming evident.

Minimum Fees for professional practice have been established for many years by the American Institute of Architects. These rules were recently revised and are now substantially as follows: For preliminary studies, working drawings, specifications, large scale and full-size details, and the general supervision of the work, the minimum charge is 5 per cent. on the cost of the work. By supervision is meant such inspection by himself or his deputy of work in studios, shops and on the building site, as he finds necessary to ascertain whether his drawings, specifications and directions are being carried out. If the constant presence of a superintendent is necessary, the owner is to pay the cost. For new buildings costing less than $10,000, and for furniture, monuments, decorative and cabinet work the charge is to be 10 per cent. "None of these charges covers alterations and additions to contracts, drawings and specifications nor professional or legal services incidental to negotiations for site, disputed party walls, right of light, measurement of work or failure of contractors; when such services become necessary, they shall be charged for according to the time and trouble involved." When heating, ventilating, mechanical, electrical and sanitary problems in a building are of such a nature as to require the assistance of a specialist, the owner is to pay for such assistance. The fees are to be paid in the following order: On completion of the preliminary sketches, one-fifth of the entire amount; on completion of working drawings and specifications, two-fifths; the remaining two-fifths from time to time.

The Works of the Egyptian Portland Cement Company.

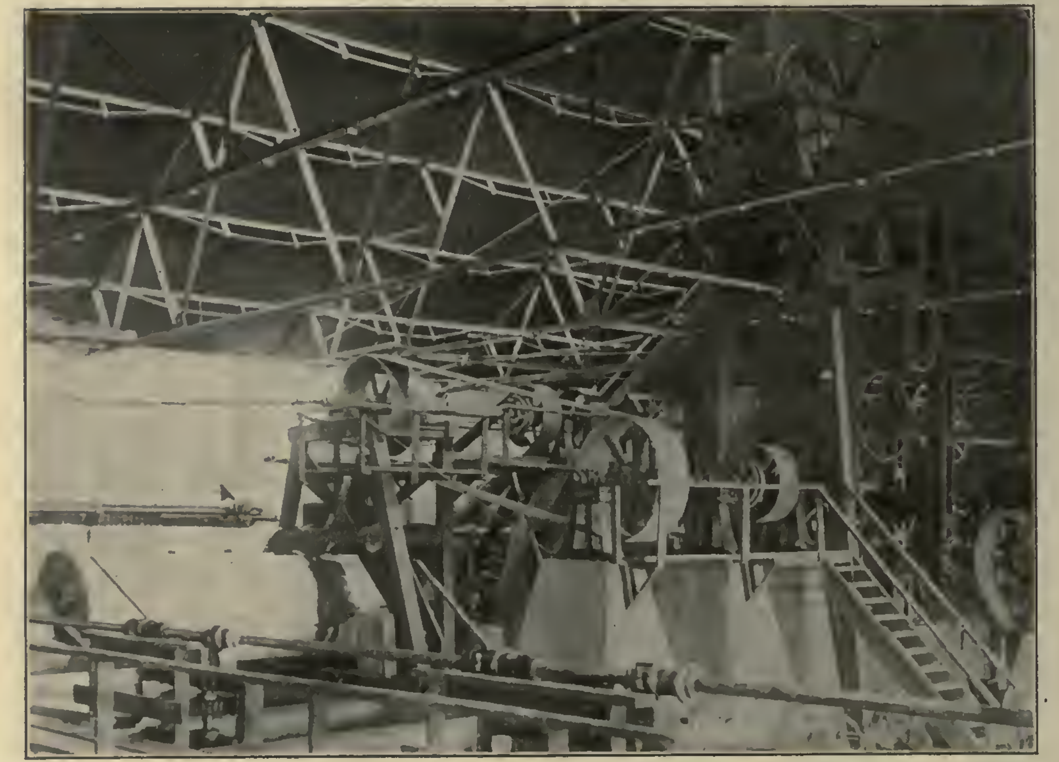
The Egyptian Portland Cement Company recently completed a marl cement mill, situated at the outskirts of Fenton, Michigan, about fifty miles from Detroit, on the Detroit, Grand Haven & Milwaukee branch of the Grand Trunk Railway. Proximity to the railroad and to the immense body of marl which the company owns determined the location of the mill, it being situated within a few hundred feet of the main line of the railroad on one side and the shores of Silver Lake on the other. The company owns in and around the chain of lakes in that locality, nearly 1,600 acres of marl, varying in depth from 3 to more than 40 feet. It is estimated that the visible supply would permit the manufacture of 1,000 barrels of cement per day for fifty years. Before undertaking actual construction, the land was surveyed and some 600 samples of marl analyzed by Robert W. Hunt & Company, the consulting engineers for the entire plant. These analyses showed that the marl was capable of being made into a high grade Portland cement. The arrangement of the plant is shown by the accompanying plan and section.

The marl lying in and around the lakes is dug up by an ordinary type of dipper dredge, the machinery for which was supplied by the Marion Shovel Company. Lashed to the side of the dredge is a "machinery boat" containing a stone separator, agitators and elevators, together with the necessary engine and boiler equipment. The marl, after passing through the stone separator, is transferred to scows placed alongside the machinery boat or is collected in the bottom of the boat and later elevated into scows, which transfer the material to the shore. Besides the dredge and the machinery boat, the fleet includes two scows, each of a capacity of fifty cubic yards, and a steam tug. On the shore of the lake, about 200 feet from the "wet end" of the mill, are two 8x14-inch duplex single-acting ball-valve, steam-driven fly-wheel Bonnot pumps for removing the marl from the scows, one of which is held in reserve for emergency use. These pumps are cross-connected at both the suction and discharge ends, and the discharge pipe, which is cast-iron and 8 inches in diameter, leads to two large iron tanks in the attic of the main building. The discharge pipes from these tanks lead to a pug mill, as shown, which mixes the marl with the clay.

The company experienced the difficulty usually met in Michigan of finding near at hand a large and good deposit of clay suitable for the manufacture of cement and is forced to haul its supply from Corunna, 25 miles away. This clay is shipped to the works on the company's own flat cars and is shoveled by hand from the cars to the floor of the clay house, some 10 feet below the track level. It is the intention to put in a system of exhaust steam heating coils on sections of this floor in order to quickly dry and use clay delivered in stormy weather. The clay is dumped into a drying pan from wheelbarrows, this being one of the few places about the mill where manual labor is required to handle any of the material. After drying, the clay is ground and screened, and then elevated by a bucket elevator and an inclined belt conveyor to a bin in the peak of the main building close to the marl tanks above mentioned. From this bin the clay is weighed as needed, and spouted into the pug mill with the marl. The slurry from the pug mill passing through the storage tank, is given a preliminary grinding in three 42-inch Emery mills, and then spouted to either of two long shallow pits, where it is held for chemical analysis and correction when necessary.

From these pits the slurry is pumped through two 5x22-foot Gates tube mills by one of two power-driven ball-valve pumps, into a large concrete storage tank having a capacity of 1,350 cubic yards. All the tanks, the pit and even the scows, are provided with agitators, and the marl and slurry is thus constantly kept in motion, in order to insure a uniform mixture being sent to the rotaries.

Coal is received in cars and run into the coal grinding department on an elevated track. From the floor of this room it is shoveled into a Sturtevant crusher and then conveyed by an open chain elevator into a Bartlett four-compartment dryer. From the dryer the coal passes directly to a No. 3 Williams pulverizer and then is elevated to a bin over two 5x22-foot Gates tube mills. A steel-legged elevator and a steel trough screw conveyor take the pulverized coal from the tube mills to the coal bins in front of the rotary kilns. The bins, which are about 8 feet square and approximately 5 feet high, have a hopper bottom. These discharge into small conveyors with double-flight screws. Just above the conveyors are cut-out slides to regulate the amount of coal feeding to the conveyors, which are driven by a speed controller made by the Power & Speed Controller Company, 147 Milk Street, Boston. The coal discharged from the small conveyors drops into an air siphon, the blast of air blowing the powdered coal into the kiln. The pipe connecting the siphon with the kiln, is made of wrought-iron and is 6 inches in diameter. The air blast is provided by means of two No. 55 American Blower Company's steel plate fans, which are designed to run at about 1,000 revolutions per minute. One of these fans is located above the other, both being supported by a steel structure. Each fan has sufficient capacity to take care of all the kilns, one being held in reserve in case of accident. In the branch air pipe leading from the main to each kiln is located a blast gate, controlling the volume and pressure.



Slurry Tube Mill Installation, Slurry Vat in Foreground.

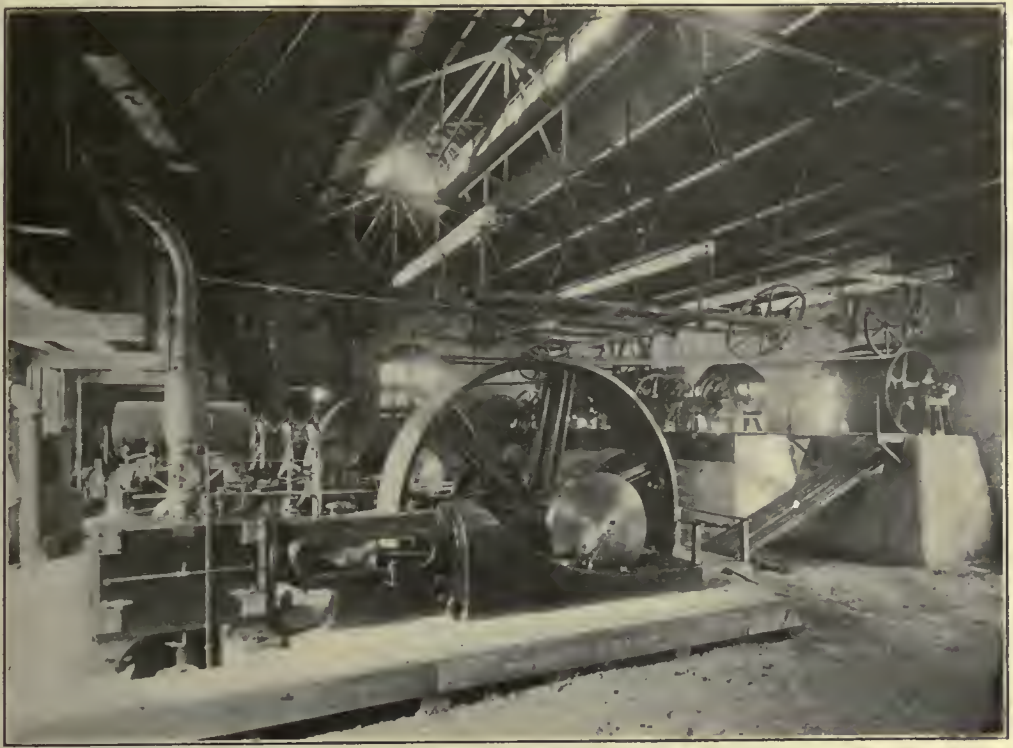
There are nine rotary kilns, 6x60 feet, each driven by an 8x10-inch non-condensing steam engine. A speed-changing pulley attached to the throttling governor of each engine enables each rotary to have a great range of speed. The counter shafts of the rotary gear bases are placed in line and just clear each other. In case of the break-down of one engine, the next engine can run two rotaries when the two countershafts are coupled together. Thus, each rotary is practically independent of the remainder of the mill. Each rotary is equipped with a power-driven ball-valve pump, the suction running to the big slurry pit, and its discharge through the stack base, into the rotary. The discharge pipes of these pumps are cross-connected so that one pump may feed two or more rotaries whenever necessary.

The marl pumps on the lake shore have a discharge head of almost 50 feet, and the rotary feed pump a lift of eight feet, when the big slurry pit is nearly empty, yet marl and slurry containing as low as 40 per cent. of water have been handled without trouble.

Underneath the discharge opening of the rotary hood, a pan conveyor is run, which collects the clinker and discharges it into the end of an inclined rotary cooler. Just before entering the cooler, water is provided for sprinkling the hot clinker. Cool air is drawn through the rotary clinker cooler by means of a 120-inch American Blower Company's steel plate fan, which obtains its air supply from the discharge end of this cooler. The air, in passing over the hot clinkers, is heated to a high temperature and is at present discharged outside. The company is contemplating installing dust collectors on the discharge of this fan and using the clean, hot air as a source of supply for the coal blast fans. The fan is designed to handle about 32,000 cubic feet of air per minute at a temperature of 200 degrees Fahrenheit, when running at a speed of 350 revolutions per minute. On this basis about fifteen pounds of air per pound of coal has been allowed.

At the discharge end of the cooler, where the clinker is weighed and the required amount of gypsum added, the clinker is elevated and spouted into bins over the grinding apparatus. This apparatus consists of four Gates ball and two Gates tube mills. The finished cement is then elevated and conveyed to large concrete storage bins. The cement is sacked and loaded by manual labor, but provision has been made in the construction of the bins to do all this work automatically. A sunken track alongside the sacking room enables cars to be loaded with but a small amount of labor.

The buildings were originally designed and built for electrical power transmission. This scheme was afterwards changed and a rope-drive transmission installed, the transmission machinery being supplied by the Dodge Manufacturing Company. The substitution of a rope drive for electrical power transmission was accomplished without meeting any serious difficulties, all machinery lying in parallel lines, except the two "wet end" tube mills. The driving of these two machines was accomplished by a quarter-twist rope drive, shown in an accompanying photograph.



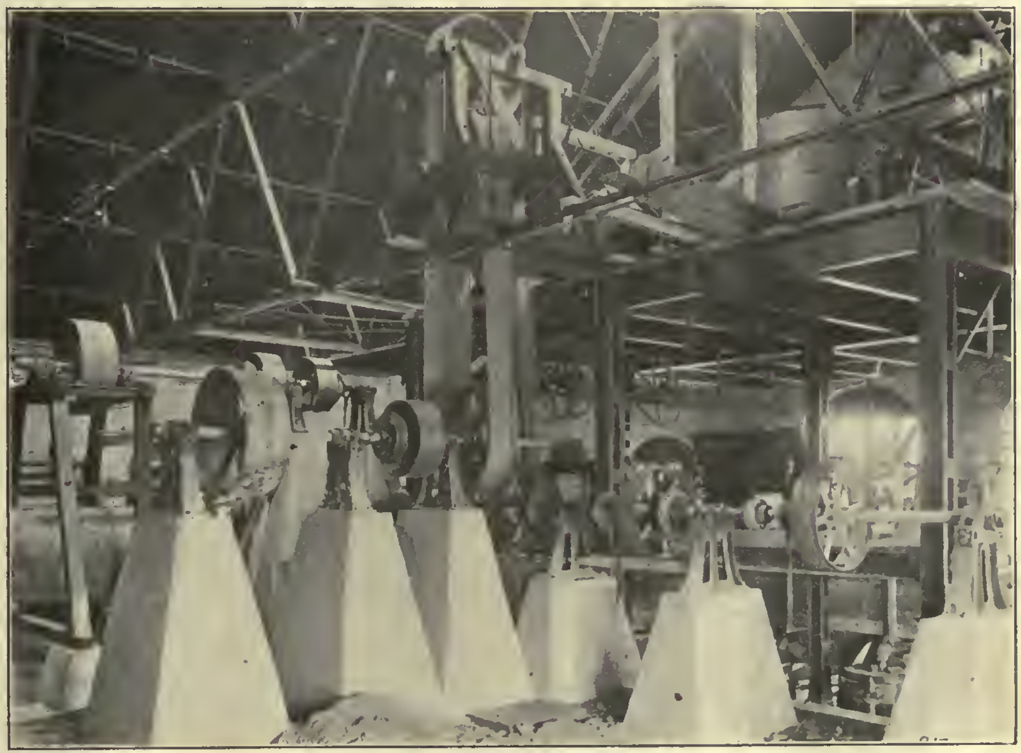
Main Engine Room, Showing Rope-Driven Jack Shaft.

Steam is supplied by two 500-horse-power and two 250-horse-power water-tube boilers working under a pressure of 150 pounds, made by the Aultman & Taylor Machinery Company. They are hand-fired, coal storage being provided in front of the boilers. The coal is unloaded directly into the boiler room from cars placed on a siding alongside of the building. A 12x8x10-inch Laidlaw-Dunn-Gordon feed water pump obtains its supply directly from the lake. Two injectors are also provided for emergency use. A 750-horse-power Cochrane feed-water heater is so piped as to receive the exhaust steam from all of the pumps and the auxiliary engines driving the rotaries.

The engine room contains two 18x36x42-inch Corliss engines, built by the Murray Iron Works, of Burlington, Iowa. Each is a 750-horse-power cross-compound condensing engine operating at 83 revolutions per minute. The two condensers are of Wheeler make, the one having its own air and circulating pump, and the other a 14x18x12-inch Walker pump of the fly-wheel type. The discharge from the condensers is pumped to the hot well in such a manner that the latter cannot overflow. The buildings are lighted by a 50-kilowatt 250-volt direct-current generator driven by a 9x15x9-inch compound Westinghouse engine installed in the engine room.

The jack shaft shown in an accompanying photograph is driven from the engines by rope drives, one drive having a cut-off coupling and the other a quill. Two more quills on this shaft supply power to the "wet end" and the "dry end" respectively. The fans, clinker cooler and conveyor are normally driven by a separate rope drive from the jack shaft, but means are provided by suitable cut-off coupling and quills to also drive this machinery from the grinding room shaft. This, together with the separate rotary engines, insures the continual operation of the rotary department.

The main building has steel roof trusses, resting on concrete pilasters, the curtain walls being built of brick. The engine, boiler and grinding rooms are of similar construction with the substitution of concrete curtain walls. The building arrangement is compact, and where space has not been left in the building itself, additions can be made in every direction.



The Wet End Showing Right-Angle Tube-Mill Drive.

The company manufactures the "Egyptian Portland" brand, of which the following is an analysis:

Silica	23.17
Oxides of iron and alumina	10 70
Lime	61.98
Magnesia	2.70
Sulphuric acid	1.30

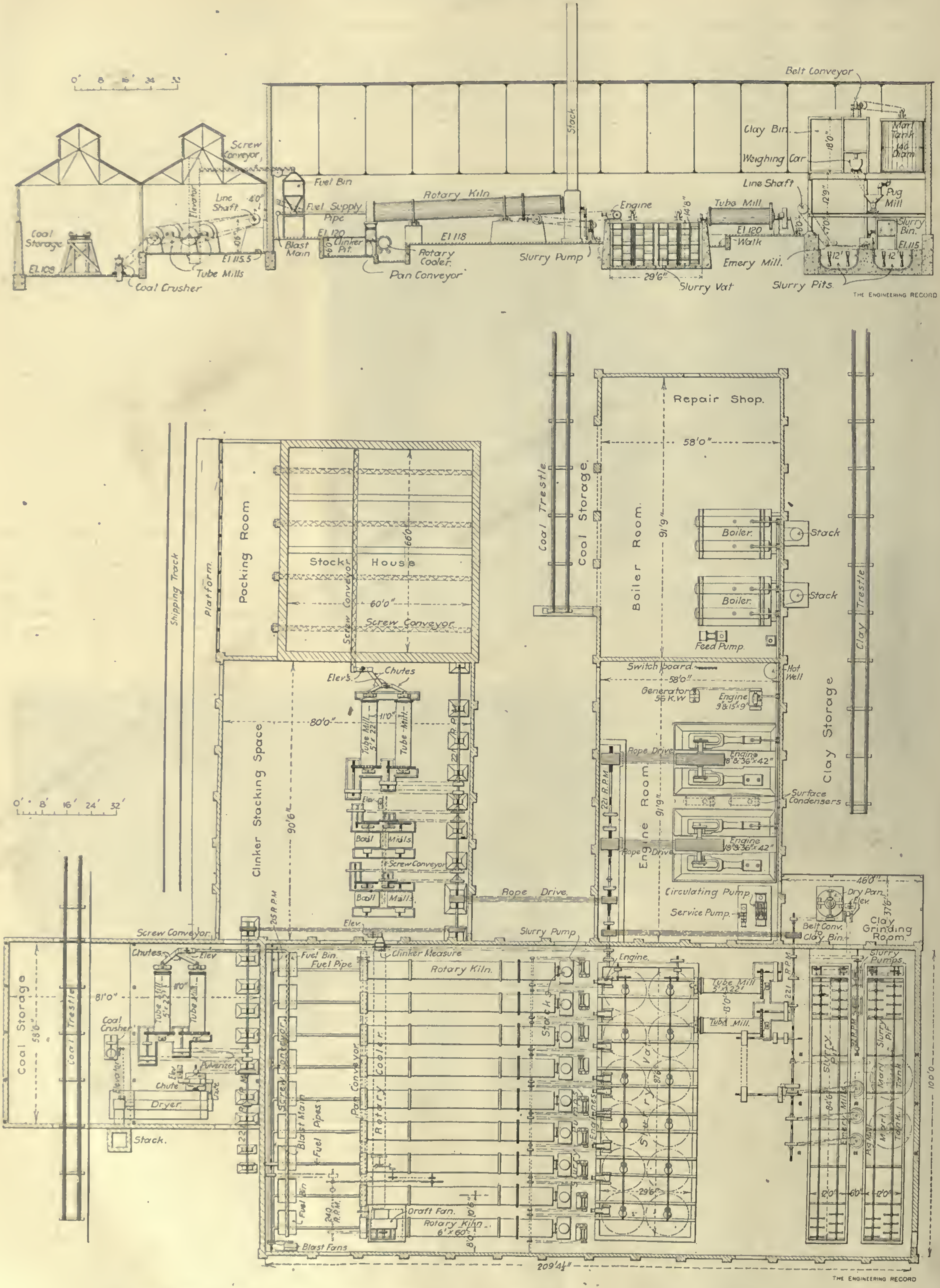
Average Tensile Strength. Pounds Per Square Inch

Time.	Neat.	Sand 1-3.
24 hours	290	98
7 days	720	350
28 days	830	470

The marl and clay give the following analyses respectively:

	Marl.	Clay.
Silica	2.20	60.00
Oxides of iron and alumina	1.24	20.88
Lime	48 39	6.23
Magnesia	1.07	3.09
Sulphuric acid	1.30	...
Loss by ignition	45.80	8.10
Alkalies	...	1.90

The McCombs' Dam Bridge, across the Harlem River, New York, has one of the largest and handsomest highway draw spans ever built. It is 400 feet long and has a 40-foot roadway and two sidewalks each nearly 10 feet wide. The moving mass weighs about 2,200 tons and until recently has been operated by a 40-horse-power oscillating-cylinder steam engine with differential-gear reducing its speed in the ratio of 19 to 1. The ends of the bridge were lifted by a separate mechanism with hydraulic jacks driven from an accumulator in the engine room, and it was locked by hydraulic centering rams. About two minutes was required to open or close the draw and the cost of maintenance of the mechanism was considered very large. In order to simplify and improve the operation of the bridge, the engine has been replaced by a 20-horse-power alternating-current motor furnished by the General Electric Company, and believed to be the first one of this size and character which has been applied to such purposes. The same motor is connected by a clutch to a system of gears and shafts which extend from the center of the bridge to both ends and operate toggle joints which replace the hydraulic lifting apparatus. The latch has also been replaced by an automatic device designed by Messrs. Boller & Hodge, New York. The new machinery is expected to effect considerable economy of maintenance and to promote the rapidity of operation. Two men less will be employed than were previously needed, and it is believed that the bridge can be swung open or shut in one minute or less. The improvements were made by the employes of the Department of Bridges, New York, Mr. Martin Gay, assistant engineer in charge of structures on the Harlem River, and the new machinery was designed by Mr. George R. Ferguson. The machine work was done in the Brooklyn Bridge machine shops.



PLAN AND SECTION OF THE EGYPTIAN PORTLAND CEMEN ' COMPANY'S WORKS AT FENTON, MICHIGAN.

The Five-Hundred-Foot Channel Span of the Clairton Bridge.

The Saint Clair Terminal Railroad connects the Pittsburgh, Virginia & Charleston Railroad, which is the Monongahela branch of the Pennsylvania Railroad, with the Pittsburgh & Lake Erie Railroad, on opposite sides of the Monongahela River at Clairton, Pa., by means of a bridge having a channel span which is the subject of this sketch, and at the same time affords additional transportation facilities for the supply and output of the Clairton Steel Company's plant, at Clairton. This plant comprises three blast furnaces, twelve open-hearth steel furnaces, with blooming mill and billet mill, all of which have been completed, and were put into operation during 1903. The road is intended for double-track service, but at present is only operated as single-track. The masonry was built for a double-track superstructure with the exception of the shore pier and the abutment for the north leg of the Y, at the west end of the bridge, which have not yet been constructed. The two through spans are built for double track, the remaining deck spans are for single track. Additional single track spans are to be placed alongside of these whenever the necessity for double-track railroad arises.

Clairton Bridge: End View of Channel Span, Showing Massive Construction.

The bridge was built by the Saint Clair Terminal Railroad Company, Mr. W. P. Snyder, president, Mr. J. B. McIntyre, chief engineer. The Drake & Stratton Company was the contractor for the substructure, and the American Bridge Company, of New York, for the superstructure, the shop work being done at its Toledo plant, with the exception of the eye-bars, which were manufactured at its plant at Athens, Pa. Mr. F. H. Bailey was the assistant engineer during the construction of the substructure, and Mr. C. D. Supplee during the erection of the superstructure. Mr. E. S. Warner was chief draftsman. The total length of the bridge is 1,154 feet, and includes one channel span, and at each end two deck and one through approach spans, varying in length from 86 to 117 feet. The piers supporting the channel span are 500 feet apart on centers and the trusses are 498 feet long, center to center of end pins.

The superstructure was designed according to the specifications of the Pittsburgh & Lake Erie Railroad for the heaviest locomotives and train loads that are used on any of the Pennsylvania railroads, and abundant mass was provided for impact, traction, secondary stresses and to secure the utmost rigidity. These conditions have resulted in some of the heaviest construction ever built for double-track service. The bridge was proportioned for a dead load of 10,400 pounds per linear foot and for a 152½-ton engine with tender followed by a train load of 5,000 pounds per linear foot for each track. Wind pressure was taken at 30 pounds per square foot on half the exposed area of both trusses, and the floor system and on a train surface 10 feet high, which gave a pressure of 900 pounds per linear foot for the bottom lateral system, 450 pounds for the top laterals, and 100 pounds on the upper floor. With these data the stresses were computed and materials proportioned as indicated in the stress diagram. The portal stresses were calculated by the method of least work, which gave a maximum of 9,300 pounds compression per square inch and 4,730 pounds bending stress per square inch in the end post. The maximum bending moment and shear in the lower deck stringers is 590,000 pounds and 78,000 pounds respectively. In the floor-beams the corresponding stresses are 2,063,000 pounds and 223,000 pounds. In the upper deck the floor-beams have a maximum moment of 641,900 pounds and a maximum shear of 64,000 pounds. All material is soft steel punched without reaming for all thicknesses up to ¾ inch, except for the pins, eye-bars and rollers which are medium steel.

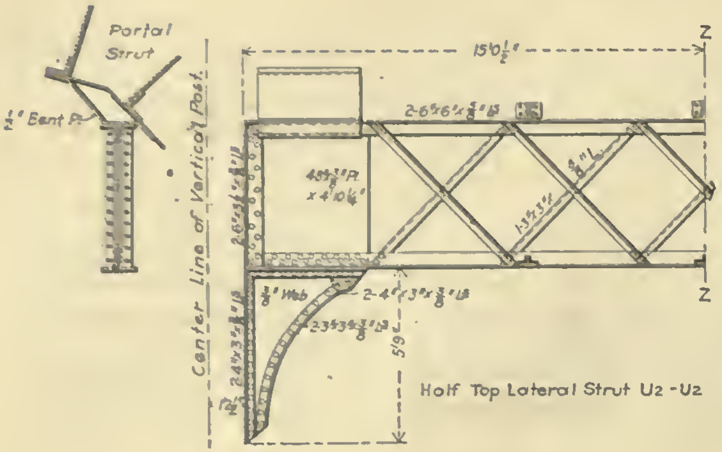
The main span is supported on two masonry piers at a clear height of about 53 feet above water level. The trusses have shoes and grillages on 10x14½-foot stone pedestals on a coping 48 feet long and 15 feet wide. The base of the pier is 17 feet wide and about 68 feet long, including a triangular cut-water at each end. There are several offset foundation courses which, in one pier, are seated on the solid rock and in the other on a timber grillage with pile and concrete footings. The superstructure is calculated for two railroad tracks on the lower deck and for future highway service on the upper deck, for which only the floor-beams have been erected, the remainder of the platform being designed to be built later when required. Most of the details of the superstructure conform to ordinary standards of high grade railroad work, and are of simple heavy construction with a few special features developed to provide for the large stresses.

All truss members are pin-connected. All floor, lateral, sway-brace and other secondary members have field-riveted connections. The pins at the main panel points are 10½ inches in diameter and have a maximum length of over 6½ feet. The pins in the middle of the diagonal members are 9 inches in diameter and the remainder are 5⅞ inches. The top chord and end posts are 4 feet wide and nearly 3 feet deep over all with four webs, each of them made with two or three plates riveted together, and a pair of 6x4-inch flange angles. The webs are connected by vertical transverse diaphragms each side of each panel point, by a single thickness of top cover-plate and by lattice bars on the lower flange. The webs are reinforced at pin points by as many as seven plates each at points of maximum stress. The top chords are made in lengths of 62 feet 3 inches, spliced on centers of the pins and locked together by the outside pin plates with full holes. The joints at the hips and at the center where there are angles, are protected by bent-plates over the top and bottom flanges.

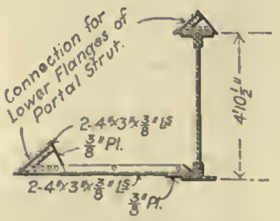
The foot of the end post is mitered on the center line of the pin Lo. The pedestal webs are mitered to correspond and each member has a half hole for pin bearing. The ½-inch clearance between the post and pedestal webs is covered by a bent plate on the upper side, which connects the end post with the inclined cover-plate across the pedestal webs. Each pedestal receives a total maximum load of 10,500,000 pounds, and its webs are heavily reinforced to give sufficient bearing area. The outer ones are 6 3/16 inches wide and the inner ones are 5 11/16 inches, thus making a total of about 250 square inches, which is distributed over a base about 5x6 feet, inclusive of a projection which carries the end floor-beams. The pedestal webs are connected by vertical transverse diaphragms on the center line. The outer web on the inner side has a horizontal connection angle to which is field-riveted a wide gusset plate receiving the end floor-beam and end lateral diagonal, and is reinforced under the bearing of the former by a vertical packing composed of transverse diaphragm plates and angles transmitting the load directly to the base plate.

At the sliding end of the bridge the pedestal rests on a grillage built of a double layer of crossed 15-inch I-beams set close together and bolted with separators made of vertical plates and angles. The beam flanges are riveted to thick plates which are planed top and bottom, and the lower plate has a transverse rib engaging a notch in the center line of a nest of segmental cast-steel rollers. Each roller is tap-bolted at each end to a top and bottom cross-bar and the center roller has a convex spur projecting from the curved surfaces on the upper and lower sides at each end, which engages a notch in the bearing plates and centers the nest in the required position. The rollers are seated on transverse bearing strips riveted to a bed-plate 6½ feet wide and 10½ feet long. At the other end of the bridge the grillages under the pedestals are seated on a special fixed bed-plate which corresponds to one tier of the grillage, but is made with ten 18-inch I-beams 9 feet long riveted to a planed 1-inch top plate and a double base-plate 2¼ inches thick, 6 feet 3 inches wide and 9 feet 9 inches long, anchored to the masonry. The webs of the grillage beams are connected by a riveted transverse diaphragm and the ends are enclosed by vertical transverse plates riveted to the top and bottom plates. The spaces between the beam webs are filled solid with rich Portland cement concrete.

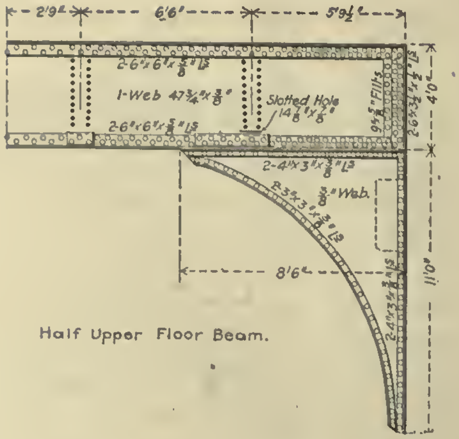
The intermediate floor-beams in the lower deck are plate-girders about 30 feet long and nearly 6 feet deep over all. The web plate is made with three sections and the short end sections project above the top flange to make the connections with the vertical posts, serving also



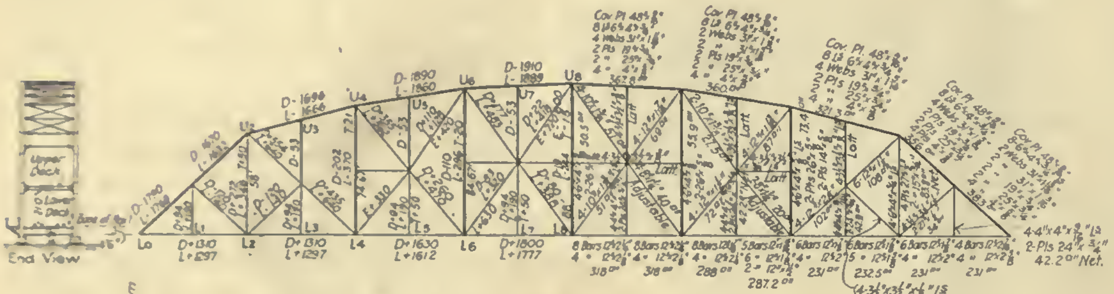
Half Top Lateral Strut U2-U2

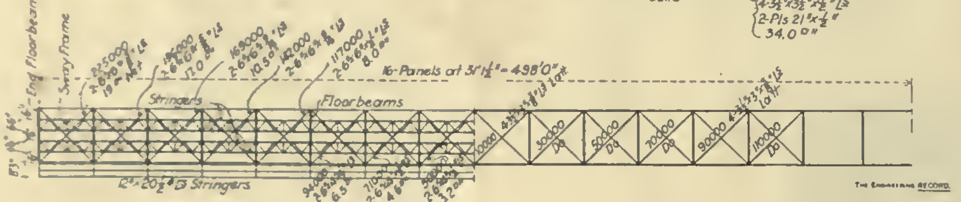


Section Z-Z

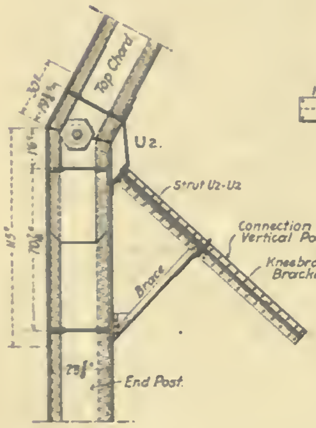


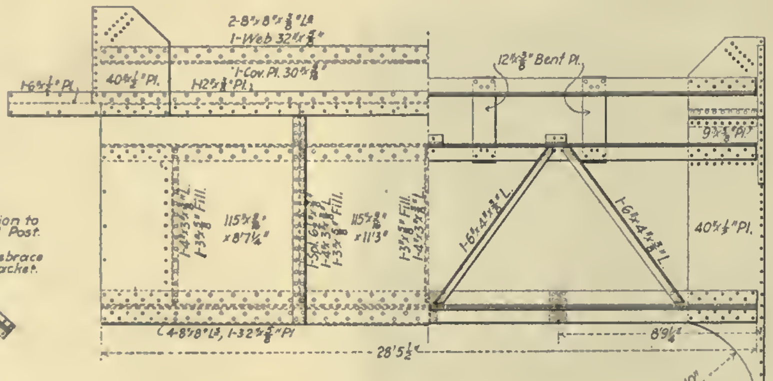
Half Upper Floor Beam.



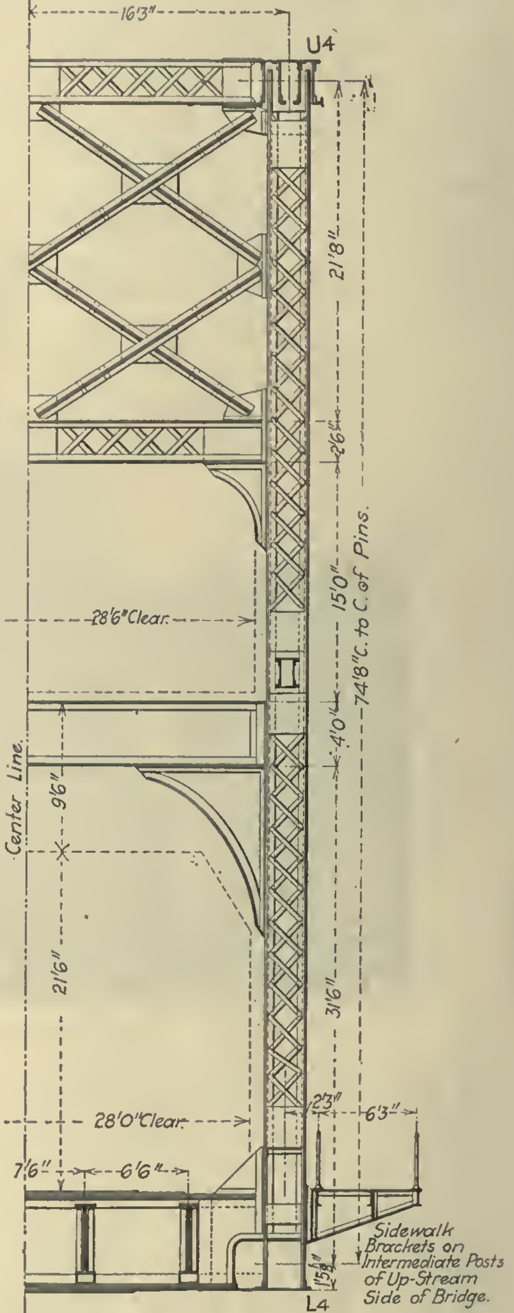


Lower Lateral System. Top Lateral System.

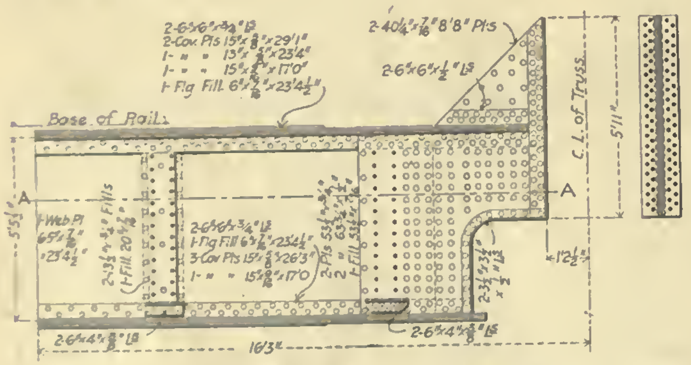




Upper Portal Strut.

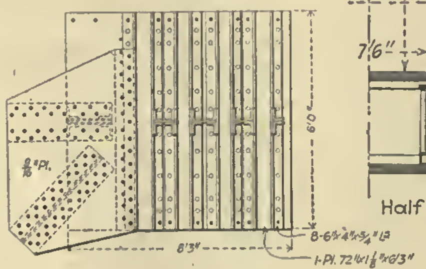


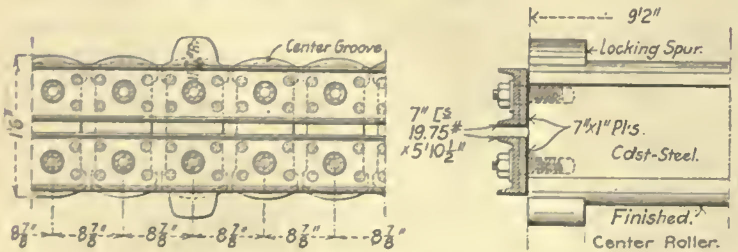
Half Cross-Section at U4-L4



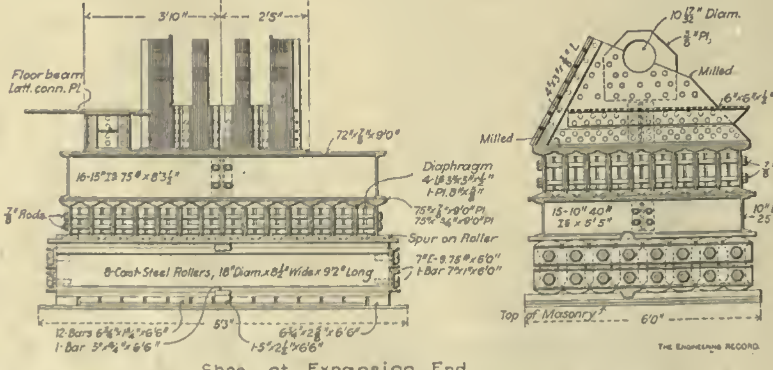
Section A-A.

Half of Intermediate Floorbeam.



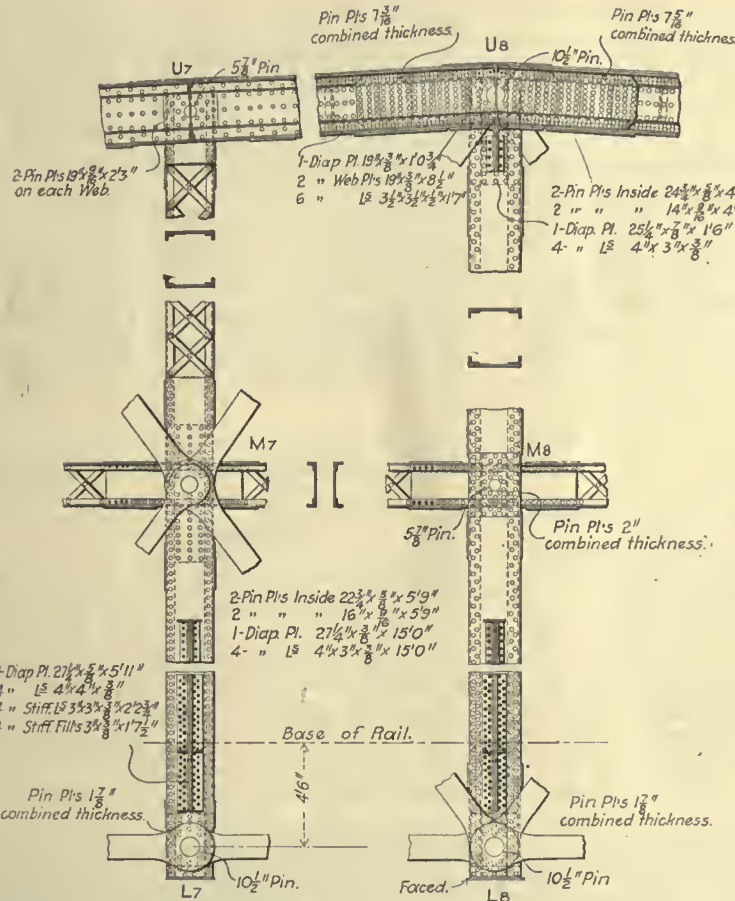


Part Elevation and Section of Roller Nest.



Shoe of Expansion End

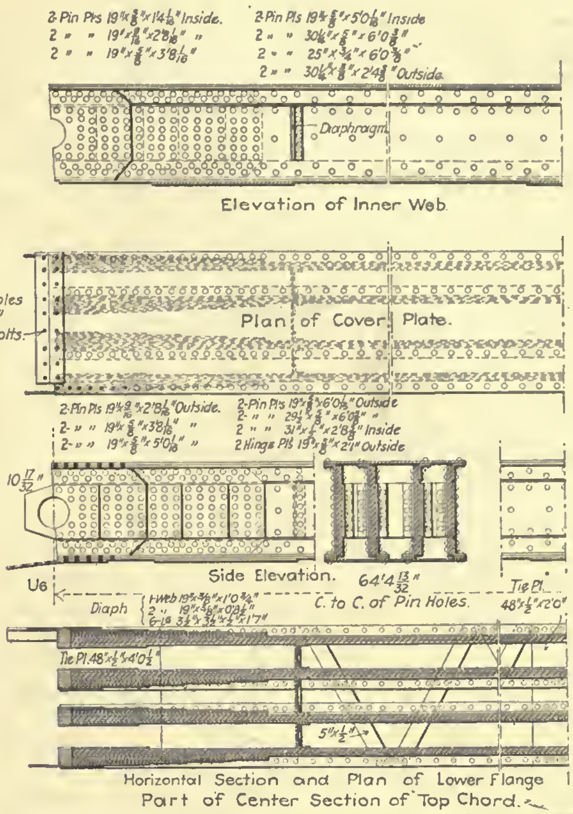
CLAIRTON BRIDGE: STRESS DIAGRAMS AND MISCELLANEOUS DETAILS OF THE CHANNEL SPAN.


Pin Pl's 7 3/16" combined thickness.
U8
Pin Pl's 7 5/16" combined thickness.
U7
5 7/8" Pin
10 1/2" Pin.
2-Pin Pl's 19"x 9/16"x2'3" on each Web.
1-Diap Pl. 19"x 3/8"x1'0 3/4"
2 " Web Pl's 19"x 3/8"x8 1/2"
6 " Ls 3 1/2"x3 1/2"x 1/2"x1'7"
2-Pin Pl's Inside 24 3/4"x 5/8"x4'8"
2 " " " 14"x 9/16"x4'8"
1-Diap. Pl. 25 1/4"x 7/8"x 1'6"
4- " Ls 4"x 3"x 3/8"
M7
M8
5 7/8" Pin.
Pin Pl's 2" combined thickness.
2-Pin Pl's Inside 22 3/4"x 5/8"x5'9"
2 " " " 16"x 9/16"x5'9"
1-Diap. Pl. 27 1/4"x 3/8"x 15'0"
4- " Ls 4"x3"x 3/8"x 15'0"
1-Diap Pl. 27 1/4"x 5/8"x5'11"
4" Ls 4"x4"x 3/8"
4 " Stiff. Ls 3"x3"x 3/8"x2'2 3/4"
4 " Stiff. Fill's 3"x 3/8"x1'7 1/2"
Base of Rail.
4'6"
Pin Pl's 1 7/8" combined thickness.
Pin Pl's 1 7/8" combined thickness.
10 1/2" Pin.
Faced.
10 1/2" Pin
L7
L8

Principal Materials given on Strain Sheet

THE ENGINEERING RECORD.

Center Panel.


2-Pin Pl's 19"x 5/8"x1'4 1/16" Inside.
2 " " 19"x 5/8"x2'8 1/16" "
2 " " 19"x 5/8"x3'8 1/16"
2-Pin Pl's 19"x 5/8"x5'0 1/16" Inside
2 " " 30 1/4"x 5/8"x 6'0 3/8"
2 " " 25"x 3/4"x 6'0 3/8"
2 " " 30 1/4"x 5/8"x 2'4 3/8" Outside.
Diaphragm
Top Holes for 7/8" Tap Bolts.
2-Pin Pl's 19"x 9/16"x2'8 1/16" Outside.
2- " " 19"x 5/8"x3'8 1/16" "
2- " " 19"x 5/8"x 5'0 1/16" "
2-Pin Pl's 19"x 5/8"x6'0 1/16" Outside
2- " " 29 1/2"x 5/8"x6'0 3/8" "
2 " " 31"x 1/2"x2'8 3/8" Inside
2 Hinge Pl's 19"x 5/8"x2'1" Outside
10 17/32"
U6
64'4 13/32"
C. to C. of Pin Holes.
Diaph
1-Web 19"x 3/8"x1'0 3/4"
2 " 19"x 3/8"x0'8 1/2"
6-Ls 3 1/2"x 3 1/2"x 1/2"x1'7"
Tie Pl. 48"x 1/2"x2'0"
Tie Pl. 48"x 1/2"x4'0 1/2"
5"x 1/2"

Elevation of Inner Web.

Plan of Cover Plate.

Side Elevation.

Horizontal Section and Plan of Lower Flange

Part of Center Section of Top Chord.

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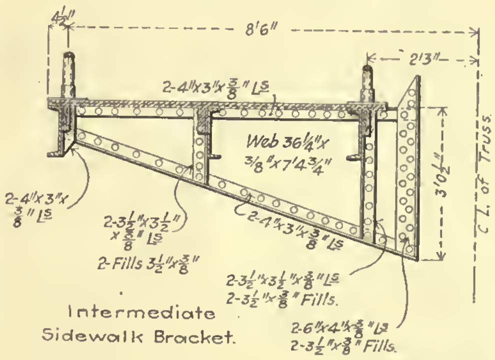

Intermediate Sidewalk Bracket.

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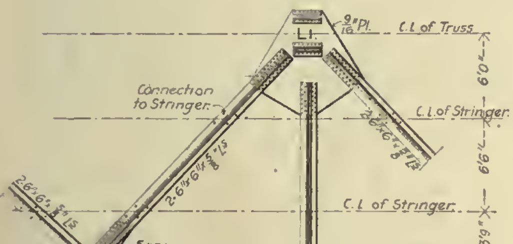

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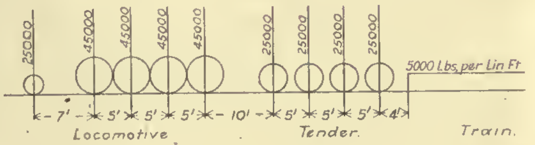
Lower Lateral connections.



Live Load spacing

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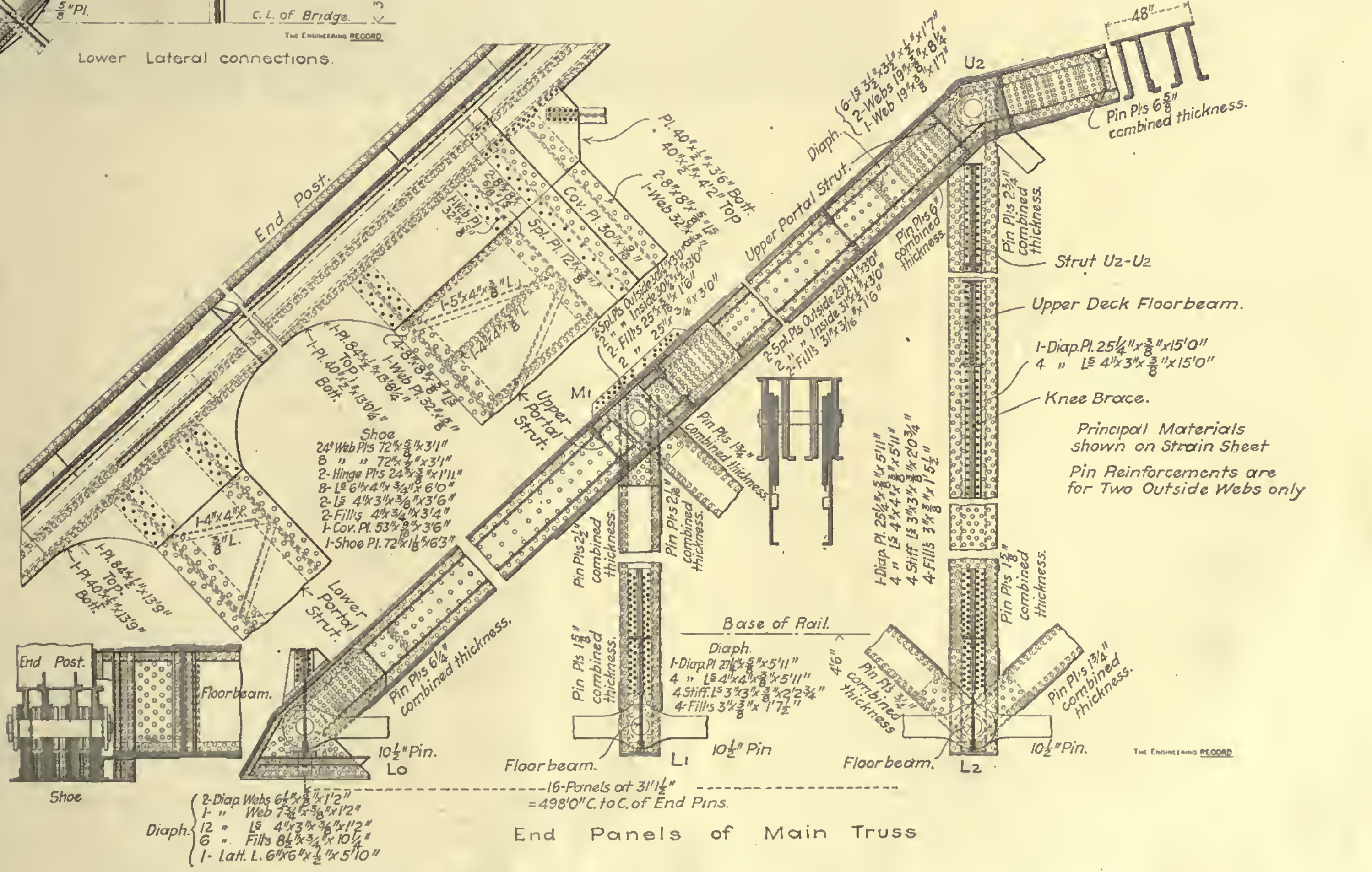
48"
U2
Diaph.
6-Ls 3 1/2"x3 1/2"x 1/2"x1'7"
2-Webs 19"x 3/8"x8 1/4"
1-Web 19"x 3/8"x1'7"
Pin Pl's 6 5/8" combined thickness.
End Post.
Pl. 40"x 1/2"x3'6" Bott.
40"x 1/2"x 4'2" Top
2-8"x8"x 5/8" Ls
1-Web 32"x 5/8"
Cov. Pl. 30"x 9/16"
Spl. Pl. 12"x 3/8"
1-Web Pl. 32"x 5/8"
2-8"x8"x 5/8" Ls
1-5"x4"x 3/8" L
1-4"x4"x 3/8" L
Upper Portal Strut.
2-Spl. Pls Outside 30 1/4"x 1/2"x3'0"
2 " " Inside 30 1/4"x 1/2"x3'0"
2-Fill's 25"x 3/16"x 1'6"
2 " 25"x 3/4"x 3'0"
2-Spl. Pls Outside 29 1/2"x 1/2"x3'0"
2 " " Inside 31"x 1/2"x3'0"
2-Fill's 31"x 3/16"x1'6"
Pin Pl's 6" combined thickness.
Pin Pl's 2 1/4" combined thickness.
Strut U2-U2
Upper Deck Floorbeam.
1-Diap. Pl. 25 1/4"x 3/8"x15'0"
4 " Ls 4"x3"x 3/8"x15'0"
Knee Brace.
Principal Materials shown on Strain Sheet
Pin Reinforcements are for Two Outside Webs only
1-Pl. 84"x 1/2"x13'8 1/4" Top
1-Pl. 40"x 1/2"x13'0 1/4" Bott.
4-8"x8"x 7/8" Ls
1-Web Pl. 32"x 5/8"
Upper Portal Strut.
M1
Shoe
24-Web Pl's 72"x 5/8"x3'1"
8 " " 72"x 1/2"x3'1"
2-Hinge Pl's 24"x 3/8"x1'11"
8-Ls 6"x4"x 3/4"x 6'0"
2-Ls 4"x3"x 3/8"x3'6"
2-Fill's 4"x 3/4"x3'4"
1-Cov. Pl. 53"x 9/16"x3'6"
1-Shoe Pl. 72"x 1 1/8"x6'3"
Pin Pl's 1 3/4" combined thickness.
1-4"x4"x 3/8" L.
1-Pl. 84"x 1/2"x13'9" Top.
1-Pl. 40"x 1/2"x13'9" Bott.
Lower Portal Strut.
Pin Pl's 2 1/2" combined thickness.
Pin Pl's 2 1/8" combined thickness.
1-Diap. Pl. 25 1/4"x 5/8"x 5'11"
4 " Ls 4"x4"x 3/8"x5'11"
4 Stiff. Ls 3"x3"x 3/8"x2'0 3/4"
4-Fill's 3"x 3/8"x1'5 1/2"
Pin Pl's 1 5/8" combined thickness.
End Post.
Floorbeam.
Shoe
Pin Pl's 6 1/4" combined thickness.
10 1/2" Pin.
L0
Pin Pl's 1 5/8" combined thickness.
Base of Rail.
Diaph.
1-Diap. Pl. 27 1/4"x 5/8"x5'11"
4 " Ls 4"x4"x 3/8"x5'11"
4 Stiff. Ls 3"x3"x 3/8"x2'2 3/4"
4-Fill's 3"x 3/8"x 1'7 1/2"
4'6"
Pin Pl's 3/4" combined thickness
Pin Pl's 1 3/4" combined thickness.
Floorbeam.
L1
10 1/2" Pin
Floorbeam.
L2
10 1/2" Pin.
16-Panels at 31'1 1/2" = 498'0" C. to C. of End Pins.
Diaph.
2-Diap. Webs 6 1/2"x 3/8"x1'2"
1- " Web 7 3/4"x 3/8"x1'2"
12 " Ls 4"x3"x 3/8"x1'2"
6 " Fill's 8 1/2"x 3/4"x 10 1/4"
1- Latt. L. 6"x6"x 1/2"x 5'10"

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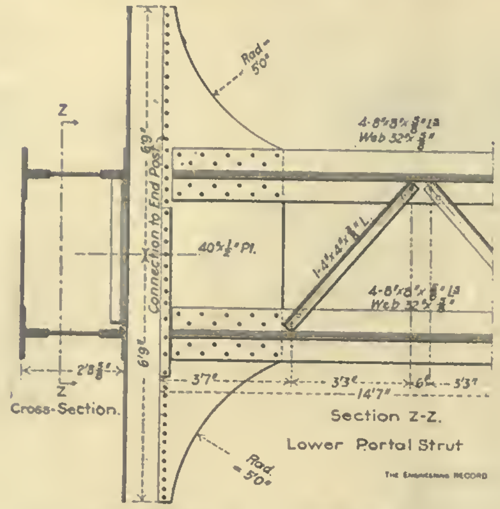
End Panels of Main Truss

CLAIRTON BRIDGE: DETAILS OF END AND CENTER PANELS OF ONE TRUSS OF THE CHANNEL SPAN.

as kneebraces. They are spliced to the middle sections by four cover plates which extend far enough to receive the stringer connections. The lower corners are notched to clear the bottom chord bars and the edges are finished with curved flange angles. The connection to the vertical post is made with seventy-eight ⅞-inch field-driven rivets in single shear. The stringer connections are made with twenty-six ⅞-inch rivets each. In the upper deck the floor-beams have 48-inch webs and 6x6-inch flange angles without cover-plates. They are seated on wide solid-web kneebraces with curved flanges resembling portal struts. Both floor-beams and brackets are field-riveted to the vertical posts through their end flange angles. The floor-beams are punched with holes for stringer connections, but the stringers are not erected.

The trusses are connected by lattice-girder transverse struts at every top chord panel point. These are made with solid web plates at the ends and are field-riveted to the vertical posts through the kneebraces and their end vertical angles. The top lateral diagonal braces are I-shaped members made with pairs of angles back to back, latticed. Their depth is equal to the depth of the top chords, to which they are connected by field-riveted horizontal plates engaging the inner flanges of the chords. At intersections one of them is continuous and the other is cut to clear it and spliced across it by top and bottom flange cover plates. The bottom lateral diagonals are pairs of 6x6-inch and 6x4-inch angles riveted together back to back and having their vertical flanges upwards. Their connection plates are field-riveted to the bottom flanges of the floor-beams and 54-inch stringers and to the feet of the vertical posts. At intersections one diagonal is continuous and the other is cut to clear and spliced across it by a bottom flange cover-plate, which is also field-riveted to the continuous diagonal.

The portal is a rather complicated member consisting of three parts, as indicated in the diagram of the cross-section. There is a deep box plate-girder connecting the upper parts of the end posts and extended at the hips to join a six-sided strut with two of the sides in the planes of the top chord flanges. These two members are riveted together to form one and are connected by continuous bent plates to an I-shaped girder on the center line of the end vertical member of the truss. The girder is seated on deep kneebrace brackets and its lower flange is braced with zigzag angles to the lower flange of the end post strut, a massive construction without diagonal or lattice members to interfere with the highway on the upper deck.



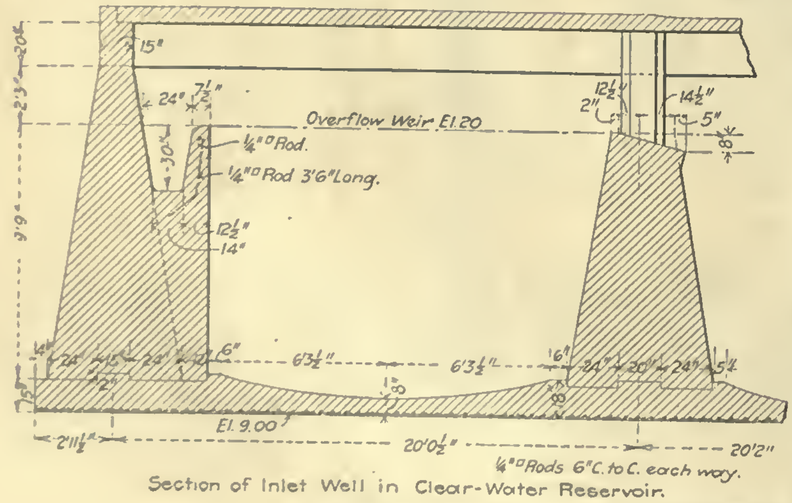
Lower Portal Strut, Clairton Bridge.

At the center and at four intermediate panel points there are upper and intermediate transverse struts from 20 to 30 feet apart with heavy latticing between them, as indicated in the main cross-section. The intermediate latticing is made with I-shaped members formed with two pairs of angles back to back, latticed. These members in one direction are continuous and in the other are cut to clear them and spliced across with large square connection plates on both flanges. The bottom portal struts connecting the end posts have rectangular cross-sections composed of two plate-girders with horizontal webs, which are connected on the outer flange by a 69½-inch cover-plate and on the inner flange by lattice-angles. They are field-riveted to the end posts through the flanges of the latter and through kneebrace plates projecting from both sides of the struts. On one side of the bridge a 6-foot sidewalk is carried by solid web cantilever brackets field-riveted to the vertical posts.

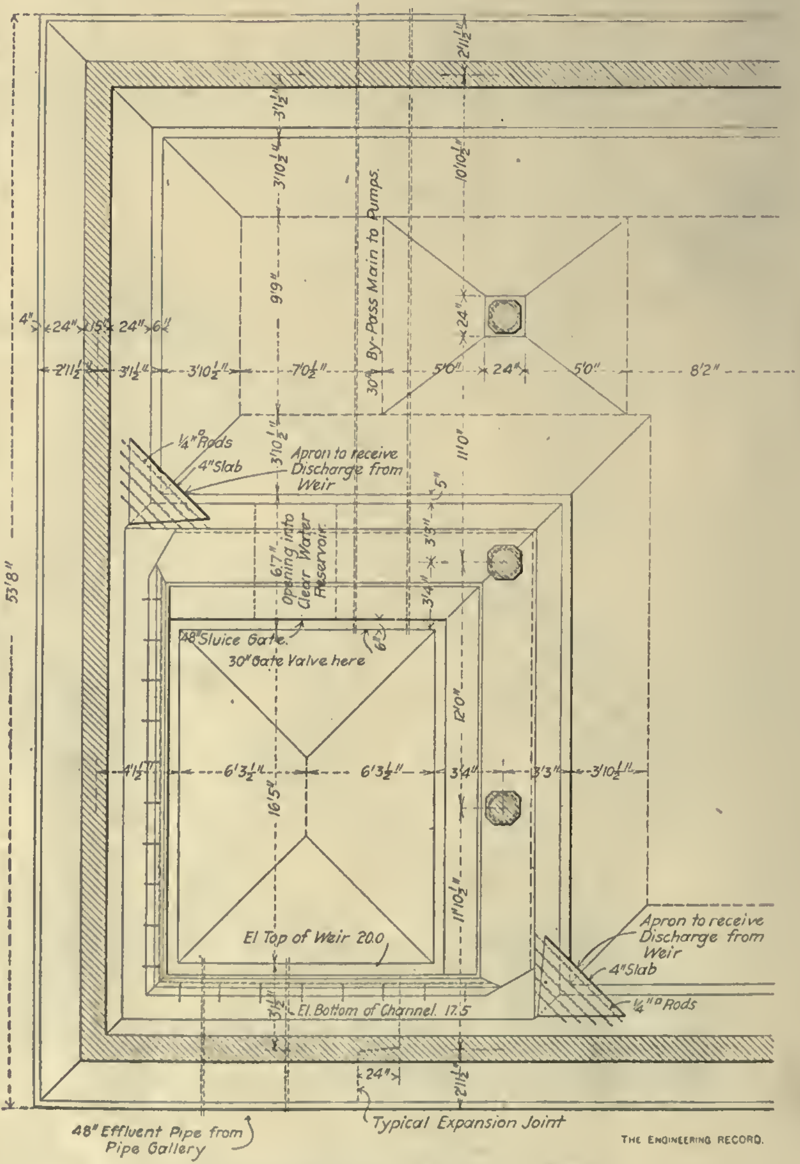
The shop work on this bridge was of the usual character for high grade railroad construction except for the top chords and the 90-foot, 60-ton end posts, which were machined rather differently from the usual custom in the shops where they were made. They were so long and heavy that it was thought too inconvenient and expensive to turn them end for end to mill and bore and the machines were accordingly brought to the work instead of bringing the work to the machines, as is customary. All these machines are driven by independent motors, seated on them or on their beds, and one of the milling machines was lifted by the girder crane and set in position to mill one end of the piece after it had been moved longitudinally from the position in which the other end had been milled by the other machine. The horizontal boring machine was removed from its foundations and set temporarily in an open space where it could bore first one end hole, and then move slowly along until it reached the center and opposite end, and bored all the holes with the piece stationary. The total weight of the structural material, in the channel span, including the sidewalk, is approximately 5,500,000 pounds.

A Concrete-Steel-Construction Filtration Plant for the New Haven Water Company.—II.

Raw water will flow by gravity from Lake Whitney to the filters and through them to the clear-water reservoir, from which the filtered water will be raised about 100 feet to Prospect Hill reservoir, through a 30-inch force main about 2,100 feet long. Not far from the clear-water reservoir are two pumping stations which have been in use for some years. The nearer station is driven by steam power and contains a 10,000,000-gallon Worthington high-duty pump, and, as a reserve, a curious horizontal pumping engine built in 1871 by Mr. Thomas Sault, of New Haven. The other station is situated just below the Whitney dam and is equipped with a single 27-inch horizontal turbine built by the Rodney Hunt Machine Company, of Orange,



Section of Inlet Well in Clear-Water Reservoir.



Plan of Inlet Well in Clear Water Reservoir

NEW HAVEN FILTERS: DETAILS OF INLET WELL IN CLEAR WATER RESERVOIR.

Mass., using surplus water from the dam and driving a 5,000,000-gallon Deane power pump. From the clear-water reservoir filtered water will flow by gravity to the Deane pump, but will have to be drafted 4 to 12 feet by the Worthington pump. The latter now receives its water from the source of supply under a pressure of about 6 feet, and there is an open surge standpipe about 30 feet high on its "suction" pipe. After the filters shall have been put into service, this standpipe will be capped and the air will be exhausted from it by the air pump used for the high-duty attachment on the main pump, so that the present operating conditions for which the pump was designed may be imitated as nearly as possible.

In each filter, just at one side of the middle, there is an inlet chamber 4 feet square and about 4 feet 2 inches deep inside, built against the wall which separates the filter from the operating gallery. Each chamber is fed by a 12-inch branch from the raw-water main, and its three walls, whose tops are at the normal level of the sand surface, each have openings 4 feet wide, 2 feet deep below the sand level and provided with stop plank grooves formed in the concrete. This provides for keeping the level of the first discharge into a filter, when empty, at or near the sand surface as the latter is lowered by scraping. A short flight of concrete steps leads down from the main floor of the operating gallery, at one side of each inlet chamber, to the level of the sand. The normal depth of water above the sand surface when the filter is in operation will be 4 feet.

New Haven Filters: Outlet and Inlet Chambers of Clear Water Reservoir.

The filter sand will be placed in various thicknesses, the minimum thickness being 20 inches and the maximum 44 inches. The sand will be placed in this way so that the filters when first started will go out of commission in proper succession, and the process of refilling a filter with the washed sand from the other filters can be begun as soon as the filtering operations are started. Thus, it will be seen, there will always be one filter in condition to receive sand from any one of the others whenever scraping becomes necessary. The sand will rest on a bed of gravel covering the collectors, having a maximum thickness of 16 inches, composed of five layers as follows: At the bottom 8 to 10 inches of gravel varying from 3 inches to 1 inch in diameter, then 2½ inches of 1-inch to ⅜-inch gravel and 2½ inches of ⅜ to ⅛-inch gravel, and on top of this 1 inch of very coarse sand having an effective size of 1 millimeter.

For the lateral collectors 6-inch octagonal perforated vitrified tile pipes, furnished by the Syracuse Stoneware Company, of Syracuse, N. Y., will be used. These pipes are to be laid with close butt joints; they have taper holes ½ inch in diameter inside and ¾ inch outside, spaced about 2 inches apart. The arrangement of the laterals in each bed is well indicated on one of the drawings printed in the preceding issue. The main collectors are wholly of concrete and are designed to be as low as practicable, the height inside being only 10 inches. To compensate in area the breadth has been increased, and in order to avoid increasing the thickness of the cover slabs, the collector is divided into two channels by a concrete wall 5 inches thick, extending nearly the full length and supporting the slabs at the middle. Each channel is 3 feet wide inside; they have free communication at the outlet end, where the form of the collector is changed, as shown, to connect with a 16-inch pipe leading into the main effluent pipe. Each collector cover is 4 inches thick at the middle and 3 inches at the ends, 7 feet 3 inches long over all, about 3 feet wide and has a 3-inch iron lifting ring at each corner. These covers are reinforced with ¼-inch transverse rods 3 inches apart and seven ⅛-inch longitudinal rods. The main collector is on the longitudinal center line of the bed.

Between the two rows of filters is the structure containing the piping and the apparatus for controlling the operation of the filters. It is about 503 feet long by 20 feet wide inside, and, in a measure, corresponds to the switchboard gallery of a large electric power plant. The lower or basement story is the pipe gallery, almost wholly below the level of the water in the filters. For a width of 13 feet the central part of its reinforced concrete floor is depressed, 3 feet 1 inch at the ends increasing to 3 feet 10 inches at the center, below the remaining portions of the floor on each side, which are continuous with the adjacent filter bottoms. There is thus formed a trough for the main effluent pipe and its connections at a suitable elevation to receive the filtered water from the main collectors in the beds, while the higher parts of the floor, 3½ feet wide on each side, from convenient passageways. The 18-inch vitrified pipe sewer is beneath the lower floor. The raw-water main is directly over the effluent main with its center line at the proper elevation for the 12-inch branches supplying the beds, which are, therefore, straight and level. At the east end of the gallery, where the raw-water main enters, it is 36 inches in diameter, and it is reduced successively to 30, 24 and 20 inches.

Near each end of the gallery the effluent main begins with a diameter of 24 inches, receiving the two 16-inch pipes from a pair of opposite beds. The main increases to 30 and 36 inches, and near the middle of the gallery, contains a three-way Globe special branch from which a 48-inch main leads off and passes beneath bed No. 5 to the clear-water reservoir. The effluent pipe from each bed contains a 16-inch Venturi meter. From each effluent pipe and from each raw-water supply pipe there is an 8-inch connection to the sewer for draining off the water when emptying a bed. Each bed has a vertical bell-mouth overflow, and these are placed in pairs at alternate partition walls so that one 12-inch pipe may serve a pair of adjacent beds; these pipes are run to the sewer, the connections being trapped. The sewer also receives trapped connections from the floor drains, from the lavatory in the operating gallery and from the laboratory. Beyond the west end of the pipe gallery it is 12 inches in diameter and takes surface water from the driveway on that side of the plant and from sub-soil pipes draining springs at the foot of the excavation. It extends beyond the easterly end to a ditch passing the plant and discharging into Mill River, receiving on the way connections from roof drains on that side.

Directly above the raw-water main is a 10-inch refill main extending nearly the length of the gallery and having pairs of 10-inch branches to the 16-inch effluent pipes from the beds. By this arrangement any bed which has been emptied can be refilled from below with the effluent from any other bed which is in commission. Still another main extends the length of the pipe gallery, 2 feet 4 inches above the refill main, namely, the 8-inch high-pressure main, from which a 6-inch branch is taken into each filter to supply water under about 40 pounds pressure through hose connections to the portable sand ejectors. Each of these 6-inch branch pipes is supported about 2½ feet above the water level on a line of columns near the center line of the bed and has three 3-inch valved outlets. The various pipes are provided with the necessary valves for their control. All these valves are either set vertically or have bevel gears, so that their stems can be extended to the floor of the operating gallery above.

The operating gallery floor surface is 1 foot above the water level of the filters and 5 feet below the soffit of the filter roof. This floor is of concrete-steel construction like that of the filter roofs, and on it will be placed the hand wheel stands of the gate valves in the pipe gallery, the registers of the Venturi meters, and the movable sand washing apparatus.

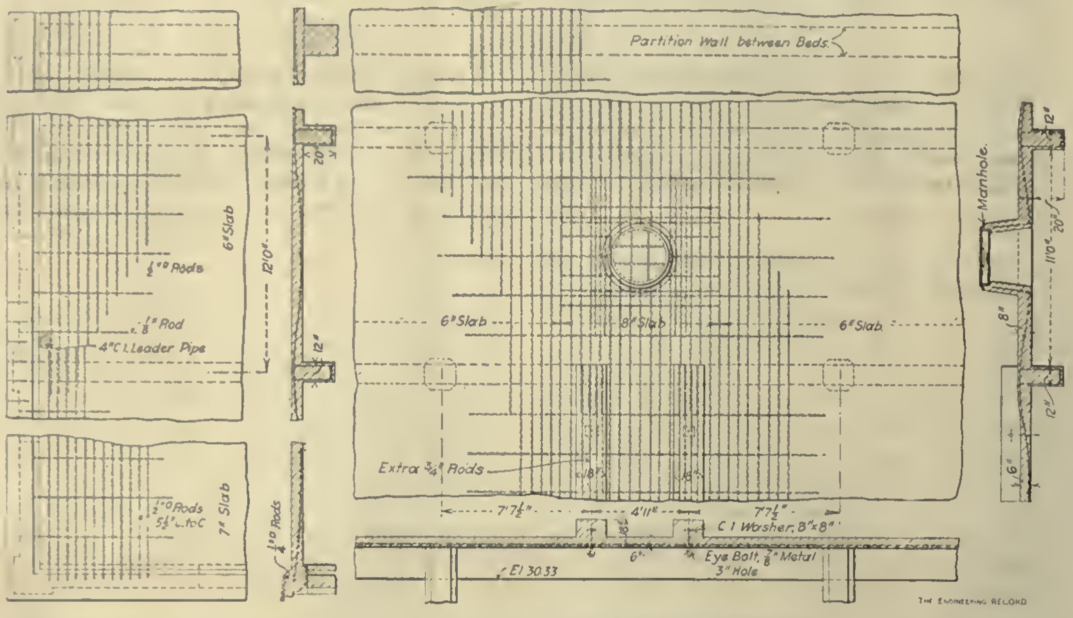
It will be observed that the gate stands are so arranged at the sides of the gallery as to leave a passageway through the middle about 10 feet wide. In each end wall there is a 9-foot double door, through which teams can be driven to bring in sand and other supplies. The walls will be faced inside with white enameled brick. Two stairways lead down from the operating floor to the sidewalks in the pipe gallery, and there are besides eighteen 2x8-foot openings through the floor covered with gratings of ⅜x1¼-inch steel bars 1½ inches apart. At the west end of the gallery a concrete-steel bridge of 19 feet 8 inches span makes possible communication at level between the tops of the two rows of filters, and a similar bridge will give access from the road on the high bank north of the filters to the top of the northerly row of filters. The laboratory will be 48x21 feet inside and will have a double wooden floor. It will be equipped with the apparatus necessary for the chemical and bacterial analyses of water.

The clear-water reservoir, as shown on the general plan, is located opposite and parallel to the ends of filters Nos. 1, 3 and 5 and about 20 feet distant from them. It is 240 feet 6 inches by 45 feet 3 inches inside at the top, and about 13 feet 8 inches high to the under side of the roof. Its capacity is about 800,000 gallons. It is of concrete-steel construction like that of the filters, but, as indicated, the outside walls are more massive. At the southwesterly corner is an inlet chamber into which the 48-inch effluent main from the pipe gallery discharges. A trough 30 inches deep and 2 feet wide at the top is formed in the upper parts of the walls on two sides of the chamber, and the tops of the walls on all four sides, as shown, are at elevation 20, or 6 feet below the normal water level on the filters, thus limiting the head on the filters, since the water will ordinarily enter the clear-water reservoir by overflowing this inlet chamber, spilling into the trough on two sides and directly into the reservoir on the other two. Through a 48-inch circular opening in the wall opposite the inlet pipe, the filtered water can pass directly into the reservoir. A 48-inch circular sluice gate, made by the Coffin Valve Company, of Boston, controls this opening. To put a negative head on the filters, so as to increase the rate of filtration in case of emergency, the 48-inch sluice gate may be opened, thus drawing the water into the reservoir at a lower level. Beside the 48-inch opening there is a 30-inch pipe through this wall, with a Chapman valve in the well. This pipe crosses the reservoir and connects to the pump suction main, thus serving as a by-pass whenever it is desired to disconnect the clear-water reservoir.

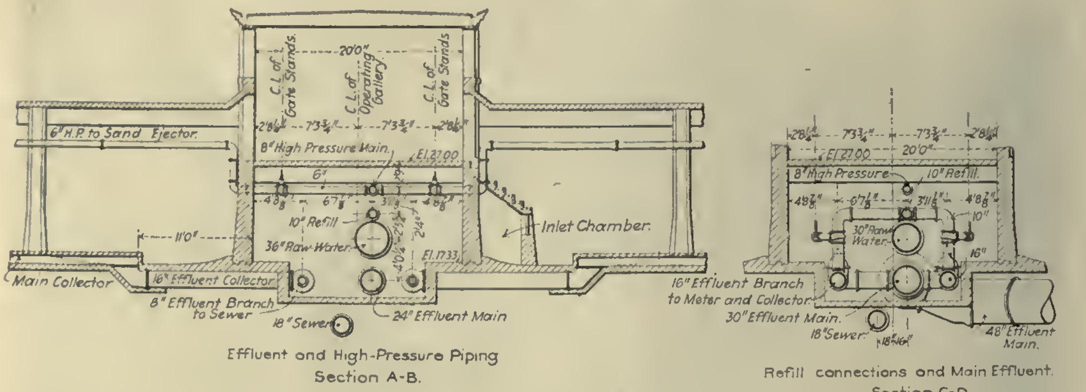
The outlet chamber, near the middle of the northerly wall of the clear-water reservoir, is merely a circular well formed in the floor, 6 feet in diameter and 2 feet 3 inches deep, into which the quarter-bend of the 36-inch suction main is turned down. Just inside the wall there is a 36-inch Chapman valve for shutting off this pipe. After piercing the wall this main continues to an intersection with the main extending, at right angles to it, east and west to the pumping stations. The portion of the inlet chamber containing the valves and the outlet chamber will each be covered by a gatehouse with 8-inch brick walls and a tin roof; the floor of each house is of concrete-steel construction and is raised about 2½ feet above the roof slab over the reservoir. The inlet gatehouse will be 12 feet square outside and the outlet gatehouse 9 feet 4 inches by 12 feet.

The method for washing and handling sand is one of the most novel features of this plant. When scraped from the surface of a bed the dirty sand will be cast into piles and then fed into a portable ejector somewhat similar in general design to those in use in Philadelphia, described and illustrated in this journal October 10, 1903, but differing from them in several details. Instead of being discharged on to a pile in a court after passing through the washer, the clean sand will be run into the bed which needs replenishing. Whenever a filter shall have been scraped so that its sand bed is only 20 inches thick it will be put out of commission and will be held in reserve to receive the washed sand from the other beds as they may be scraped from time to time. The operation of the plant will be so arranged that one bed will always be in condition to receive sand. The sand washer will be portable and will be set in the operating gallery at a convenient place between the filter being scraped and the one receiving the sand. The ejector will discharge into the washer and from the latter the clean sand will be conveyed, by the aid of water, through a hose into a large steel receptacle hung from the eye-bolts in the roof of the filter being replenished. From the bottom of this receptacle the sand can be drawn through any one of three gates, while the water runs away from the top of the receptacle and discharges through a pipe into the sewer in the pipe gallery.

The rate of filtration, it will be seen, is automatically restricted by the height of the overflow of the inlet chamber in the clear-water reservoir to the limit of 3,000,000 gallons per acre per day. Ordinary regulation is based on the indications of the Venturi meter registers and accomplished by hand operation of the gate valves in the effluent pipes. The details of the sand apparatus and of the regulating devices for the filters cannot be published at this time. A fuller description of them must, therefore, be postponed; as also the details of the cost of

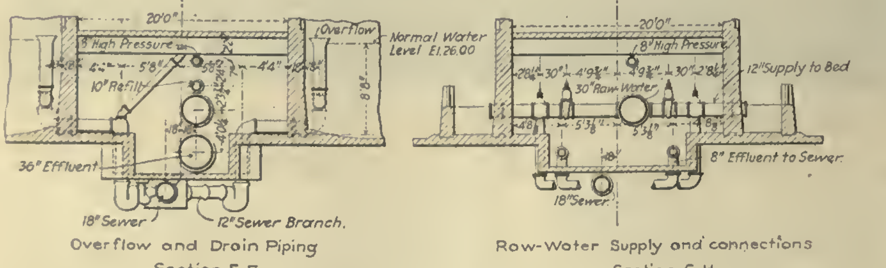


Partial Plan and Cross-Sections of Filter Roof



Effluent and High-Pressure Piping
Section A-B.

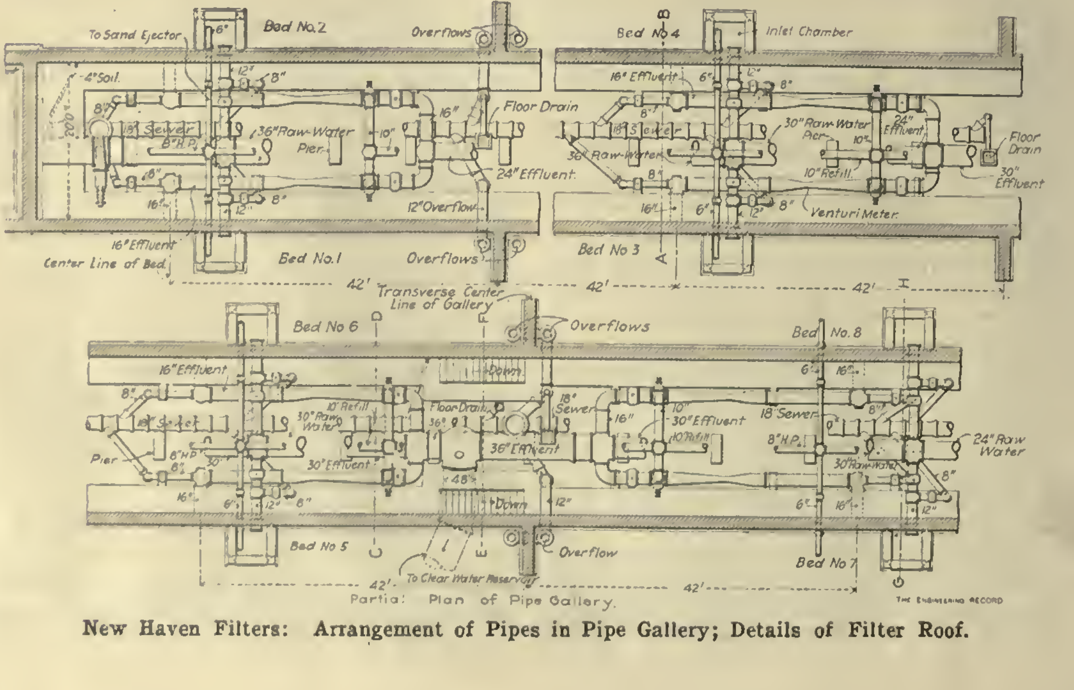
Refill connections and Main Effluent.
Section C-D.



Overflow and Drain Piping
Section E-F

Row-Water Supply and connections
Section G-H

Cross-Sections of Pipe Gallery



Partial Plan of Pipe Gallery.

New Haven Filters: Arrangement of Pipes in Pipe Gallery; Details of Filter Roof.

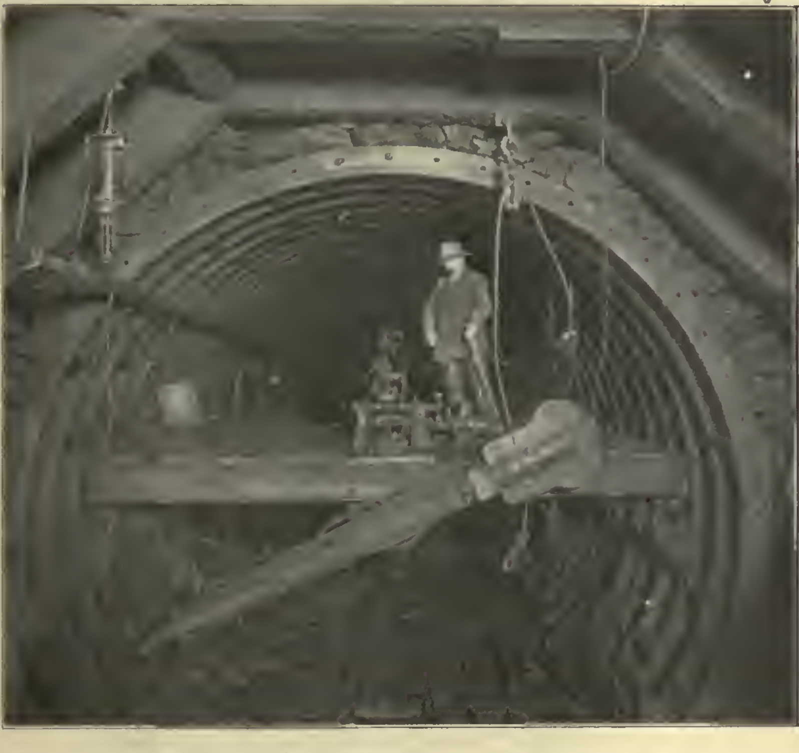
the plant, which cannot be accurately determined until the work is completed.

Each filter bed, when its masonry is completed and before the collectors are put in, is subjected to a leakage test by filling with water. It is specified that if the leakage from any bed or from the clear-water reservoir should exceed 500 gallons in twenty-four hours the source of the leaks must be discovered and the cracks or defective work cut out and properly repaired. The bottoms and walls of five filters and the clear-water reservoir have been built and one filter has been roofed during the past season. It is to be observed that no clay puddle nor any other special means for securing watertightness have been employed, reliance being placed wholly on proper concrete construction. Where the form bolts were built into the walls without the cast-iron sleeve nuts damp spots have appeared on the surfaces when the filter beds were filled with water and a few tiny leaks have been found in other places. No difficulty is anticipated in making all of these absolutely tight.

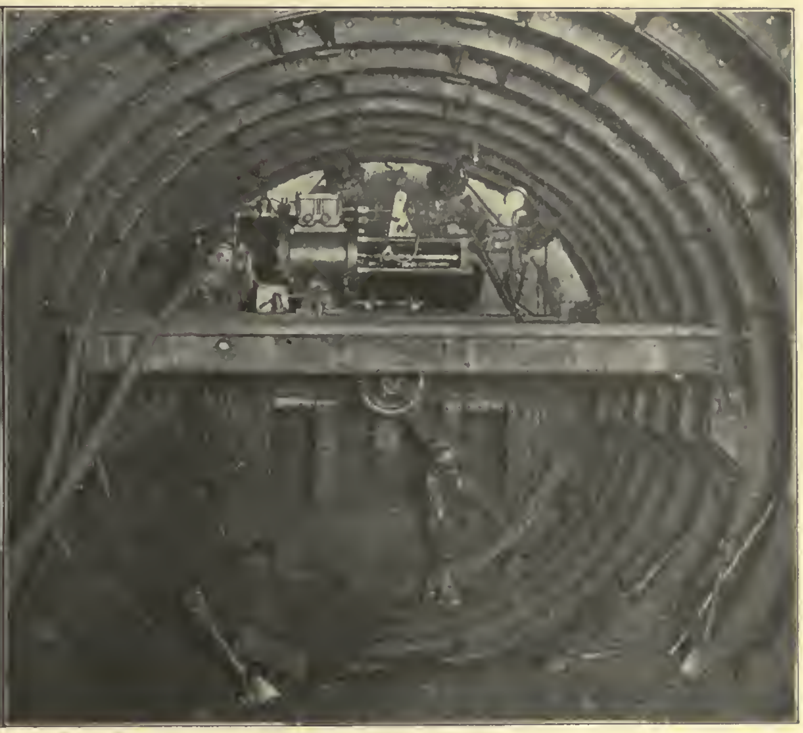
Mr. George W. Fuller, of New York, is the consulting engineer for this plant, and the preliminary studies for the filters were made in his office by Messrs. William B. Fuller and John H. Gregory. Mr. Albert B. Hill, of New Haven, is the chief engineer of the New Haven Water Company, and the detail design and execution of the work is under his direction. Mr. Charles A. Ferry is the resident engineer in charge of construction, and Mr. E. M. T. Ryder elaborated the details and made the contract drawings. All the grading and pipe work has been done by Mr. Edward Dillon, superintendent of the water company, and he has also had charge of the inspecting of the contract work.

Goods Damaged by Fire are usually turned over by insurance companies to salvage concerns, which dry them to render them salable. A special kiln for such a purpose has been designed by the B. F. Sturtevant Company, of Boston, Mass., for use in New York. It has a number of small rooms of different sizes, served by overhead tracks from which are suspended the frames for the water-soaked materials. The mechanical plant consists of a steam-driven fan and heater, with galvanized-iron ducts for distributing the heated air.

The New York and Brooklyn Tunnel for the Rapid Transit Railroad.—II.



Erector, New York Side, Looking Towards Air Lock.

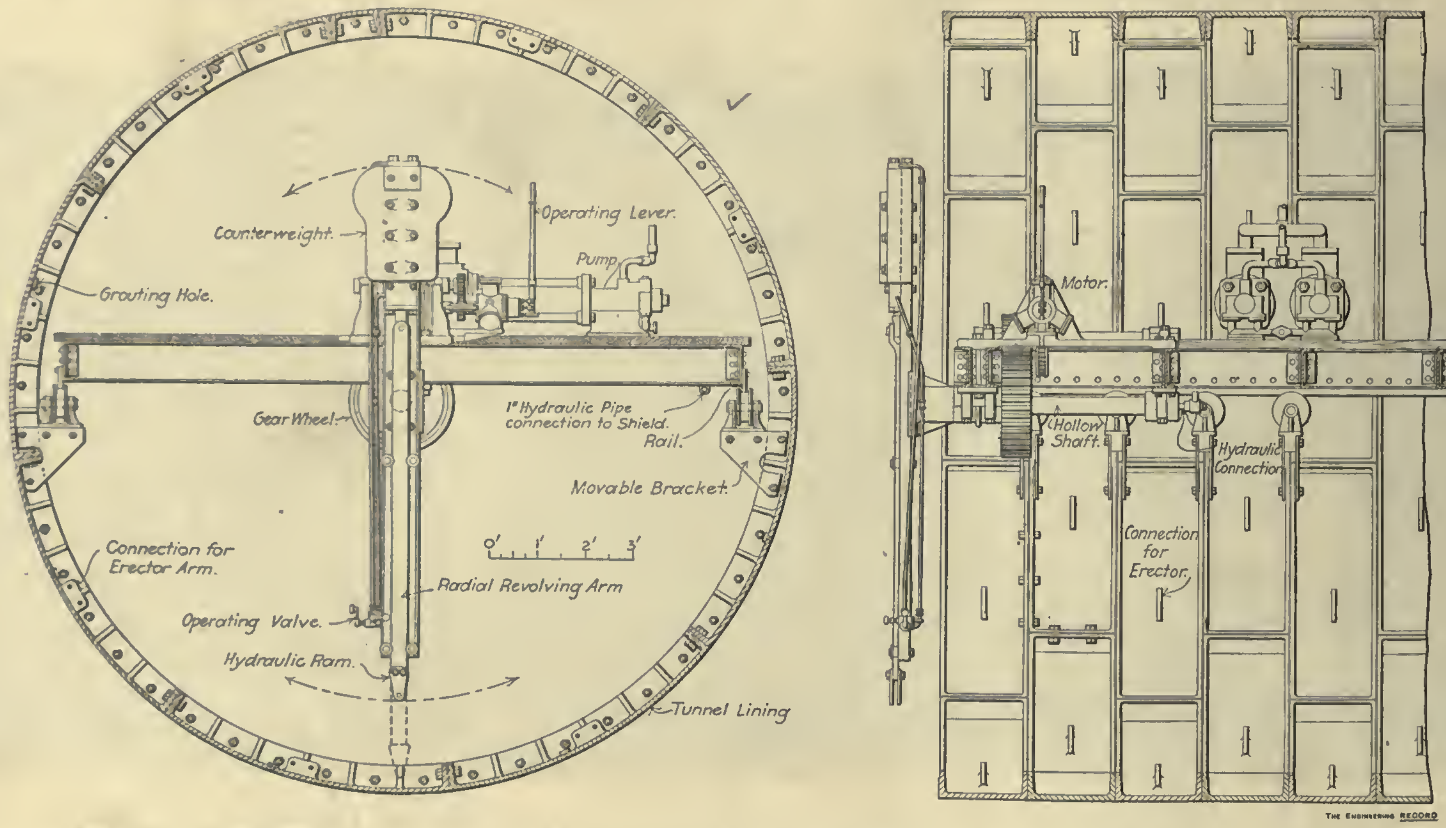


Erector and Rear of Shield, Brooklyn Side.

The four special shields used in the excavation at the Brooklyn end of the tunnel are 16 feet 11¼ inches in diameter and 9½ feet long over all, exclusive of a removable hood about 3½ feet long. The design corresponds in general appearance to cylindrical steel shields used for previous tunnel work, but differs from them in a number of new improvements adopted to surmount the difficulties anticipated. The cylindrical shell of the shield is made double with an outer plate ⅝ inch thick and an inner plate ½ inch thick riveted together. About 5 feet from the forward end of the shield, there is a vertical transverse bulkhead made of a steel plate ⅞ inch thick stiffened by a framework of vertical and horizontal angles. In front of the diaphragm and about 39 inches from it, the shell is stiffened by an annular girder about 22 inches deep. The inner flange of this girder is connected with the diaphragm by a steel cylinder about 14 feet in diameter and concentric with the shell. The annular space between this cylinder and the shell is divided by fourteen radial longitudinal diaphragms, and the spaces between them serve as chambers for the hydraulic jacks. In the plane of each longitudinal diaphragm there are kneebraces connecting the inner cylinder with the transverse diaphragm and connecting the annular girder with the outer shell and the conical plate.

The cutting edge of the shield projects 20 inches beyond the annular girder and is braced to the inner flange of the latter by a ¾-inch conical plate with its bent edges riveted to the shell and to the girder. The rear end of the shield projects about 4½ feet beyond the diaphragm and this portion of it serves as a tailpiece engaging the permanent iron shell of the tunnel, which has a clearance of 1 inch reduced by the thickness of a 7x¾-inch flat riveted to the inner side of the shell around the upper third of its circumference at the rear end to serve as a sort of packing piece. Just above the center of the shield, there is a horizontal platform reaching from the diaphragm to the cutting edge. It is made of ¾-inch plates supported on 15-inch channels, serves as a working floor for the excavators and is accessible through a door in the diaphragm about 4½ feet high and 4 feet wide. A corresponding door symmetrically placed just below the working platform gives access to the cutting edge in the lower part of the shield and both together may be considered as a single opening crossed by the working platform. Each of these two doors is closed by a pair of steel-plate shutters sliding in horizontal top and bottom guides attached to the diaphragm. When open, they are close to the diaphragm on either side of the shield; when closed, they meet on the center vertical line of the shield. They are operated by hydraulic cylinders commanded both by the men in the shield and from a point outside the air lock so that in case of accident or emergency they can be closed after the tunnel is abandoned. The shutters are made of solid plates ⅞ inch thick reinforced by pairs of vertical Z-bars extending from top to bottom to resist heavy horizontal pressure. The lower edges run in grooves 1⅛ inches wide between bearing strips on the diaphragm and the horizontal flanges of 9-inch deck beams which are riveted across the bulkhead diaphragm to resist flexure. The opposite face of the diaphragm is stiffened by pairs of vertical 6x3½-inch angles. A semi-circular removable hood about 3½ feet long is provided which can be bolted to the upper part of the shield so as to project still further into the soft earth and afford additional protection for miners working on the face. It is built like the shell of the shield of an outer ½-inch plate and an inner ⅞-inch plate reinforced by a flange angle on the cutting edge of the shield. It is also stiffened by five inclined shores from the outer edge to the front part of the elevated working platform.

The working platform also has a removable forward extension of about 3½ feet, which is supported similarly by inclined shores. Both the upper and lower sets of shores are provided with connections for transverse horizontal beams on which poling boards can be driven in the face to subdivide it into five vertical sections, thus, in very bad ground, aiding to keep the excavation under better control, and, with a flat angle of slope, limiting the flow of soft material to short distances. The shield is equipped with fourteen hydraulic jacks set equidistantly around the outer rear edge and having pistons 8 inches in diameter with a 30-inch stroke. They were made by the Watson-Stillman Company, New York, and are operated under a maximum pressure of 6,000 pounds, which gives a total pressure of about 4,222,000 pounds available to advance the shield. The jacks engage the annular girder and react against the last ring of the assembled tunnel shell. They are supplied with hydraulic pressure furnished by a Watson-Stillman pump carried on the platform of the erector and operated by pneumatic pressure brought from the power plant on the surface to drive the tunnel machinery. The shield and fittings complete weigh 102,720 pounds. It requires nine men to operate each shield and excavate for it, and when all is in readiness it can be advanced 22 inches, the width of one ring of the tunnel shell, in 60 minutes. The best progress made by either of the four shields which have been installed is 4 feet in one eight-hour shift. The principal features of the shield which are considered novel by its designer are: the removable hood and platform, the inclined shores, beams and poling boards to support the working face, the absence of vertical protection in front of the working platform, the single opening in the center of the bulkhead, and the operation of the sliding doors and their control from outside the air lock, for all of which patents have been applied for.



New York and Brooklyn Tunnel: Transverse and Longitudinal Sections Showing Cast-Iron Shell and Erector, with Platform.

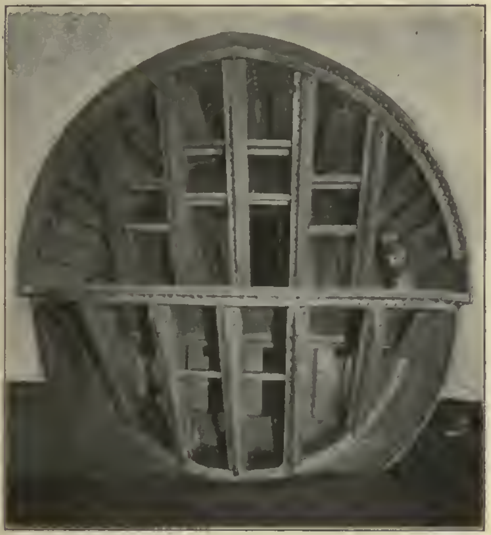
The shields are each followed closely by an erector which assembles the segments of the tunnel shell and is of simple construction designed to be easily operated and to avoid obstructing the tunnel or interfering with the operation of the shield or the handling of spoil. It consists essentially of a traveling platform provided with an extensible radial arm pivoted in the tunnel axis and revolving at right angles to it. The platform is about 14½ feet wide and 10½ feet long with a framework of 10-inch channels. At each side a horizontal flat bar projects down so that its lower edge serves as a rail engaging four double flange rollers in bracket pedestals bolted to the tunnel lining. This arrangement permits the rollers to be moved from rear to front as the erector advances and successive rings of the tunnel shell are added, and provides for the support of the platform without jacking it up as would be necessary if the rails were fixed and the rollers attached to the platform.

The radial arm has a 4x1-inch extension bar moving between guide rollers and fitted with jaws at the outer end which engage the erection lugs on the shell segments. At the opposite end it is connected to the 3-inch rod of an hydraulic piston 4¼ inches in diameter with a 24-inch stroke. The arm is mounted on a horizontal main shaft in the axis of the tunnel, which is driven with gear and pinion by an Ingersoll-Sergeant three-cylinder air motor on the platform. The end of the radial arm is connected to a shell segment on a car in the tunnel and the arm is then revolved by a man on the platform until the segment is in the required angular position, when the hydraulic piston is operated to extend the arm and carry the segment out to its place in the ring.

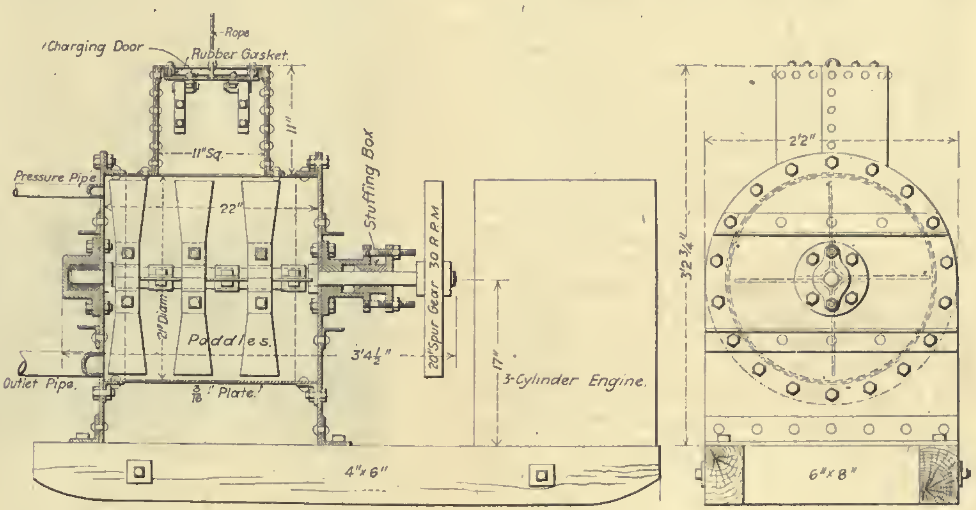
Water under pressure is delivered through the hollow main shaft to both ends of the cylinder, and as the piston is twice as large as the rod the pressure on the outer end of the cylinder is great enough to force out the segment and when it is released the constant pressure at the opposite end of the cylinder returns the piston to position for another segment. The waste water is discharged into the heading and thus only one connection is required and simplicity of operation is secured. A 1,000-pound pressure is used and the cylinder is operated from the extremity of the arm by the man who assembles the ring segments. Pressure is furnished by the pump which also operates the shield jacks and is driven by air at a pressure of 100 pounds. The erector and machinery weighs about 3 tons and requires a total force of four men to handle it and erect the lining segments. The short end of the erector arm is counterweighted so that with the cylinder it about half counterbalances the weight of the long end and a 900-pound segment of the tunnel shell. Applications for patents on this erector have also been made.

The erector is followed, as described in the previous article, by a grouting party which injects 1:1 Portland cement grout under pressure through holes left in each segment of the lining and closed by screw plugs. In each heading the grout is mixed by power in a closed steel box to which pressure can be admitted to force it through the shell against the exterior hydrostatic pressure to fill the interstices in the dry stone packing and thus form concrete filling in the space between the shell and the rock on the New York side and forming an enclosing sleeve several inches thick in the sand on the Brooklyn side. The grout machine used on the Brooklyn side has the dimensions shown in the accompanying engraving, but on the New York side is made 3 feet long instead of 22 inches. A shaft through the axis of the horizontal cylinder is driven through spur and pinion gears by an Ingersoll-Sergeant three-cylinder air engine. This shaft makes about 30 revolutions per minute and carries six double paddles which thoroughly mix the ingredients. On the upper side of the cylinder there is a small hopper with a flap door opening downwards. Three bags of Giant Portland cement and three bags of crusher dust are emptied into the hopper from the working platform above. A sufficient quantity of water is admitted and the hopper door is pulled up to set against the upper gasket. The shaft is revolved to mix the grout for about three minutes and then air pressure of 90 pounds is admitted to the cylinder and forces the grout through a 2-inch outlet in the bottom and a flexible hose connected with the 1¼-inch hole in the tunnel shell. The contents of the mixer are usually discharged in about 1½ minutes. A batch can be measured, mixed and injected, and the machine made ready for another in five minutes. Two hundred bags of cement were thus used in a single-eight-hour shift by one gang which also has to move the machine, arrange the scaffolds and calk the joints. The hose generally used is 30 feet long, but it is sometimes extended; the machine is moved at least every 100 feet. Every plug in every plate is tried, but it is not always necessary to connect the hose to each one. The machine and its motor are mounted on a solid wooden platform with rounded ends which is easily skidded along on the tunnel floor, and when in service is lifted up to a position just under the tunnel platform, close to the tunnel wall, where it affords little obstruction to the passageway. The working platform is made of loose planks laid across 4-inch horizontal pipes about 16 feet long which rest on the center flanges of the shell segments.

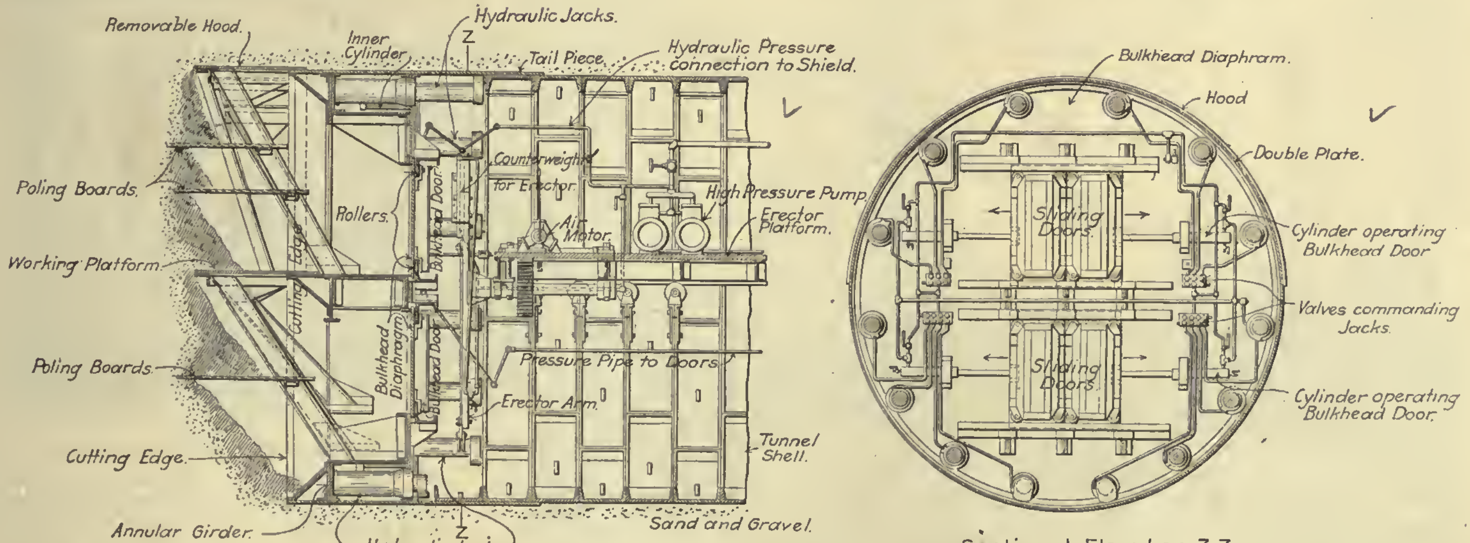
The shields and erectors were built by Alexander Miller & Brother, of Jersey City, and the grout machines were built by the Cockburn Barrow & Machine Company, Jersey City, all having been designed by Mr. Walton I. Aims, chief engineer of the New York Tunnel Company, which is the sub-contractor for the tunnel.



REMOVABLE HOOD AND PLATFORM.



GROUT MIXING AND INJECTING MACHINE.



Longitudinal Center Section.

Sectional Elevation Z-Z showing Fittings on Bulkhead Diaphragm

Front of Shield, Grout Machine and Sections in Heading, Showing Tunnel Shell, Erector and Shield, with Hood and Poling Boards in Position.

Report of the Northern New Jersey Flood Commission.

The Northern New Jersey Flood Commission, appointed by the governor of New Jersey, to investigate the causes of disastrous floods in the river basins of the State, and to recommend measures for their control, has presented its report to the Legislature. The Commission has confined its attention mainly to the territory drained by Passaic River, where the most serious damage was wrought by the floods of 1902 and 1903. The recommendations are, in brief, that the substantial control of the river be effected by the construction of a dam at Mountain View, where by closing the sluice gates when indications point to a flood, the entire flow of Pompton River can be impounded until the waters from the other tributaries shall have subsided. About half of the total area drained by Passaic River, above Little Falls, is tributary to the Pompton River and is of a hilly, rocky, and "quick spilling" character, while the southern branch of the stream is flanked by broad swamps and meadows which serve as natural reservoirs and greatly retard abnormal flows in the river. By thus intercepting and retaining for a time the more rapid outflow from the hill country, it has been ascertained that, in such an unprecedented storm as occurred in October of last year, the maximum flow of the river through the cities of Paterson and Passaic, would be reduced from the devastating volume of 37,300 cubic feet per second, to the practically harmless quantity of 14,000 cubic feet per second.

It is further recommended by the Commission that the State acquire title to the lands of Pompton Plains, which are to be subjected to this periodical inundation, and that the works be designed with a view not only to the prevention of floods in the lower river, but also for the purpose of conserving the water resources of this district. To effect the latter purpose, the Commission advises that the dam shall ultimately be constructed to such a height as will give a maximum depth of water in the reservoir of 60 feet, flooding 17 square miles of land, and impounding 15,000,000,000 cubic feet of water. Nearly half of this immense storage capacity would be held in reserve for floods, while the balance would develop a yield from the tributary watershed amounting to 229,000,000 gallons daily for municipal water supply or for sustaining the draft for power purposes at the numerous mills below.

The cost of the proposed works for effecting flood control only, is estimated at $3,340,000, while the completed project is placed at $5,260,000. As the losses occasioned by the single flood of October, 1903, are said to have aggregated the sum of $7,000,000, it would appear from the report that an investment of half this amount would assure permanent immunity from such havoc. The report of the Commission will be printed as a State document. The members of the Commission are Franklin Van Winkle, of Paterson, president; Richard Morrell, of Passaic, treasurer; John M. Bell, of Rutherford; Marshall O. Leighton, of Montclair, and Morris R. Sherrerd, of Newark. Mr. Walter H. Sears is resident engineer and Mr. William L. Dill, secretary. The peculiar stream conditions of the portion of New Jersey which would be benefited by the construction of the works recommended in the report of the Commission were briefly outlined in an editorial in The Engineering Record of October 17, 1903.

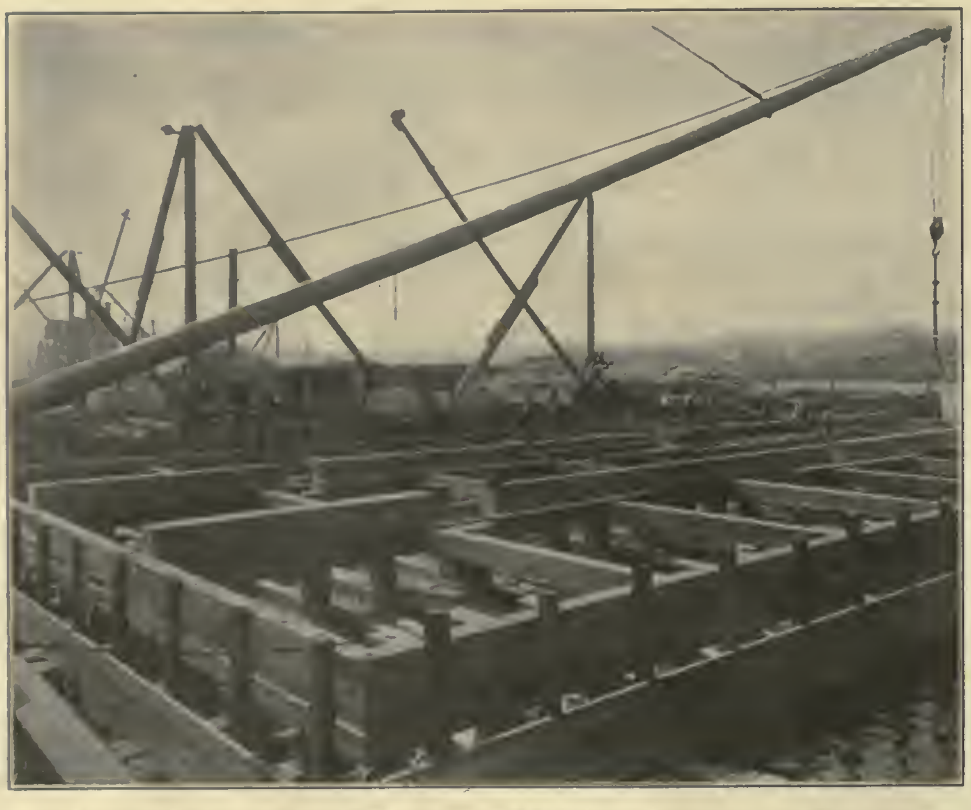
THE TECHNOLEXICON, the English-French-German technical dictionary which the Society of German Engineers has had under preparation for several years, is now so well advanced that the editor, Dr. Hubert Jansen, states that all outside contributions which are not received by Easter of this year will probably prove too late to be of service. He has asked The Engineering Record to request American contributors to this important work to send him their lists of words and definitions at once. It is reported 363 technical societies have helped in the compilation of material and over 2,500 firms and individuals have promised assistance. Over 1,920,000 word-cards have already been prepared and it is believed that several hundred thousand more will be added before the middle of 1906, when the work will go to press.

Tower Foundations of the Manhattan Bridge across the East River, New York City.

The Manhattan bridge from New York to Brooklyn, officially known as bridge No. 3, occupies a site between the old Brooklyn bridge and the new Williamsburg bridge, which are respectively designated as No. 1 and No. 2. It will be a double-deck structure about 120 feet wide, 9,330 feet long and will have 135 feet clearance above high water at the middle of the 1,470-foot suspended span. Bids for the Brooklyn tower foundation were opened March 11, 1901. These foundations have now been completed and those for the New York tower are well advanced. The towers are to be of steel 330 feet high and for each there is a single masonry pier about 68 feet wide and 134 feet long on top at a height of about 23 feet above mean high tide. The piers are faced with granite masonry backed with limestone and concrete, and are seated on concrete footings about 33 feet below high water level. The footings and the lower parts of the piers have been built with pneumatic caissons and coffer dams, which are substantially alike on both sides of the river, but vary slightly in height and in minor details of construction, as described in The Engineering Record March 2, 1901, and November 29, 1902. The New York caisson is 78 feet wide, 144 feet long and 47½ feet high. It has a working chamber about 7 feet high divided into three parts by two longitudinal bulkheads 2½ feet thick, built of solid timber. The deck 2 feet 9 inches thick is stiffened by these bulkheads and in the upper part of the caisson by the interior bracing of horizontal timbers 2 feet apart vertically on centers, reaching from wall to wall in the planes of the bulkheads and connected together by diagonal strips thoroughly spiked to them from top to bottom. The timbers are also secured to the bulkheads by long vertical bolts, so that the whole construction is substantially equivalent to deep lattice-girders with lower chords 7 feet deep formed by the bulkheads. There are also transverse timber struts connected by diagonal vertical braces so as to give great rigidity to the caisson in every direction. The concrete filling of the caisson is thus supported by the roof and by the horizontal timbers, interlocking with them in such a way as to thoroughly distribute its weight throughout the whole pier and make any concentration of it or definite assumption of specific loading impossible. The caisson is built chiefly of 12x12-inch and 3x12-inch timbers and corresponds in most respects to the drawings of the Brooklyn caisson published in previous articles. The principal differences are that the arrangement of the cross braces has been varied so that their intersections form pockets about 10 feet square in the clear instead of 6 feet on centers as was originally designed, thus affording clearance for lowering the buckets and placing the concrete. The cutting edge was modified by the addition of a 6x8x1-inch angle with the vertical flange downwards in the plane of the outer surface of the caisson. This flange was countersunk-riveted to the 22x½-inch vertical plate on the lower edge of the wall and the upper flange was riveted to a 20x⅜-inch horizontal bent-plate protecting the lower timber of the caisson walls. This gave a much sharper cutting edge than was afforded by the 11-inch horizontal face of the oak sill originally designed, and proved very satisfactory in cutting through old cribwork and riprap, which it pierced without becoming bent.

Above the caisson there was a coffer dam 50 feet high whose walls were made with solid courses of one thickness of timber, spiked together and bolted to vertical timbers. At the joint between the caisson and the coffer dam the horizontal courses were not spiked together, but the vertical timbers were continuous across them to form solid splices. Flanges will be bolted to the verticals just below the top of the caisson and engage vertical screw-ended rods attached to the top of the coffer dam. After the masonry has been constructed the verticals will be sawed through horizontally in the plane of the joint between the caisson and the coffer dam. This will leave the two attached by means of the vertical rods only, and when these rods are unscrewed from the top, the coffer dam will be free to float up and be removed.

Sheathing Lower Part of New York Caisson before Removing Float.


Lower Courses of Brooklyn Caisson, Showing Walls and Bottom of Floating Platform.

The New York caisson was not built on shore and launched from ways as was the case with those for the Williamsburg bridge, but was built on a temporary float moored between two docks at One Hundred and Forty-ninth Street and Harlem River, several miles from the bridge site. The float was practically a false bottom about 150 feet long and 84 feet wide, which, with vertical sides 5 or 6 feet high, was built of 3-inch planks bolted to vertical and horizontal timbers and thoroughly calked. It was built in two halves connected by a longitudinal joint through the center line. On its floor there were long distributing timbers on which blocking was set to receive the cutting edge and bulkheads of the caisson, which was thus accessible from below and was easily and rapidly built with derricks on the docks on both sides of the caisson. As the weight of the caisson and the submergence of the float increased, the sides of the latter were built up as required to a total height of about 8 feet.

When the walls of the caisson had been carried up to as great a height as could be conveniently served by the adjacent derricks, the joint between the two sections of the float was unlocked; sand was dumped through the shafts on to the floor of the float or pontoon, tending to separate it from the cutting edge of the caisson, and tugs attached to the opposite sides of it pulled them apart until, with the help of long levers operated with tackles on the top of the caisson, the two portions were removed from under the caisson and the latter was left floating in the water supported by its own buoyancy. The derricks were thus enabled to complete the caisson, and since the air shafts were built in place as the work progressed, the water rose in these shafts to the level of the water outside. The completed caisson, weighing about 3,400 tons, drew only 13.6 feet of water. It contained about 130,000 cubic feet of timber and 170 tons of iron. Five tugs towed it from One Hundred and Forty-ninth Street to the site. They started with the tide against them, but on the second day the tide was so strong in their favor that they were swept by the site before they could arrest their progress, and had to wait until the next turn of tide to bring the caisson back to the required position.

The site is at Pike Slip, between piers 31 and 32. Here piles had been driven for temporary piers on each side of the foundations between the permanent piers, and after the caisson had been towed to place, additional piles were driven to complete these piers and enclose the caisson on opposite sides. It was thus thoroughly protected from the strong tides and the river current and was moored by long ropes at each corner arranged so as to allow it to rise and fall about 4½ feet with the tide without permitting much lateral displacement. An excavation had been dredged to a depth of about 40 feet and in it the caisson was sunk by over 5,000 cubic yards of concrete. The caisson was kept only approximately in position until it was nearly landed on the bottom, when the load was adjusted so that it could be sunk to bearing at a single ebb tide. It was then adjusted to accurate position in both directions by tackles on the mooring lines, and the concrete was added so rapidly that it became immovable as soon as it was settled in position.

Laying the Coping of the Brooklyn Pier, Manhattan Bridge.

One of the temporary piers was provided with a large boom derrick on each of its four corners. Two of these derricks commanded half of the caisson and the other two commanded sand, stone and cement boats moored alongside the pier and delivered their contents to the concrete mixer. A small car operated by an endless cable delivered the buckets of concrete to the two derricks, which either deposited the concrete in the caisson or delivered it to a pair of derricks on the opposite temporary pier, which commanded the other half of the caisson. Six derricks thus sufficed for all the works. The concrete pier was connected to the shore by a pile trestle bridge about 200 feet long, on which were carried the compressed air and water pipes.

At the shore end of the bridge was located the men's quarters and the compressor house in which were installed the boilers and one battery of compressors. A barge was moored alongside the compressor house and on it was installed an auxiliary battery of compressors. Between the barge and the shore there was space for the coal and ash barges. This arrangement provided an abundance of power so that the compressors, although ordinarily all in service, were run much below their capacity. In case of emergency either battery of compressors would have maintained the service alone until the others could be repaired. Air was delivered from the compressors through one 4-inch and two 5-inch mains, which branched so as to discharge into the working chamber through one 5-inch and three 4-inch pipes terminating in short horizontal sections with swinging iron flap valves. The work was done in cold weather so that the temperature of the air in the chamber did not rise above 60 or 70 degrees, although the pressure reached a maximum of 44 pounds above atmospheric and no artificial means were employed to cool it.

The excavation confirmed the indications of the test borings, which located the rock from 100 to 129 feet below mean high water. The cutting edge was sunk to a depth of 92 feet below mean high water and rested on a satisfactory dense stratum of sand and gravel. The caisson passed through about 7 feet of cribwork and riprap of an old pier. Below that it penetrated coarse sand and fine gravel containing very few boulders, some of which at the lower depths were not removed but were undermined and allowed to descend with the excavation. The caisson excavation amounted to nearly 22,000 cubic yards in all, equivalent to 416 yards per linear foot. The material was nearly all removed by the wet blow-out process using a water jet at 100 pounds pressure, nearly 60 pounds above maximum caisson pressure. There were seven 4 and 5-inch vertical blow-out pipes terminating above the water's edge with short U-shaped return bends. These were made of cast-iron and although reinforced to a thickness of 2 inches or more were so badly cut by the sand that in some cases they required renewal before the work was finished. The riprap, cribbing, etc., from the old pier encountered in the course of the excavation, as well as most of the boulders, were removed by means of excavating locks of the Moran-Barr type. This part of the work was done principally at night when the derricks were not otherwise engaged.

The most rapid caisson sinking was 7 feet in a week of six working days of 24 hours each, with a working force of about 25 men at one time. The maximum pressure was 44 pounds, and, although great care was exercised in the selection and supervision of the men, there were several cases of the "bends" and four deaths from paralysis. The pressure under which the men worked varied from 20 pounds at the start to 44 at the finish, as above stated, and the hours per day which the men worked varied from 8 to 3 as the pressure increased. This time was divided into two equal shifts with an interval between, which at the finish was 4½ hours.

The caisson contains about 2,300 cubic yards of concrete, which was mixed in a Haines gravity mixer and was delivered to the working chamber through three special concrete locks designed for rapid operation. They were steel cylinders 36 inches in diameter and 8 feet long with the ordinary hinged doors opening downwards at the upper and lower ends. Above the lower door there was an interior conical lining which guided the contents of the lock to the orifice in the diaphragm and prevented any material from lodging on the sides. To the lower door was attached a steel rope passing upwards through the lock and the upper diaphragm just clear of the upper door. This line was made fast to the lower block of a hand tackle by which it was operated. When the upper door was open, the lower door was held closed by the unbalanced air pressure in the caisson. This was sufficient to hold it up against its own weight, and against the weight of 1 yard of concrete which was dumped from the bucket into the lock. The upper door of the lock was then closed and air was admitted from the caisson to the lock so as to quickly equalize the pressure in the latter. As soon as this was accomplished, the lower door automatically opened and allowed the concrete to descend to the foot of the shaft. As soon as the lock was emptied, the attendant outside pulled up the lower door to its closed position and released the pressure in the lock. The upper door was then opened and the lock was ready to receive another bucket of concrete, the complete operation taking only a minimum time of about one minute.

Three of these special locks were shifted as required to the eight material shafts and were sufficient for an abundant supply of concrete. The concreting was done by four 40-men shifts of 3 hours each, making 12 hours of work daily. The concrete was thoroughly rammed, but was not grouted. After concreting was commenced, the 4-inch water supply pipe was used as a ventilation pipe and by keeping its valve partly open at times, the air was kept very pure and conditions were more comfortable than is often the case in concreting deep caissons. As the caisson descended, the upper portion was filled solid with concrete well rammed around the cross timbers, and the pier masonry was commenced on it at the foot of the coffer dam. The stones and concrete were lowered between the braces and as the courses were built up, the lower tiers of braces were successively cut away to clear it and the sides of the coffer dam were wedged against the masonry.

The construction of the New York caisson was commenced in January, 1903. It was moored in position July 28, concreting was commenced August 11, the caisson was landed on the bottom August 31, air pressure was admitted September 18, 1903, and concreting was finished in the working chamber January 29, 1904. About 350 men were the maximum force.

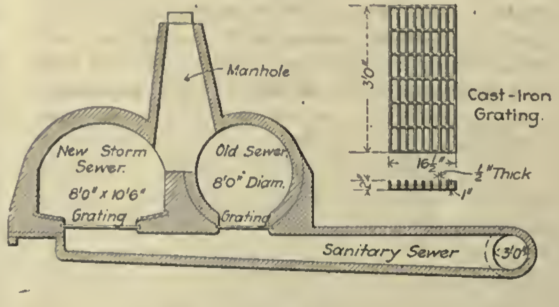
The methods of building and sinking the Brooklyn caisson corresponded to those used for the New York caisson and it was sunk through sand and gravel to a depth of about 92 feet below mean high water involving a maximum pressure of 47 pounds. There were three deaths among the men employed in this caisson. It was towed to place March 17, 1902 and the work on it was completed in December, 1902, after which the machinery and plant was removed to the Manhattan side of the river for use on the New York pier. The contract price for the Brooklyn foundation was about $470,000, and that for the New York foundation, about $485,000, including the extra amount paid for unit quantities below a level of minus 79.15.

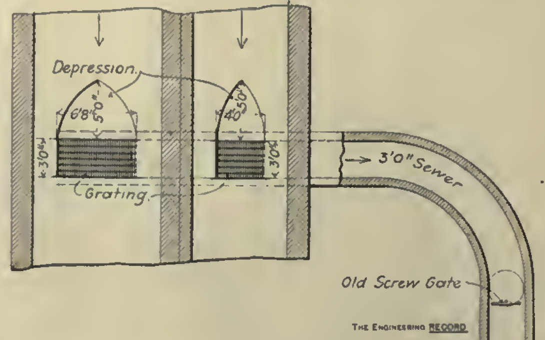
The designs for these piers and caissons were prepared by the Department of Bridges of Greater New York, John L. Shea, commissioner; Mr. S. R. Probasco, chief engineer and Mr. R. S. Buck, chief engineer in charge. Since then several changes have been made in the department, and the work was continued under the direction of Mr. Gustav Lindenthal, commissioner, and Mr. H. A. La Chicotte, engineer in charge, and is now under control of Mr. George E. Best, commissioner; Mr. O. F. Nichols, chief engineer; Mr. R. S. Buck, consulting engineer; and Mr. H. A. La Chicotte, engineer in charge. Mr. J. A. Knighton is the resident engineer of the New York foundation, and Mr. F. M. Sylvester was the resident engineer of the Brooklyn foundation. Both foundations were built by Mr. John C. Rodgers, contractor; Mr. Walter Ritner, superintendent.

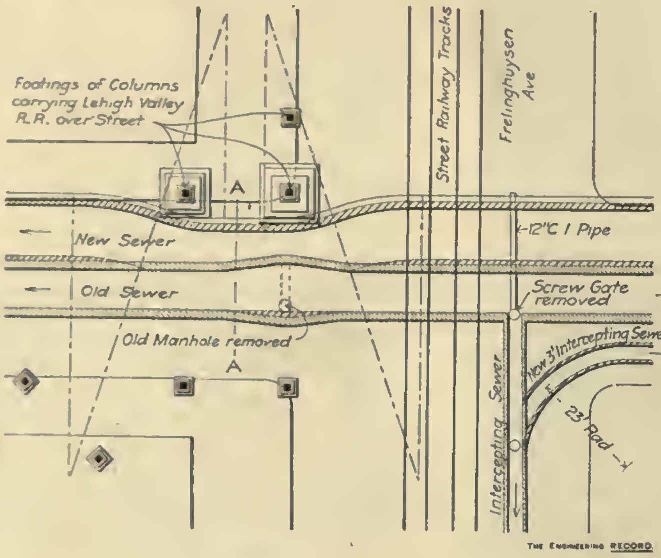
A Large Concrete and Brick Storm Sewer in Newark, N. J.

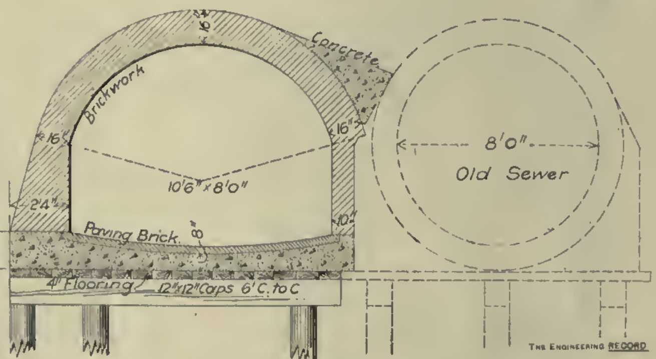
For some years past a low-lying territory in the southerly part of Newark, N. J., has been subject to more or less serious flooding with each occurrence of an unusually heavy rain and with every freshet. A storm-water sewer serving this district was frequently surcharged, and in August, 1903, during a heavy rainstorm, it was put under such pressure that a portion of it was burst. The cast-iron covers of the manholes were hurled several yards from their former places and even masses of the brick arch were thrown a number of feet to one side. The upper part of the sewer was destroyed, and the surrounding earth was washed away down to the rock, for a distance of several hundred feet. Temporary repairs were made by building rubble masonry side walls, but these were badly damaged by the great storm of October 8 and 9, which left this portion of the sewer in the condition shown in an accompanying view. This 5x7½-foot egg-shaped sewer was built in 1872 with 8-inch brick walls and arch. The invert was in rock excavation, at the place where the break occurred, but the upper part of the trench had been excavated through gravelly clay. There were 2 to 3 feet of earth over the arch.

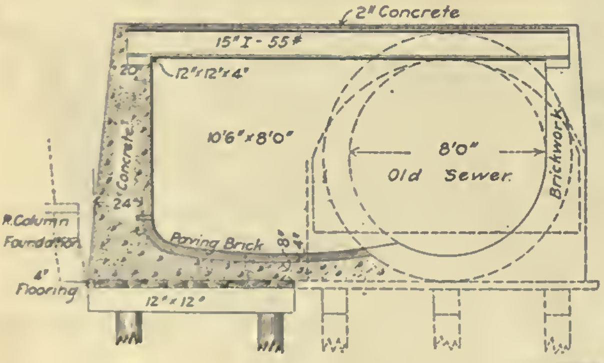
In order to provide additional capacity for the removal of storm water, it was decided to build a large new sewer paralleling the old one. Like the old sewer, the new is to discharge into Peddie ditch, 30 feet east of the Pennsylvania Railroad, in the marshes beyond the built-up portion of the city, through which the water runs directly to Newark Bay. Besides the storm water from about 1,600 acres in the southwesterly part of the city, these sewers will receive considerable quantities of sanitary sewage. A 3-foot intercepting sewer is being built to remove this sewage, or at least the dry weather flow, up to a rate of about 14,000,000 gallons per day, and convey it into the existing trunk intercepting sewer, which discharges, by the aid of a pumping station, directly to the bay at the southern boundary of the city. The present dry weather flow is about 7,500,000 gallons per day. The quantity intercepted will be governed in part by the areas of the openings of the gratings in the bottoms of the large sewers at the point of interception and in part by a screw gate in the intercepting sewer, which may be shut tightly if desired, thus preventing any flow into the interceptor. The arrangement of the sewers and the special manhole at the point of interception is shown by a drawing herewith.



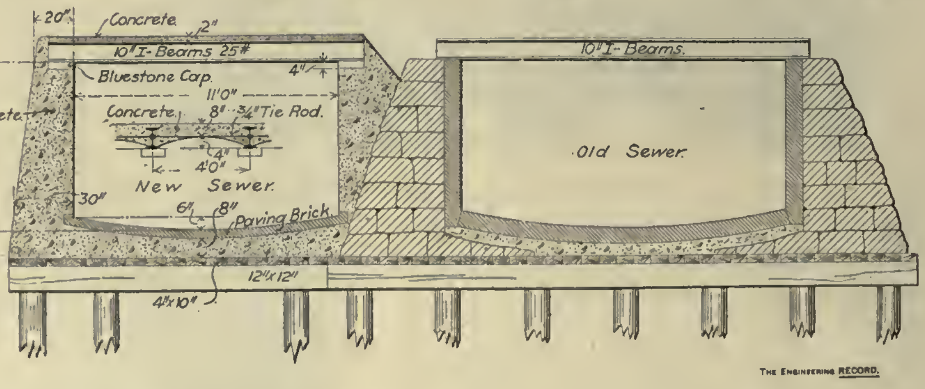








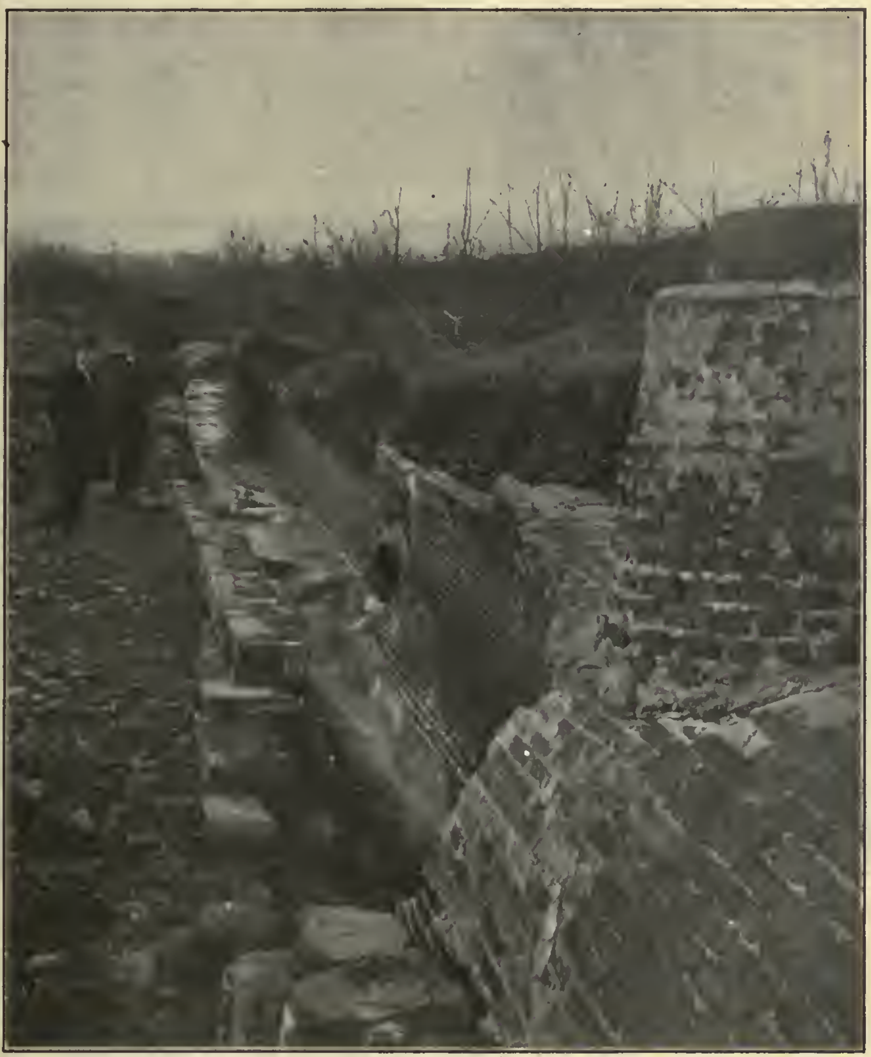
Section A-A



Storm Water Sewer, Newark: Crossing Under Lehigh Valley Railroad; Sections of Old and New Sewers; Connection with Intercepting Sewer.

Section 1 of the Peddie Street and Badger Avenue relief sewer, as the new sewer is called embraces an outlet 30 feet long, 116 feet of 6x12-foot rectangular conduit under the right of way of the Pennsylvania Railroad, 360 feet of 7x11-foot rectangular sewer, 1,570 feet of 8x10½-foot sewer with arched top, 1,590 feet of 6-foot 9-inch circular sewer and 60 feet of 5-foot by 7-foot 6-inch egg-shaped sewer, an aggregate of 3,726 feet, besides which there are 850 feet of the 3-foot circular brick intercepting sewer. The grades, beginning at the outlet, are as follows: For 976 feet, .06; for 560 feet, .56; for 300 feet, .90; for 240 feet, 1.00; for 1,590 feet of circular sewer, 1.76, and for the 60 feet of egg-shaped sewer, .86. Section 2 has not yet been put under construction, and may not be for a long while, but Section 1 is nearing completion and will probably be finished during the spring. The contract was awarded to Mr. J. R. Shanley, of Newark and Jersey City, for about $140,000, and work was begun soon after the first of November, last.

From the Pennsylvania Railroad to Elizabeth Avenue, or the beginning of the 6-foot 9-inch circular section, the new sewer is built against the wall of the old, considerable economy of masonry being thus effected, although the old wall has been reinforced as was deemed necessary. Beyond the point just mentioned, the two sewers continue side by side, separated by only a small space. Beneath the Pennsylvania Railroad the new sewer, like the old, has heavy stone masonry walls and a roof composed of 15-inch, 70-pound I-beams, two beams being placed under each rail of the tracks and the whole structure tied together with 12-inch 25-pound channels riveted to the I-beams, one at each end and one in the center. The track ties are laid on the upper flanges of the I-beams. The floor of the sewer is two courses of crossed 3-inch yellow pine planks on 12x12-inch timbers laid close together, and is carried on the 12x12-inch longitudinal caps of the 15-foot spruce piles made necessary by the soft marsh formation. The transverse rows of piles are spaced 4 feet on centers and in each row there are three piles under each wall and one under the middle of the sewer. The established grade of the tracks and the limitation of the elevation for the sewer bottom determined the height of this portion.



Portion of Old Storm Sewer, Newark, Destroyed by Heavy Rains.

The other photograph is an interior view of a partially finished portion of the 7x11-foot sewer. Its walls and bottom are of Portland cement concrete, with an invert lining of paving bricks, and the roof consists of 10-inch I-beams 4 feet apart on centers and solid concrete arches turned between the beams, as indicated in an accompanying drawing. The roof arches are 8 inches thick at the crown, have a rise of 4 inches and are finished level on top 2 inches above the upper flanges of the beams. This part of the sewer is supported on a platform of 4-inch longitudinal planks on 12x12-inch pile caps. The piles are 10 inches in diameter at the butts, are spaced as shown in transverse rows, and the rows are 5 feet apart on centers.

The 10½x8-foot portion of the new sewer has the cross-section shown in one of the drawings, with brick walls and arch and a concrete bottom, the latter lined with paving brick. A part of this stretch required a timber platform and piles, but beyond the crossing with the Lehigh Valley tracks, 1,000 feet from the outlet, the bottom of the trench is solid enough to receive the concrete of the sewer bottom directly.

There are two railroad crossings on Section 1 and the second occurs in this stretch of the sewer near Frelinghuysen Avenue, where the Lehigh tracks are carried over the street on an elevated structure, the footings for the columns of which restricted the space available for the sewers. Accompanying drawings show plainly the relative positions of the railroad columns and the sewers and the special construction adopted in the sewer for a length of about 40 feet at this place. As indicated, the wall of the old sewer was torn out and the roof beams were made long enough to reach from the outside wall of the new sewer to the outside wall of the old sewer, which latter was modified as required for the support of the beams. In Frelinghuysen Avenue the sewer crosses beneath two surface tracks of an electric railway. The existing intercepting sewer formerly connected with the old storm-water sewer at this place, but it was thought desirable to intercept the sanitary sewage at a point farther up the line of the sewers, in order to have the connection above the point reached by tide water and thus permit the removal of the tide gates, which materially obstructed the flow. Consequently, from Frelinghuysen Avenue the new intercepting sewer parallels the storm-water sewers for somewhat over 800 feet.

The circular sewer is of 8-inch brickwork with an invert of paving bricks. The egg-shaped portion of the sewer has an 8-inch brick arch and the lower part of the cross-section is of concrete having vertical sides and flat bottom on the outside and lined with 4 inches of brick below the springing line of the arch. The concrete was all hand mixed in the proportion of 1:3:5, being made rather wet. Spading forks were used to work the stones back from the faces of the walls and smooth surfaces were thus obtained. The cement used was Vulcanite Portland. The sewer was designed by Mr. Edward S. Rankin, engineer of the Sewer Department of Newark, and is being constructed under his direction.

In the Production of Pig Iron Germany is now second only to the United States, having outstripped Great Britain during the past year. During 1903 Germany produced 10,085,634 metric tons, and the United States 18,009,252 long tons.

A Mechanical-Draft Fan installed in a power plant in a commercial house of Berlin did not consume more than 0.88 per cent. of the total indicated engine power, according to the designer of the plant, Prof. E. Josse, of the Royal Technical High School of Charlottenburg, in the "Zeitschrift" of the Society of German Engineers. Its cost was about $1 per day. There are two fans of the Sturtevant make, one the reserve of the other, each rated at 18 horsepower and capable of handling the gases produced by the combustion of 2 tons of coal per hour. The average draft is 0.98 inch of water and a leakage through the brick flues of 1.18 per cent. excess of air has been noted behind the bridge wall and 2.5 per cent. in the fan stack.

A Trade-Mark Ruling has recently been rendered by the Circuit Court of the United States for the Massachusetts district which confirms the right of the General Electric Company to exclusive use of its mark "G. E." on electric lamps. It was claimed that this mark was so placed on the stem of the lamp that no company could obliterate it in remaking the lamp, and that under color of a suit for the protection of a trade-mark the General Electric Company was in reality seeking to destroy the business of a company remaking such lamps. The court decided that it is perfectly possible to remake such a lamp and obliterate the trade-mark, and that when this is done the lamp is no longer a General Electric lamp. But if the remaking is done by any other company than the General Electric Company and the trade-mark is not obliterated, the latter is then in use on an article where it does not belong. The court has accordingly granted an injunction against any such practice. The justness of this decision is evident to all who will stop to consider what a trade-mark signifies, and in some respects the opinion is as important as the noted ruling which confirmed the Babcock & Wilcox Company's exclusive right to the use of its name in connection with water-tube boilers.

A Sulphur-Sand Composition for Pipe Sewer Joints.

By Alexander Potter, Consulting Engineer, New York City.

The difficulties connected with the use of cement for joints on pipe sewer construction are well known. The objectionable features of cement for this service are numerous—leakage, admission of tree roots, the seasonal restrictions of its use on account of frost. These objections are not even eliminated when the work is under the supervision of competent engineers. As an instance of this, Professor A. P. Folwell, in an address before the American Society of Municipal Improvement records the fact that in a city in New York State the ground water infiltration in the pipe sewers was only limited by the capacity of the sewers. While the name of the city was withheld, I believe it to be a city where the designing and supervising engineer, and also the resident engineer, are members of the American Society of Civil Engineers, and are men who stand well in the profession. Many other cases of leaky sewers have been cited from time to time, and most other sewers could come under the same category if they were subjected to ground water infiltration. It is axiomatic that it is impossible to make a joint even approximately water-tight with the use of cement applied in the customary manner.

The writer has devoted much of his time in attempting to secure water-tight work, and has used cement in various ways and in combination with tar and other materials, with indifferent success, notwithstanding highly satisfactory laboratory results. The method now in use upon his work secures as nearly water-tight joints as can be devised. In the construction of pipe sewers the writer has largely dispensed with the use of cement as a joint material and has substituted therefor a mixture of sulphur and sand in the proportion of 1 to 1, approximately, heated together at a temperature of 230 degrees Fahrenheit, and poured in a manner similar to that for lead. The sulphur-sand mixture, however, requires no calking.

The physical and chemical tests of the mixture show it to be superior in all important respects to Portland cement mortar, both neat and mixed with sand. The tests indicate that while the tensile strength of pure sulphur is about 100 pounds to the square inch, the sulphur and sand composition has a tensile strength of 400 to 700 pounds to the square inch, depending on the quantity of sand used. Several briquettes tested two hours after they were poured broke at 670 pounds to the square inch. The average of one-day and five-day tests of pure sulphur briquettes gave 100 pounds per square inch, while for the same time a two of sulphur to one of sand mixture gave 400 pounds per square inch, a one to one about 650 pounds, and a five to seven about 670 pounds. After cooling, time does not seem to be an element affecting the strength of the mixture.

The writer sent samples of the mixture to Messrs. Ledoux & Company, chemists, who report that under 72-hour test the composition was not affected by any of the acids or alkaline liquors to which samples were submitted, when present in such quantities as are likely to be found in sewage. A five per cent. solution was used for the tests. The tests made by the chemists further show that the mixture is practically impervious to water, the absorption averaging .017 of one per cent. The material melts quite sharply at 230 Fahrenheit without any apparent preliminary softening. This is the same as for sulphur, and means that until the sewer should be subjected to 230 degrees Fahrenheit, the joints could in no way be affected.

The tests conducted by the writer to determine the tensile strength developed the interesting fact that the more sand the sulphur could take up and yet run freely, the stronger the resultant mixture. It also shows that the finer the sand the more satisfactory the results. The coarser sand precipitates more rapidly. The sand now being used has an effective size of 0.135 millimeter and a uniformity coefficient of 2.5. All this sand passed a No. 40 sieve, and 30 per cent. of it was held on a No. 60 sieve. This is a very fine sand, the ordinary New Jersey quicksand. Experiments were made with the use of fine Long Island beach sand, but the results obtained were less satisfactory than with quicksand. At last a use has been discovered for quicksand! The amount of the compound used is less than one-half the quantity of cement mortar required for making joints, and the labor of making the joints is less than required in making a cement joint *as it ought to be made.*

This new form of joint has a further important advantage in construction, that water can be allowed to rise in the ditch and run through the pipe one minute after the joint has been made. It is also proof against the intrusion of roots into the sewer. The universal application of this mixture as a joint material for sewer work would unquestionably tend to increase to a slight extent the cost of sewer construction, because the enforcement of specifications concerning cement joints on sewer pipes are more honored in the breach than in the observance, and the prices of the contractors are figured on this basis. But, as has been said, if any reasonable effort is made to secure tight sewers with cement joints, the cost of joints with sulphur and sand will be no greater than with the cement.

Interior of Concrete Storm Sewer, Newark, Showing Steel Roof Beams Ready for Arches.

In laying the sewer in wet trenches the ditch is excavated 6 inches below the bottom of the pipe, which is blocked up to grade. The water is thus more readily kept away from the bells. A heavy gasket of oakum, about six-tenths of a pound for a 24-inch pipe, is thoroughly caulked into the joint. Any ordinary form of pipe jointer used in water pipe laying is fastened around the pipe and the joint poured as in laying water pipe. It is advisable to have several pipe jointers in use so that a section of 9 feet can be jointed while the water is being temporarily held down below the bottom of the sewer in a wet trench. Material for three or more joints can be heated more economically than for one joint. For the smaller pipes, that is to say, for 8-inch, 10-inch, and 12-inch, temporary cradles can be set up on the bank and three or four lengths of pipe can be readily jointed together, lifted out of the cradles and lowered into the ditch as one pipe.

The rigidity of the joints makes it almost essential to deposit concrete under the haunches of the large pipe and on 24 and 22-inch pipe sewer 2.3 cubic feet of concrete per foot of sewer is found sufficient to give the pipe a proper bearing. A lean natural cement concrete gives satisfactory results, and the cost will depend upon the accessibility of materials. Where it is possible to lay pipe simply by digging out bell holes the concrete can be dispensed with; but in the opinion of the writer concrete is essential under all large sewers, at least in wet trenches and in rock cuts, when an attempt is made to secure perfect joints with cement or otherwise; for then the pipe becomes a rigid beam, and without a continuous foundation is liable to rupture.

Tests were made with various kinds of sulphur; the crude Sicilian (1.5 cents per pound), the roll sulphur (2 cents per pound), and the flour sulphur (2.4 cents per pound). The latter, while most expensive, is most satisfactory and melts much more rapidly than the crude or roll sulphur. The labor element of cost is thus reduced sufficiently to offset the difference in cost of material. The most serviceable size of melting pot is one that will hold enough material for at least three joints on the larger pipe and a dozen on the small pipe at one time. The specific gravity of the melted mixture is 2.46.

The following table gives information concerning the cost and amount of material in making sulphur-sand joints:

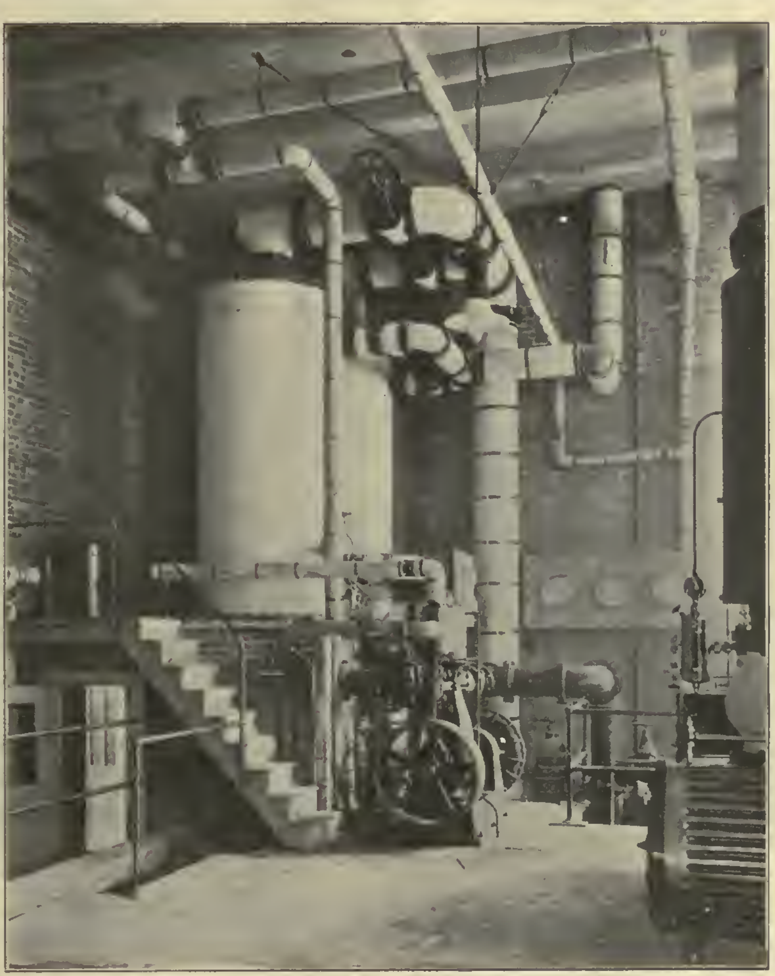
Approximate Costs.

Size of pipe, ins.	Amount of mixture, lbs. per joint.	—Cost per joint, dollars.— Mixture.	Gasket.	Fuel.	Labor.	Total.	Cost per foot. 3-ft. lengths.	2-ft. lengths.
24	10.0	.125	.02	.02	.13	.295	.10	.15
22	9.0	.1125	.02	.02	.13	.282	.095	.14
20	8.0	.10	.02	.02	.12	.260	.09	.13
18	7.0	.087	.02	.02	.11	.247	.08	.12
15	5.5	.069	.01	.01	.10	.187	.065	.095
12	4.2	.052	.01	.01	.09	.162	.055	.08
10	3.3	.041	.01	.01	.08	.141	.045	.07
8	2.5	.031	.01	.01	.07	.121	.04	.06

The exclusion of ground water will increase the capacity of the sewer from 10 per cent. to 100 per cent. through territory subject to the admission of ground water, so that the increase in cost becomes a trifling matter, especially when it is considered that tree roots are kept out of the sewer.

Works of the Smith Premier Typewriter Company, Syracuse.—II.

The description of the works of the Smith Premier Typewriter Company, printed last week, brought up the account to a consideration of the heating system, but before proceeding with this, a few additional notes may well be made with respect to the design of the factory building. The general exterior walls are spandrel walls and non-bearing, the bearing portions being practically a series of piers formed by the pilastered parts thereof. The floor loads that are transmitted to the spandrel walls by the transverse beams coming over the window openings are transmitted in turn from the point where they enter those walls to the piers, formed by the pilasters, by a series of steel lintels over the window openings. These not only serve for transmitting the floor loads to the piers, but also furnish a means of supporting the spandrel walls as well. The maximum thickness of these piers is 3 feet through the first story, 2 feet 8 inches through the second story, 2 feet 4 inches through the third and fourth stories and 2 feet through the rest.



Heaters in Engine Room for Hot-Water Warming.

Heating System.—As noted in the last issue the heating apparatus can be called a vacuum exhaust hot-water heating system. It is the design of Mr. C. S. Hopkins, now with Messrs. McDonell & Dumond, of Rochester, N. Y., and he has made applications for patents covering it. The two heaters, which are of the steam-tube type, built by the Ames Iron Works, of Oswego, are connected in parallel so that a portion of the water as well as a portion of the steam can be sent through one while the rest goes through the other, or either may be cut altogether. As shown in an accompanying drawing, the main exhaust enters each at the top and leaves it for the jet condenser at the bottom. The usual relief or back-pressure valve is fixed in the exhaust system, so that if it is necessary to cut out the jet condenser, the heating apparatus can be operated at atmospheric pressure. In all cases the condensation in the heaters is pumped into the feed water heater. Live steam can also be added, should the engine load be light or the weather extremely cold, a vacuum reducing valve providing for lowering the pressure of the boiler steam, so as not to destroy the vacuum. To protect the heaters as much as possible, a Cochrane grease separator, made by the Harrison Safety Boiler Works, is placed in the main exhaust leading from the engine. The jet condenser is of the Deane pattern, with a 9x18x12-inch pump, which obtains water from an adjoining cistern, this connected through a 12-inch tile pipe line to the creek.

The hot-water system from the heaters through the building and back again is arranged to circulate by gravity, but a centrifugal circulating pump, installed at the heaters, has been provided for accelerating the circulation and is ordinarily used, except when the temperature is not below 40 degrees and during nights or Sundays in colder weather when the circulation by gravity is intended. The pump is a Baldwinsville pump, direct driven at 300 revolutions per minute by an 8x8-inch vertical steam engine. The radiation is generally in the form of pipe coils suspended close to the ceiling in every story, along the outside walls. As indicated in the accompanying part plan, the heating main is carried vertically to a point in the seventh story of one of the stairway towers and then run under the roof to a central point where it drops through the building with branches for the ceiling coils in every story. The return connections for the coil headers drop, as indicated, in the four corners of the building to the first story, where they are united into the return main leading to the centrifugal pump. An expansion tank, about 12 feet long and 4 feet in diameter, is located in one of the stairway towers, opposite the top of the flow riser. The high-pressure steam piping is wrapped in H. W. Johns 85 per cent. magnesia covering and the low-pressure piping in asbestos covering.

The calculations and observed results of such a system will, of course, be of interest. According to Mr. Hopkins, the generating unit develops about 350 indicated horse-power with a steam consumption of about 18 pounds per horse-power per hour. This at 15 inches vacuum means the hourly supply in the latent heat of the exhaust at full load of 6,230,000 British thermal units. The factory building contains 1,750,000 cubic feet of space and there are 51,800 square feet of wall surface, 29,850 square feet of glass and 29,100 square feet of roof. The heat losses, Mr. Hopkins states, approximate 5,250,000 thermal units per hour with inside temperature at 70 degrees Fahrenheit and outside temperature at 15 degrees below zero. In determining the requisite amount of radiation the fact had to be recognized that the polishers and buffers in the first story are connected to the exhaust system, which is designed to remove 25,000 cubic feet of air per minute, and in consequence, with the comparatively low temperature of water that would be circulated, 35,000 square feet radiation were installed in the main building. The guarantee was that the building would be maintained at 70 degrees when the outside temperature was 15 degrees below with a 15-inch vacuum on the engine exhaust. As a matter of fact, Mr. Hopkins says that this temperature was secured with an 18-inch vacuum when the outside temperature was 26 degrees below zero. Besides the main building there are about 2,000 square feet of radiation in the office building and about 1,000 square feet in the japanning department on the second floor of the power house.

It will be seen from the foregoing that the hot-water radiation is calculated on a basis of giving up 150 thermal units per square foot per hour. When the outside temperature is 20 degrees below zero, it has been observed that the return water averages 144 degrees and the flow water from the centrifugal pump averages 176 degrees, so that, assuming a 30-degree loss during weather when the thermometer registers 15 degrees below outside, some 2,900 pounds of water or 47.5 cubic feet of water must be circulated per minute. When the outside temperature is 20 degrees above zero the difference in temperature of the return and flow water is 20 degrees; and similarly, for 30 degrees outside, it is 15 degrees; and for 35 to 40 degrees, it is 9 to 10 degrees. Each of the heaters has 120 2½-inch tubes 8 feet long, or 600 square feet of condensing surface, so that the two together, to furnish the 5,250,000 thermal units lost per hour in heating the building, must absorb about 4,400 thermal units per hour per square foot of tube surface, or must bring about the condensation of some 4.4 pounds of exhaust steam. The number of thermal units required to warm the building approaches 90 per cent. of the number available in the exhaust discharged from the engine at rated load, leaving the excess for the jet condensers. The condenser, it may be stated, is regulated to suit weather conditions largely by throttling the supply of water to the condensing cone. At a recent visit to the plant, the various gauges showed a steam pressure of 162.5 pounds, a receiver pressure between cylinders of the engine of 16 pounds, a vacuum in the heaters of

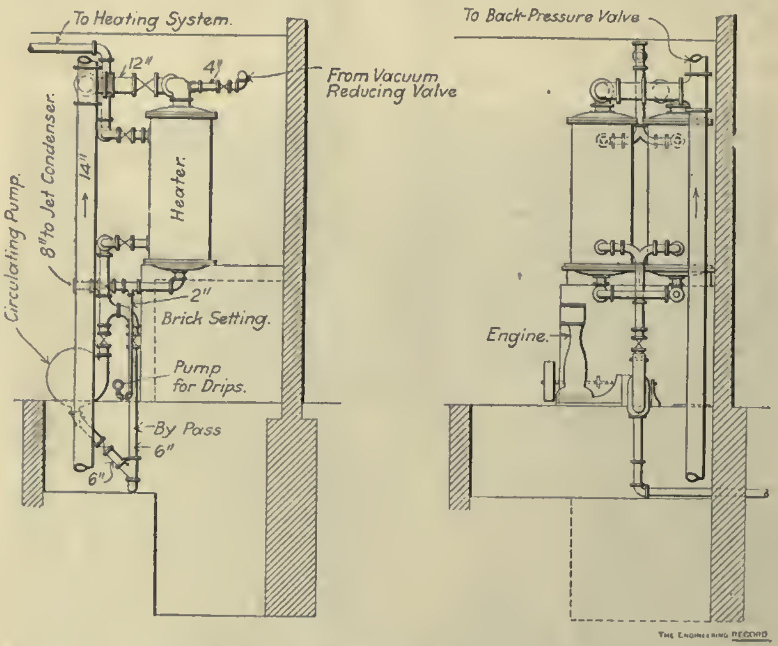
17 and 17.5 inches, a vacuum at the condenser of 17.2 inches and a suction and pressure head at the centrifugal pump of 34.5 and 39 pounds, respectively.

Power and Lighting.—For power and lighting the three-phase 60-cycle alternating-current system has been adopted. Some 29 induction motors aggregating 400 horse-power are at present installed, and altogether about 3,000 220-volt 16-candle-power, incandescent lamps and seventeen 110-volt, arc lamps are provided for, the lights on separate two-wire feeders controlled in the power-house. The system of wiring, a typical layout of which was given in an illustration last week, is quite interesting.

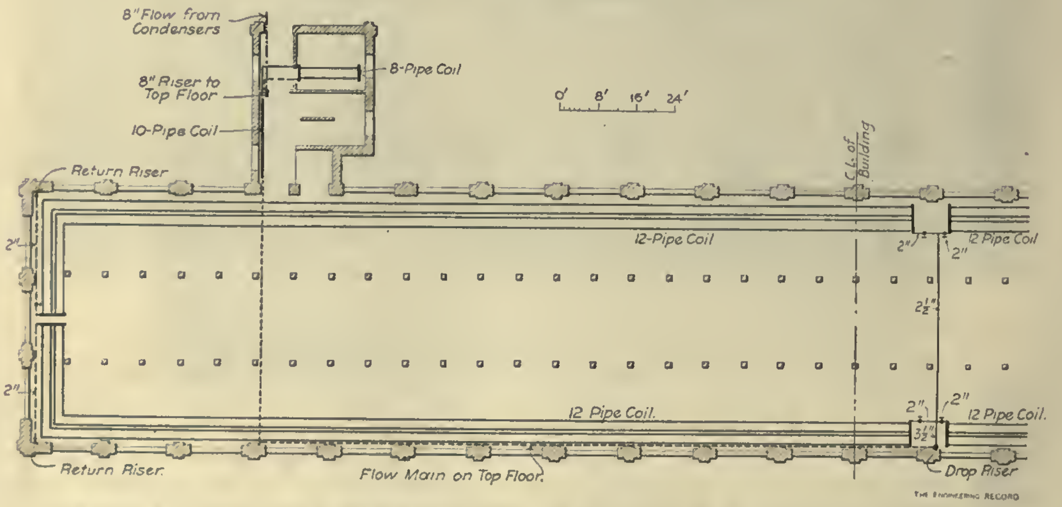
The switchboard in the engine room comprises seven panels equipped for the most part with usual instruments. The generator panel has among other things three ammeters one for each phase, two indicating wattmeters and one voltmeter, all these of the horizontal edgewise pattern; and the main switch is double throw to allow for connecting a public service supply to the bus bars. The provision of an outside supply, besides serving against a break-down of the plant, makes it possible during holidays, for example, to maintain lights or run a portion of the works without keeping the engine unit in operation. The street alternating-current service is at 2,200 volts and accordingly there are installed in a pit in the engine room a bank of 50-kilowatt, 10 to 1, step-down, General-Electric transformers. On one side of the generator panel is the exciter panel and on the other, four feeder panels. The exciter is a 125-volt dynamo belt-driven from the alternator. The seventh panel, at the left end of the board, next to the exciter panel, contains a General Electric TA regulator for maintaining the voltage of the alternator constant. Two of the feeder panels are for power circuits, four per panel, and the other two for lighting circuits, likewise four per panel. There are four recording wattmeters on each panel, that is, one for every feeder, both power and light. In addition each lighting panel, or group of four lighting feeders, is provided with a feeder regulator for boosting or lowering the bus-bar pressure to compensate in part for the drop between switchboard and lamp terminal, thereby maintaining a better equalization of voltage throughout. The two-wire lighting feeders are arranged with respect to their load to keep a balance so far as possible on the three-phase system.

The feeders are carried in conduits underground to the first story of the main building, and then pass, in pipe conduits suspended from the first-story ceiling, to the rising points. There are fourteen of these conduits, and the pipes, which are 2, 2½ and 3 inches in diameter, are run side by side. Aggregating with their contents considerable weight, special hangers were designed to hold them against the ceiling. These are cast-iron beams provided with lugs for fastening to the timber beams and are formed at the upper edge into a sort of comb with the spaces between the teeth for the pipes. The largest hangers, having fourteen such channels for the fourteen feeders, are 4 feet long, 4½ inches deep at each end but increasing to 5¼ inches in the center, with the top horizontal. The thickness of these beams varies from 2½ inches at the top to 1 inch at the bottom, so that the section is trapezoidal; and the teeth are 1-inch walls separating the pipes. The hangers are fastened to the under side of the timber beams by six ½x7½-inch lag screws. The hangers were erected by first placing them in a wooden horse and then forcing them into the correct position against the beams by means of jacks. The conductors themselves were inserted in the top of each vertical, wall pipe-conduit and the force of gravity utilized for drawing the wires from the vertical through the horizontal conduits.

The wiring diagram shown was selected as comprising all the various systems of lamp location that obtain. The lighting feeder terminates in the main box indicated, where subdivision is made for the four panel boxes. The power is separate, feeding generally to a separate distributing box. It will be seen that the central aisle is lighted by clusters of three lamps every 48 feet, or one 16-candle-power lamp for every 300 square feet of floor area, assuming no illumination is counted on from the lamps in the side aisles. These are generally all pendant, individual lamps at machines or at benches. A feature of shop arrangement made feasible in the day time by the large window area is the setting of working benches perpendicular to the side wall opposite each window. This provides for placing six men with good light, where with benches facing the windows there would be room conveniently for only four. These benches are in pairs, six lamps per pair or one per man. Besides the 2,670 lamps in the main building, there are 180 in the office building, with feeder large enough for 300, and 150 incandescent lamps in the power house in addition to the arc lamps enumerated, the last being supplied in parallel and requiring a transformer to secure the working voltage.



Heater Connections for Warming System.



Part Plan of the Typical Heating Layout in the Smith Premier Typewriter Works.

The circuits from the panel boxes are all strung in open fashion with fire and weatherproof wire, 140,000 feet all told. The wires run in neat parallel lines against the ceiling of each story and pass through the timber beams in porcelain sleeves 2½ inches below the ceiling. Between the beams there are two porcelain cleats for each wire and after the wires were pulled taut through the sleeves they were further tightened by being fastened to the cleats. The number of holes required for the sleeves was so large that a motor-driven outfit, mounted on a portable tower, was employed for boring, with current obtained from the street railway system. The whole building was wired in two months, with three shifts of workmen per day. The panel boxes are of slate in pine boxes with asbestos lined doors.

The electric driving of machinery is on the group system, the machines requiring in general little power individually and intended for more or less constant operation. The motors are fixed to the ceiling, generally over the center aisle, with the starting compensators on an adjacent column. In the factory building there are 25 General Electric induction motors of 5 to 20 horse-power, mostly 10 and 15 horse-power, and aggregating 350 horse-power, and also three Westinghouse motors for the elevators. These are worm-geared machines built by the Howard Iron Works, of Buffalo.

Offices and Administration.—The office building, as shown in the general view, is a two-story frame building with an attic. It is about 40x70 feet in plan with a pyramidal roof and is an attractive building. On the main floor are the main offices, counting room and order department, on the second are the offices of the leading officials, while on the third or attic story are filing cases for correspondence and records. A brick ell at the rear of the building contains the vaults, one on each floor and the building is connected with the factory building, as already stated, by a covered frame bridge which is equipped with automatic sprinklers. The offices are tastefully decorated, the counting room, for example, having oak wainscoting with dark-green burlap-covered walls and white ceilings. The visitor enters a commodious reception hall in which is located the works central telephone exchange, whence the object of the call is transmitted to the proper official.

Mr. Timothy L. Woodruff is president of the company; Mr. Alexander T. Brown, vice-president; Mr. Frank F. Peard, secretary; Mr. William A. Dyer, treasurer and Prof. John H. Barr, M. Am. Soc. M. E., factory manager. The power plant and the general engineering for power and lighting was entrusted to Mr. George M. Brill, M. Am. Soc. M. E., of Chicago, whose representative during construction was Mr. F. A. Lindberg. Mr. R. J. Reidpath, of Buffalo, was the structural engineer. The shop equipment, including the choice of some machinery and the design of the rest, is the work of Mr. Brown and Prof. Barr, while the shop arrangement and installation of tools was in charge of Mr. George F. Stillman. Mr. Edward Joy was contractor for the heating, wiring and steam piping, Mr. Edward P. Bates, M. Am. Soc. M. E., for the sprinkler system and Mr. W. N. Tobin for the plumbing, all of Syracuse. The building was erected by day labor in charge of Mr. W. F. Burns.

THE HOT-WATER HEATING EQUIPMENT of the Concordia Nurseries, Wetteren, Belgium, consists of a series of tanks or canals below the floor of the greenhouse, through which canals water is caused to circulate by means of small steam ejectors. According to "Engineering," each canal is a trough 3½ feet wide and 15 inches deep, the full length of the greenhouse and there are a sufficient number to extend the full width. Each trough has a wall running down its center, stopping short of each end. Across the end of one of the two branches thus formed is built a wall and in this is fixed an ejector fed by a ⅜-inch pipe, the steam escaping from an orifice about 1/12 inch in diameter. The water 1 foot in depth is circulated by this means and heated by the condensation of the steam. The degree of heat is regulated by a valve on the steam supply to the ejector. Porous slabs above the tanks form the greenhouse floor.

The Darlington Hotel Collapse, in New York City.

The Darlington Hotel was designed to be a twelve-story building occupying about 72½ per cent. of the 50x100-foot lot at 59 West Forty-sixth Street. It had an iron and steel skeleton-construction frame, brick walls and concrete floors. The framework of the eleventh story was being erected when, on March 2, the building collapsed suddenly and completely, causing the death of at least twenty-one persons, including one victim in an adjacent building. Several arrests have been made and the accident is being investigated by the district attorney and by the coroner. Most of the plans and recorded data are now in the hands of these officials, and the architects, contractors and surviving workmen are not in a position to discuss the matter freely. The removal of the ruins was immediately commenced by a wrecking party, whose first efforts were to rescue any of the victims who might still survive. These conditions make it impossible to describe accurately the details of the design or the condition of the work immediately before the accident, but from a study of the ruins and from such data as, in the absence of drawings and records, could be secured from those associated with the work, the following statement has been prepared and is believed to be essentially correct.

Wreckage at Darlington Hotel, New York City.

The original designs for the building were filed by the architects with the Bureau of Buildings, Borough of Manhattan, and were approved after ordinary minor changes. Subsequently a second set of iron and steel plans for the same building was filed by the owner and rejected by the Bureau. Finally, a third set was filed by the owner and was also rejected. The original approved plans called for a structure with a basement about 10 feet high and a roof house having a total height of about 150 feet above the street. The cast-iron columns were of rectangular cross-section with a minimum section 6 inches square and ¾ inch thick and a maximum section 9 inches square and 1¼ inches thick. They were made in one-story sections with horizontal connection flanges on two opposite sides and the usual brackets and lugs to receive the beams and girders. They were seated on separate offset brick piers with concrete footings and granite caps, and were spaced at a maximum distance of about 13 feet apart. They carried I-beam girders and floorbeams of about 12 inches and 8 inches depth, respectively, the floorbeams having an average spacing of about 4 feet. The beam and girder connections were not specified by the architects, but, according to their custom, were left to be detailed by the iron contractor. Such beam connections as were shown on the architects' plans were the Carnegie standards. All beam, column and girder connections and splices were specified to be bolted, no rivets being required in the work. No kneebraces, diagonals or other bracing was designed for the structure.

The structure was proportioned for a total live and dead floor load of 130 pounds per square foot, and the plans filed were for a hollow-tile floor construction. This, however, was considered a mere formality as the architects expected that the owner would afterwards receive estimates for various other types of fireproof floor construction, from which a choice would be made. In proportioning the foundations the soil was assumed to be gravelly and the loads upon it were in all cases less than 4 tons per square foot. The excavation was not carried down to ground water line, but the adjacent buildings were said to have been underpinned. The beams and girders were proportioned for working loads of one-fourth of their ultimate calculated strength, the columns for loads of one-fifth.

The architects' contract with the owner specified that they should furnish plans and specifications only without supervision of the construction, and neither of them visited the building at any time. According to the statements by the daily press, the superintendent of the building, who was killed, was one of the owners and was a young man who had recently concluded a term of service in the United States Navy, and presumably had little experience with construction work. The owners also employed as superintendent a man who had previously been engaged as a draftsman with the architects, but who had resigned his position with them to accept this work.

During the construction of the building a number of violations of the building law had been reported and part of them had been removed, but five or six still remained and at the time of the accident the contractors were prosecuting the work in opposition to the instructions which they had received from the Bureau of Buildings to suspend the erection of the iron and steel work until the walls and fireproof floors had been carried up to within three stories of the top of the steel work. These injunctions were disregarded by the contractor and the Bureau of Buildings was unable to enforce them. After the first violations were reported, the inspector of iron and the inspector of construction both made daily visits to the building and exercised careful and continuous supervision of it. Two at least of the violations were the improper bolting of the beam and girder connections and of the column connections, and another was the relative rate of construction of the walls and steel work, the former reaching only a height of about three stories when the steel was ten stories high.

At the time of the accident, a large quantity of iron and steel for the eleventh story was said to have been stored on the tenth story and was being erected. The concrete floors had been built up to, and including, the ninth story, except in the third story where the centering was in position ready for the concrete. In the ninth story the concrete was laid and was ready for the filling. In the other stories the filling was laid. In the ninth story the concrete was wet and probably weighed 40 per cent. more than dry concrete, which is assumed to have a total weight of 50 pounds per square foot for this form of construction. In the lower stories it was well dried and probably did not weigh much in excess of the estimate. The floor builders had no materials stored on any of the upper floors, excepting a moderate quantity of boards on the tenth floor. All the concrete materials were stored and the concrete was mixed in the basement. Concrete was delivered to the upper floors by a platform elevator. There was also a hod elevator for the bricklayers, and there were ordinary derricks for the erection and hoisting of the steel and iron.

The collapse of the building was sudden and complete; all the beams, columns, girders and floors fell in a mass of debris, which reached from the basement floor to the second or third story, and did some injury to the adjacent buildings in falling. A brick stair or elevator shaft at one side of the building and a few of the lower columns and beams remained standing, but all the rest of the columns and girders were displaced, broken and twisted into a compact mass of wreckage. The separate pieces were unbolted or cut apart and dragged out of the ruins one by one and piled in the street. A hasty examination of them showed no evidence of unusual design, "skinned" work or bad materials or workmanship for that class of construction.

The cast-iron columns were badly broken and the beams and girders were twisted and bent as they necessarily would be by the collapse of the building. Many of the bolts were still in position in the beam and girder connections and in the column flanges, and many of them were missing, so that no opinion could be formed as to whether or not all the holes had been filled. In most cases the connection angles between the beams and girders were unbroken, although frequently distorted. A few of them were sheared through the rivet holes or through the root of the angle. The cast-iron columns had been exposed to the rain and their fractures were rusted, but there was no obvious appearance of poor metal and they seemed to be of uniform thickness, showing some of the test holes that had been drilled to gauge them. The column flanges, so far as observed, were solid, well filled out and planned for bearing. Of all the columns observed there were fifty-two ends where the flanges or lugs were badly broken, and only seventeen in which the flanges were intact. Besides these there were a number of columns without flanges at one end which were not broken. There were also seven pieces of columns which had been snapped across in the middle and broken into two or more pieces.

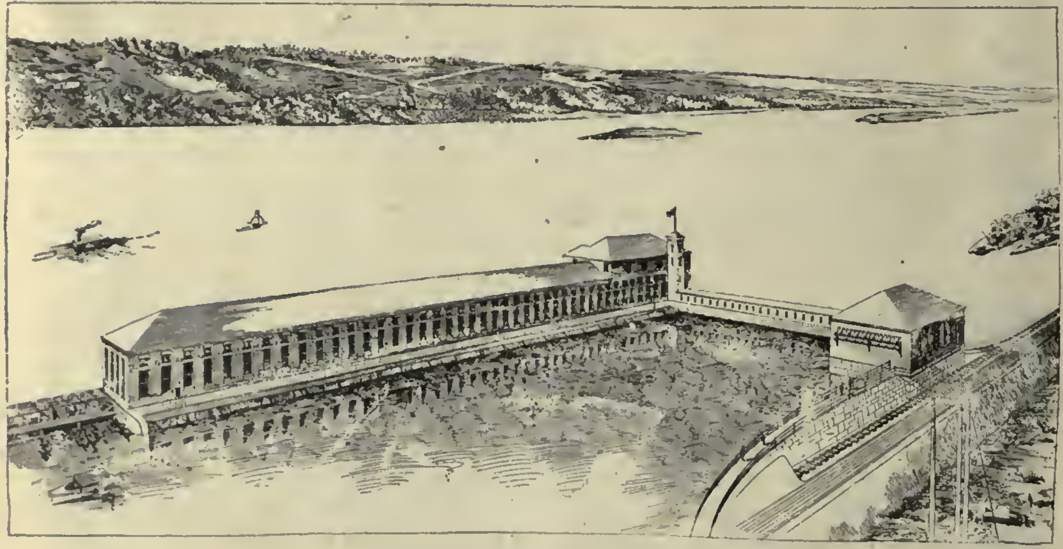
WATER FOR STEAM BOILERS should be softened when it contains more than 12.5 grains of calcium carbonate per gallon (15 grains per English imperial gallon), according to Mr. John B. C. Kershaw in a paper read before a recent meeting of the Liverpool Engineering Society.

THE TUNNEL VENTILATING PLANT for the Mont Cenis tunnel comprises a water-power electric station, a fan-house a quarter of a mile or so distant from the water power development and an electric transmission between the two. There are two 235-horse-power turbines working under a head of 151 feet, each driving a three-phase 50-cycle 3,700-volt alternator, and at the ventilator station, two 3,500-volt 210-horse-power motors, each keyed to a fan 16 1/3 feet in diameter and 5 feet wide run at 360 revolutions per minute. The fans are located on the hillside in direct communication with air chambers in the tunnel below, which are built according to the Saccardo system. "The Engineer" states that the aggregate power required by the fans is 345 horse-power and the calculated speed for the air driven into the tunnel is 6.56 feet per second, its area being 441.17 square feet.

Water-Power Development at York Haven, Pa.

As the initial installation of the generating machinery was being made ready for regular operation in the plant of the York Haven Water & Power Company, at York Haven, Pa., an ice-laden flood of the Susquehanna River, on whose bank it stands, rose to such proportions late in the afternoon of March 5 that some damage, though not with very serious consequences, was done to the station. It happens that the development is a conspicuous example of water harnessing, being planned to develop 20,000 horse-power under a head of 22 to 25 feet, and the present occasion offers an opportunity of describing briefly in advance of its final completion the general scheme of the design and the utilization of the power. The following review will thus serve in addition to outline the conditions existing coincident with the rapid rise of water and the jam of ice.

The plant was located to take advantage of a fall in the river and the natural head was increased by a timber dam at the head of the fall. A long head-race separated from the river by a heavy masonry wall runs along the right bank of the river from the dam to a forebay, on the river side of which is the power-house. This arrangement is shown in the accompanying general view, and, as will be seen, the wall of the head-race canal terminates in the foundations of the power-house, which contain the water-wheel flumes or penstocks. A wing or cross-wall extends from the power-house to a transformer house on the river bank, this wall forming the end of the forebay.



Scheme of the York Haven Water-Power Development.

The dam is constructed of heavy timbers, ballasted with stone, and anchored to the bed rock of the river by heavy anchor bolts. It is 30 to 20 feet wide, varying in proportion to height, which ranges from 18 to 7 feet, and it is 3,000 feet long. The head-race is approximately 500 feet in width and 16 feet deep, and the wall from the dam to the power-house is some 3,500 feet long, 28 to 34 feet high, and 6 feet wide at the top and 16 to 20 feet wide at the bottom. It is built of granite of which it required 100,000 cubic yards. The wall is 6 feet higher than the crest of the dam, or 9 feet above low water.

The power-house is 478 feet long and 51 feet wide and is designed to receive forty turbines of 600-horse-power each, connected in pairs to 750-kilowatt alternators, and two turbines of 250-horse-power for the generator exciters. The ultimate installation will thus comprise twenty main units, each to employ two 79-inch turbines, and two exciter units, each to have one 62¼-inch turbine. The foundations are of stone masonry with masonry walls between turbine chambers, and for the construction of this work a coffer dam some 500x240 feet was constructed around the site. For this dam 45,000 bags of sand, 250,000 feet of timber and 10,000 cubic yards of stone were required. The usual pumping equipment to draw off the leakage was provided, and twelve derricks and portable railways were included in the contractor's plant.

The station is situated about 11 miles from York, 8 miles from Middletown, 12 miles from Steelton and 16 miles from Harrisburg. Apparatus was installed in the transformer house for stepping up the current pressure to 24,000 volts for the over-land transmission. Each generator is of the Stanley type giving 60-cycle current at 2,400 volts. All the apparatus in the power-house is placed on the main floor of the building. At the south end there is a second story 70 feet long, in which is situated the switchboards for the individual generators, with instruments for measuring the output of each machine and the total output of the station. From this point the switchboard operator is to control all the generators and water-wheel governors on the main floor. The current is carried from this point to the transformer house through a wire alley, with accommodations for twenty-four 1,000,000-circular-mil cables. The transformer house, which is 200 feet west of the power station, is connected to the power building also by a covered walk.

In the transformer station there is space for twelve 1,400-kilowatt transformers, together with lightning arresters, switches and indicating devices. A pole line has been built to carry the current to York over two distinct three-phase circuits, each of 5,000 horse-power capacity. The poles, it may be mentioned, are 40 feet in length, 8 inches in diameter at the top and set 6 feet in the ground. At York the current is passed through six transformers of 800-kilowatt capacity each, where it is stepped down to 2,400 volts for local distribution.

The consummation of the development is largely the result of the efforts of Mr. Henry L. Carter, president of the York Haven Water & Power Company. The plans were laid out by Major Geo. B. Burbank, of New York, and it was constructed under the supervision of Mr. Thomas Green, of York Haven, superintendent of construction. The turbines and some of the detail plans for the masonry work in connection with the turbine installation were designed by the Robert Poole & Son Company, of Baltimore. Judge W. F. B. Stewart is vice-president and Mr. Henry W. Stokes, treasurer. The work of installing the machinery was in charge of Mr. T. A. W. Shock, electrical engineer of the company, and the plans for the buildings by Mr. J. A. Dempwolf.

The damage from the flood, as intimated, does not appear to have been very great, so far as the plant is concerned, notwithstanding the fact that the conditions at times threatened serious destruction. From reliable information it seems that the ice carried by the river became lodged in the channel along the head-race wall and power-house, and an ice jam resulted with blocks some as large as an ordinary barn, raising the river level to a height approaching 50 feet. At this writing the long wall is only visible in one or two places, so it cannot be stated definitely whether or not it has suffered injury, but the power-house structure was only wrecked slightly, it is stated, with repairs already in progress.

Transformer House and End Wall of Forebay.

The Cleaning and Flushing of Sewers.

At the annual meeting of the Sanitary Section of the Boston Society of Civil Engineers, held March 2, the cleaning and flushing of sewers was discussed by a number of members who have had extended experience along these lines. A brief résumé of the papers presented follows:

Mr. J. L. Woodfall read a paper descriptive of the construction and maintenance of two inverted siphons at Gardner, Mass., and one at Andover, Mass. These siphons have worked satisfactorily except that dust and silt have been washed into the settling basins by heavy rains. The velocities in the siphons have been from 0.25 to 0.40 foot per second. In connection with the second siphon built at Gardner, the sewage was passed through coke strainers before entrance to the siphon. These strainers have acted well as far as removing the solid matter is concerned. It is desirable to deliver sewage to them in doses. This siphon was not flushed from July, 1898, to February, 1899, and the following figures show the increased efficiency due to cleaning:

	Foot.
Before cleaning—	
Flow 300,000 gal. per day, loss of head	0.886
Flow 422,000 gal. per day, loss of head	0.940
After cleaning—	
Flow 255,000 gal. per day, loss of head	0.230
Flow 412,000 gal. per day, loss of head	0.509

This indicates that, in figuring the size of an inverted siphon, one should use 3½ times the loss of head for clean water. Mr. Woodfall makes these recommendations: Build siphon chambers to assist in cleaning and inspection, provide settling tanks, also blow-off pipe at the lowest point. Inverted siphons should not be built unless absoutely necessary. He objected very strongly to the use of open manhole covers on a separate system.

Mr. Bertram Brewer, city engineer of Waltham, stated that the outlet of the sewerage system of Waltham is located on the south side of the Charles River and two-thirds of the population is on the north side. A 24-inch iron pipe siphon, with sump at the lower end, crosses the river, but has given no trouble. Sewers are cleaned by means of an ejector, operated by water from the water mains, by which stones as large as the fist and dirt are raised 10 to 12 feet from the bottom of the sump to the street. The system comprises 38.25 miles of sewers, 50 per cent. being 6-inch pipe and 25 per cent. 8-inch pipe; the main is an egg-shaped brick sewer 32x55-inches. Relative to manhole covers, he said that when the system was introduced tight manhole covers were strongly recommended. It was later decided to have them perforated, and so holes were bored in large numbers. Mr. Brewer believes in tight covers, and since he has had charge of the system has unsuccessfully tried several means of plugging the holes. There are no running traps in the system; ventilation is effected through house stacks. In the Spring the entire system is cleaned; in the Summer it is flushed five times, and once just before Winter. The cost of flushing sewers alone, including incidentals, such as horse, wagon and repairs, is $6.56 per mile. There are 104 flushing manholes in the city, located at the summits and directly connected to the water mains. In 1903 there were fifteen stoppages, largely caused by roots, the average number for the last three years being fourteen.

Mr. Charles R. Felton, city engineer of Brockton, in describing the system there, said they had five short inverted siphons, each with two lines of pipe, mainly 12 inches in diameter, without sumps, three of which have never been stopped, the other two having been stopped each on one side. The velocities range from 0.7 foot to 1.5 feet per second. All summit manholes are connected with the water mains, the sewers being flushed from flushing manholes. In the whole system there were only two stoppages last year, the average being from four to five per year, caused mostly by plumbers testing plugs getting caught in the Y connections. The minimum grade governs the trouble with sewers and this should be as steep as possible to prevent deposits. All connections are intended to be laid at a 4 per cent. grade, 2 per cent. being the minimum. There are no running traps, and ventilation is obtained through the houses.

Mr. W. C. Parmley, president of the Civil Engineers' Club, of Cleveland, O., and engineer in charge of sewers, described the system there. With hardly an exception it is a combined system. Regular inspections are now made and the results obtained are satisfactory. Much trouble is experienced in the sandy portion of the city, where, of necessity, cleaning is frequent and sewers 3 to 4 feet high are often filled one-half full with sand. A number of sewers are laid on a grade of 0.25, the grade aimed to be maintained being 0.40.

Mr. W. D. Hubbard described the sewerage system and methods of cleaning sewers in Concord, Mass. The system is separate, is built of vitrified pipe and has been in operation four years. The mileage is 7.53, with 143 manholes. The main trouble from stoppages has been caused by tree roots. The entire system is cleaned once a year and for this purpose a steel brush drawn through the sewers with a ¾-inch manila rope has given the best satisfaction. The cost of cleaning the dust pans and the entire system last year was $175.50. The grade of 6-inch street sewers is 1 per cent., that of 8-inch and 10-inch sewers, 0.5 per cent., and that of 12-inch sewers, 0.15 per cent. House connections are all 5-inch; the minimum grade adopted is 2 per cent. Stoppages average three or four per year, and are caused largely by newspapers. On the lower levels 320-gallon flush tanks are operated once a day, being ef-

River Side of Power House during Construction.

fective for a distance of 500 feet; on higher levels flushing manholes are used, the manhole being filled by use of rubber-bound wooden plugs inserted in the pipe openings. The price of flushing for the past three years has averaged from $20 to $25 per mile.

Mr. Dana Libbey, deputy-superintendent in charge of sewers in Newton, described the methods used and results obtained in that city, which has a separate system covering a large area about 4½ miles in length by 4¼ miles in breadth. Three men with a three-wheeled push cart clean the system in from four to five weeks. Flushing manholes, operated by the use of rubber-bound wooden plugs are usually enough to flush the entire system. The streets are lined with shade trees, so that a number of stoppages are caused by roots gaining entrance to the sewers through defective joints. Roots are successfully cut out by means of a spring-steel cutter made up of thin strips of steel ¼ inch thick and ¾ inch wide. The cost of flushing and cleaning last year was $19.08 per mile.

Mr. E. S. Dorr described the methods of cleaning sewers in vogue in Boston. Formerly flush tanks were used, but these have been discontinued and flushing is now done entirely by means of fire hose connected to hydrants. Scrapers are also used attached to jointed rods. At times, sewers have been found packed solid with sand. In one such case, in East Boston, the cost of cleaning was 17.5 cents per running foot. Where there has been trouble from deposits from factories, such as from marble dust, the proprietors have been obliged to construct and clean a manhole to intercept the solid matter. The Dorchester Bay siphon is the largest one on the system, it being 7½ feet in diameter and having a drop of 160 feet. There is no difficulty in keeping this cleaned except at the outlet end, where about 25 cubic yards of grease accumulate each month. Mr. Dorr stated that the best form for a siphon on a combined system is to have a double pipe, the pipes being of unequal sizes, the smaller one designed to take the dry weather flow, the larger one the storm flow. The velocity in the small pipe will keep it clean, and no trouble will be experienced from the larger one.

Comparative Boiler Tests with Ordinary and Pulverized Coal Firing.

In one of the boiler rooms of the McCormick works of the International Harvester Company, at Chicago, two tests were conducted on February 2 and 3, to determine the relative performance of the boilers when equipped for machine firing of coal dust and when operated in the usual way with hand firing. Two boilers were selected and the pulverized coal test made on the first day and the hand-firing test on the second, each of 8 hours' duration and under as near as possible the same conditions. The trials were made under the direction of Mr. C. C. Smith, chief engineer of the works.

Each of the boilers was a Babcock & Wilcox water-tube steam generator, having a straight grate, 63 4-inch tubes 18 feet long, one 36-inch drum, a total heating surface of 1,200 square feet and a grate surface of 4.5x7 = 31.5 square feet. The system of powdered coal burning employed was that developed by the C. O. Bartlett & Snow Company, of Cleveland, and described in these columns December 20, 1902. Illinois coal screenings were burned in both tests, pulverized 40-mesh fine for the dust-burning test. The data and results are given in the accompanying table.

The cost of evaporation may be calculated from the figures in the table. Assuming coal delivered into the boiler room at $1.72 per ton of 2,000 pounds, it will be found that the cost of evaporating 1,000 pounds of water from and at 212 degrees Fahr. is 17.7 cents; with the pulverized coal costing $2.10 per ton, the cost of 1,000 pounds of steam under the same conditions is 14.55 cents. As a figure of interest, it is said at the works that it costs 19 cents per ton to dry and pulverize the coal. The heating value of the powdered coal was found to be 12,555 British thermal units per pound, so that the latent heat of vaporization being 965.8, the theoretical possible evaporation is 13 pounds per pound of coal. The actual equivalent evaporation being 7.21, the efficiency is 7.21 ÷ 13 = .555 or 55.5 per cent. The coal used in the hand-fired test gave 11,300 thermal units per pound, corresponding to 11.7 pounds best possible evaporation, and, the actual evaporation being 4.86, an efficiency of 41.5 per cent.

The difference between the two unit figures tabulated for evaporation per pound of fuel is 2.22, which is 48.4 per cent. of the evaporation based on fuel actually used in the hand-firing test, or an increase of evaporation of 48.4 per cent. in favor of the pulverized coal. The difference in the boiler capacity in the two cases is 88.4 horse-power, or an increase of 53 per cent. To determine the coal saving, 570 pounds, or 71¼ pounds per hour, were added to the actual consumption of pulverized coal to equalize for the greater amount of moisture in the hand-fired coal, so that to evaporate 8,283 pounds of water per hour, the pulverized system was charged in the report with 1,285 pounds of coal. The hand-fired method requiring 1,175 pounds of coal to evaporate 5,399 pounds of water per hour would require 1,803 pounds to evaporate 8,283 pounds of water, or 518 pounds more than charged to the pulverized system. This is about 29 per cent. of 1,803, indicating a coal saving of that amount with equal amounts of evaporation. In short the tests show with the same amount of coal an increase of evaporation of 48.4 per cent. or with the same evaporation a saving in coal of 29 per cent.

Results of the Comparative Coal-Firing Tests.

	Pulverized coal.	Hand firing.
Coal per hour, lbs.	1,214.1	1,175
Coal per hr. per sq. ft. grate, lbs.	19.27	18.65
Water per hour, lbs.	8,283.1	5,399.1
Equiv. evapn. per hr., lbs*	8,758.8	5,709.1
Equiv. evapn. per hr. per sq. ft. htg. surf., lbs.*	3.65	2.38
Boiler pressure, lbs.	79.8	79.4
Feed water, deg. F.	169.7	172.1
Flue gases, deg. F.	506	458.3
Draft, ins. water	0.52	0.42
H.-P. developed	253.9	165.5
Per cent. of bldrs. rating	105.83	68.9
Water per lb. fuel, lbs.	6.82	4.6
Equiv. evapn. per lb. fuel, lbs.	7.21	4.86
Equiv. evapn. per lb. dry coal, lbs.	7.48	5.43
Equiv. evapn. per lb. comb., lbs.	9.13	6.94
Analysis of coal—		
Moisture, per cent.	3.5	9.36
Volatile, per cent.	32.3	31.1
Fixed carbon, per cent.	40.7	40
Ash, per cent.	17.5	19.54
Analysis of ash—		
Volatile, per cent.	2.74	8.8
Fixed carbon per cent.	1.78	25.52
Ash, per cent.	95.48	65.68
Flue gases—		
Carbonic acid, per cent.	5.4	4.4
Oxygen, per cent.	14.6	16
Carbonic oxide, per cent.	...	...
Nitrogen, per cent.	80	79.6

*Corrected for moisture, which was assumed at 2 per cent.

As a matter of further interest the report states that the furnace was practically smokeless, with the pulverized system in operation, while considerable smoke was produced during the hand-fired test. In the test with the pulverized firing, a small amount of fine dust, ashes, fell off the tubes, a bright red light showed through the bars, there was a light bed of clinkers, 1 inch thick, used on test, which were not fused, and there was a light dust on tubes, but no soot and no appreciable fusion on outside of tubes. The fires were cleaned three times during the hand-fired test and a small amount of clinkers and soot was found on the tubes.

The Quarterly Meeting of the Association of Portland Cement Manufacturers.

A quarterly meeting of the Association of Portland Cement Manufacturers was called to order on Tuesday morning at the Hotel Walton, Philadelphia. Vice-President A. F. Gerstell was in the chair in the absence of the president, Mr. J. B. Lober. All parts of the country represented in the Association had delegates at meeting. The business sessions were mainly devoted to routine Association subjects, and were not of general interest except to members.

It is understood that the behavior of concrete and other materials in the Baltimore fire was discussed at some length, and the necessity of an impartial investigation of the subject was urged. In view of the importance of the topic, it is to be hoped that a special committee of the American Institute of Architects can be formed to make a report of this nature. Owing to the time which must elapse before the American Society of Civil Engineers can appoint such a committee, under the constitutional provisions governing such an action, that body is not in a position to act in the matter. The Institute, however, had a large number of its leading members in Baltimore immediately after the fire, and a comprehensive impartial committee could readily be formed to make a report on the condition of the fireproofing in the important buildings of the city, which would be of the highest importance. The many civil engineers who also examined the injured buildings would doubtless gladly furnish such a committee with the information in their possession. Another subject of general discussion was the standard weight of cement per barrel when put up in bags, and it was unanimously decided to be 95 pounds to the bag or 380 pounds to the barrel. The very important subject of a uniform sales contract is understood to have received much attention.

On Tuesday evening, the Association and its guests were entertained by Mr. Robert W. Lesley at his country place at Haverford. It might be stated that the house is itself a very interesting example of the applicability of cement for decorative building. It is designed on the style of the best of mission buildings of Southern California, with modifications adapting it to a severer climate. The large interior court with its central fountain is glazed at the top, and in this court dinner was served, about fifty members being present. At its close, the beautiful loving cup presented last year to Mr. Lesley by the Association was industriously circulated and some informal remarks were made. The single subject of technical interest discussed after the dinner was that of cement burning.

Cement Burning.—The subject was introduced by Professor Joseph W. Richards who explained his important investigations on a 60-foot kiln at the works of the Dexter Cement Company in Nazareth. These have already been mentioned in The Engineering Record of February 27. The kiln is run on bituminous slack from Fairmount, W. Va., having 0.60 per cent. moisture, 38.10 volatile combustible matter, 53.24 fixed carbon and 8.06 ash. The ground mixture of raw materials contains 13.38 per cent. silica, 6.04 aluminum oxide and ferric oxide, 41.96 calcium oxide, 1.53 magnesium oxide, 34.65 carbon dioxide, and 0.43 moisture. The burnt clinker contains 21.27 per cent. silica, 6.42 aluminum oxide, 3.18 ferric oxide, 66.70 calcium oxide and 2.43 magnesium oxide. The kiln turns out 3,635 pounds of clinker per hour from 5,980 pounds of mixture, and also produces about 200 pounds of flue dust. The amount of coal used is 110 pounds per barrel.

The temperature of the clinker as it left the kiln was measured by a Le Chatelier pyrometer and found to be about 2190 degrees Fahrenheit, and the sensible heat of the clinker was determined by a calorimeter to be about 522 B. T. U. per pound. The waste gases 4 feet from the upper end of the kiln had a temperature of 1500 degrees and contained 10.2 per cent. carbon dioxide, 11.8 oxygen and 0.2 carbon monoxide.

The theoretical heating power of the fuel was calculated from the proximate composition by the formula of F. Haas, and was found in this way to be 14,200 B. T. U. per pound.

One of the most striking points made was the importance of the heat of formation of the clinker. Using the metric system for convenience of computation, it was stated that for every 100 kilos of coal burned, 345 kilos of clinker were produced. Of this 230 kilos were calcium oxide, 8.4 magnesium oxide and 11.0 ferric oxide. It was assumed that these occurred as carbonates in the charge, and that the heats of combination with silica or alumina to form silicates or aluminates are 591 calories per kilo of lime and 827 calories per kilo of magnesia, in accordance with the data given by Berthelot. Hence the heat of formation of the clinker, when raised to the temperature at which combination takes place, is $230 \times 591 = 135,930$ calories for the lime and $8.4 \times 827 = 6,889$ for the magnesia, a total of 142,819 calories. As the theoretical heating power of the 100 kilos of coal is 790,000 calories, Professor Richards felt he was justified in calling attention to the important part evidently played by the heat of combination in the burning.

The distribution of the heat produced in the burning of the 100 kilos of coal and during the formation of the clinker was accounted for as follows:

The clinker at 1200 degrees Centigrade had a sensible heat of 290 calories per kilo, and as there were 345 kilos produced, there would be $290 \times 345 = 100,050$ calories accounted for in this manner.

The carbon going into the gases per 100 kilos of coal burned is made up of 73.6 kilos from the fuel, 49.3 expelled as CO_2 from the calcium carbonate and 2.5 from the magnesium carbonate, a total of 125.4 kilos. A cubic meter of the gases was found on analysis to contain 0.104 cubic meter of carbon monoxide and dioxide, each having 0.54 kilo of carbon per cubic meter. The carbon in a cubic meter of the chimney gases is therefore $0.104 \times 0.54 = 0.05616$ kilo. The volume of gas per 100 kilos of coal burned is $125.4 \div 0.05616 = 2,233$ cubic meters. The gases composing this volume are 1,737 cubic meters of nitrogen, 263 of oxygen, 4 of carbon monoxide, 228 of carbon dioxide and 128 of water vapor. Their mean specific heats were calculated from the experimental data of Mallard and Le Chateller, and these, multiplied into the volumes escaping, measured at standard conditions, give the sensible heat going up the chimney, per degree of temperature of the gases. This waste heat per 100 kilos of coal burned was found to be 676,000 calories.

This feature of his investigation was dwelt upon very strongly by Professor Richards. In his opinion there was no question but what a very large proportion of the 676,000 calories was carried off by air in excess of that needed for perfect combustion. Of the 263 cubic meters of oxygen, 2 would be needed to burn the carbon monoxide completely, leaving 261 cubic meters in excess. This carried into the kiln with it 988 cubic meters of nitrogen and 39.5 of moisture, and therefore carried out 336,000 calories. If no excess of air were used, there would be left to be carried out by the normal gases produced $676,000 - 336,000 = 340,000$ calories.

There were 12 kilos of dust carried out per 100 kilos of fuel burned. This caused a loss of $12 \times 0.22 \times (820 - 20) = 2,112$ calories. In this computation the specific heat of the dust is taken as 0.22, and the range of temperatures, 820 and 20 degrees Centigrade, is that between the flue gases and the atmosphere.

There were 4 cubic meters of carbon monoxide escaping unburned, causing a loss by imperfect combustion of $4 \times 3,062 = 12,248$ calories.

The charge contained 2.44 kilos of water per 100 kilos of fuel consumed. Allowance has already been made for the sensible heat which this carried out of the kiln, but, in addition, the heat needed to convert it into vapor must be taken into account. This is 593 calories per kilogram at 20 degrees Centigrade, or 1,446 calories for the whole amount.

The heat required to expel carbon dioxide from the carbonates of the charge was ascertained by using the figuers of Berthelot, who states that 990 calories are required to drive off the carbon dioxide from a kilo of calcium carbonate and 407 calories from a similar amount of magnesium carbonate. The computations already mentioned under the head of the heat appearing in chimney gases as sensible heat show that there are 180.8 kilos of this gas from the first source and 9.2 kilos from the second. From these data it is found that the heat required to expel the carbon dioxide from calcium carbonate is $180.8 \times 990 = 17,896$ calories, and that required with the magnesium carbonate is $9.2 \times 407 = 3,732$ calories, a total of 21,628 calories.

The heat lost by radiation and conduction was found by taking the difference, 119,335 calories, between the heat generated and the sum of all the other items of heat distribution.

Much interest was shown by the members in these figures, particularly in the statements that the heat in the clinker represents only a trifle over one-tenth of that developed in the kiln, and that of the total amount of heat developed nearly three-quarters is carried away by the products of combustion and excess of air. In the opinion of Dr. Richards this last fact points to the greatest losses in the burning process as now conducted, and he discussed a few of the methods of reducing it, such as lengthening the kiln so as to use the heat at the upper end in raising the temperature of the charge.

Although much informal discussion of these results took place after the meeting broke up, the only formal discussion was by Mr. S. B. Newberry. In his opinion, it was undoubtedly true that the heats of combination to which Professor Richards called attention were an influence of importance in striking the heat balance in the burning process, but there was also some absorption of heat in other chemical changes that took place within a kiln, and unless these were taken into account as well it would hardly be right for the owners of cement works to call their managers to account for the heats of combination mentioned by Professor Richards. On the other hand, he considered the investigation into the amount of heat lost by the excess of air and through the products of combustion to be of the highest importance. They showed a source of possible economies offering great possibilities, and he was sure that the cement industry was under deep obligation to Professor Richards for pointing them out.

Grinding.—On Wednesday morning, the meeting opened with a discussion of grinding apparatus by Mr. George W. Frazer, of New York. In his introductory remarks he traced the development of pulverizing processes from the earliest types of pestle used by savages down to the apparatus employed at the present time. He pointed out that the grinding processes of to-day are of three general classes: stamping, attrition and grinding proper. In the first the pulverizing is done by impact, and finds its best example in the stamp mills of mining undertakings. Attrition takes place when the materials assist in the pulverizing process by rubbing over each other. Grinding proper takes place between surfaces very close together, so that the pulverizing is mainly due to the action of the abrading stones or other grinding apparatus. He traced the development of these processes in the tube, Huntington and Griffin mills, and explained the principles on which they worked. The Kent mill was next described, and most of the speaker's remarks were concerned with it.

This mill was originally designed by a man sent to the cement works in the Lehigh district to install and operate the older types of grinding apparatus until they were accepted by the purchasers. In the course of this work he evolved the idea of utilizing centrifugal force to hold the clinker in place on the inside of an annular die, rather than to employ it in forcing a set of grinding rolls or other mechanism against the material held in a stationery die. This produced a machine in which there are no stationary parts, somewhat difficult to understand unless examined in the light of its various stages of development. The first mill consisted of a ring die, having its inside surface concave so that at the deepest place about an inch thickness of clinker could be retained. When this ring was revolved with sufficient rapidity the centrifugal action kept the clinker against its inner surface, to which it was fed by a spout. The ring was supported in a vertical position by external rollers while inside it there was a crushing roller drawn against the inner face by powerful springs capable of adjustment. This roller crushed the clinker, which fell over the edges of the ring to the bottom of the casing where the discharge opening was located. The coarser particles of the clinker were forced by the centrifugal action to the lowest part of the concave face and as they became pulverized they were gradually shoved to the edges by the succeeding coarse material.

It was found that this mill was successful as a pulverizing machine, but it proved unsatisfactory on account of its lack of durability. The shafts of the rollers supporting the ring would become crystallized and break in a single working day, although the grinding roll shaft caused no trouble. It was accordingly decided to do away entirely with any external support for the ring and to carry it on rollers placed inside, each provided with powerful adjustable springs. In this way there was none of the shock of grinding communicated directly to the shafts of the rollers and the pressure they exerted on the ring was in a sense equalized. The pressure between the upper roller and the ring was utilized in driving the latter, the roller acting as a driving wheel for this purpose. The shafts of the rollers were themselves mounted in spring-held boxes on the casing of the mill, so that very little jar was communicated to it. A certain amount of longitudinal play was permitted these shafts, just as in the boxes of railway cars, for it was found in practice that such play was necessary for the most satisfactory operation of the machine. By means of these improvements the mill was given a long life and the power required to operate it was greatly reduced. Its capacity depends, of course, on the degree of fineness required in the product and on the character of the clinker fed to it. Mr. Frazer recommended the use of screens with it in many classes of work, and there was some discussion on this subject.

Mr. S. B. Newberry gave some figures of the operation of mills of this type in the cement works at Syracuse, Ind. He stated that they worked well and required somewhat less than 25 horse-power for their operation. The product was finely ground and complied satisfactorily with specifications, but he was not prepared to say yet that the character of the grinding, as respects the proportions of particles of different sizes, was the same as that done in a tube mill. Mr. Daniel McCool stated that the mills of this type at the Newago works were giving good results and he was satisfied with them. The product of the mill was ready for the stockhouse, while the power requirements for running it were low.

The Society of German Portland Cement Manufacturers.—The final paper of the meeting was an account by Mr. S. B. Newberry, of the organization and work of the Society of German Portland Cement Manufacturers. This society was organized in 1877 and its first president held office for about twenty years. At the present time it carries 96 companies on its list of members, of which 84 were German and one American, the last being the Alamo Cement Company, of San Antonio, Tex. The representation is apportioned on the basis of one share or vote per 50,000 barrels capacity per year, and the dues are $25 per share. Mr. Newberry outlined many of the important results accomplished by the Association, such as its work in excluding inferior and adultered cements from the market as Portland cements. He sketched the work done in conjunction with the German government and the Royal Testing Laboratory at Charlottenburg in establishing standard requirements for cement.

In order to add strength and weight to these standards the members of the Association have pledged themselves to sell no cement which does not comply with them, and in order to show that the cement is sold under this guaranty they use a small uniform label on each barrel. This has a picture of the Association's testing laboratory in the center with a band around it carrying the words: "Member of the Society of German Portland Cement Manufacturers." In order that this label and all that it stands for may not fall into disrepute, the Association maintains a laboratory where every year tests are made of the product of the various companies, from samples purchased in the open market. Last year 81 brands were tested, of which all but 3 passed. These 3 fell below the standard requirements slightly and the companies making them were privately notified of the fact. The laboratory cost about $17,500, exclusive of land. It is an attractive concrete building, having on the first floor rooms for the preparation of test pieces and for storing them under various conditions, and for a small experimental kiln. On the second floor there are rooms for chemical and physical testing and an office. The laboratory is under the charge of a head chemist, who has under him an assistant chemist and a number of helpers. The expense of running it is gradually falling and it is hoped before long that it will become self-supporting. It is not only intended for carrying on the work of the Assocation, but is also equipped for conducting investigations for the members who wish to have oils, coals and other materials examined. The laboratory is accomplishing a great deal of good in demonstrating the importance of scientific work in the chemical industry.

The Association has done much of its best work through committees, either acting alone or in cooperation with the government or other organizations. Its commercial committee has accomplished a great deal in the way of securing good freight rates, a satisfactory handling of empty sacks, and particularly in building up the foreign markets for the German cements. In this last field in particular the Association has well shown the powerful influence which hearty cooperation can wield. The committee on normal sand has found and opened a deposit of that material of a uniform quality which must be employed in standard tests. Another committee has been studying for some years the effect of salt water on cement, both pure and mixed with trass and other materials of like general character.

The most interesting work of the Association to the engineering public is the publication of a series of "Proceedings" giving an accurate report of what takes place at the meetings of the organization. These gatherings are characterized by the large number of technical men present and by the discussions of the technical features of cement manufacture and use. No concealment of the proceedings is attempted, and the sessions are open to any one. In order to show the value of the papers presented at the meetings, Mr. Newberry read an interesting summary of a recent one on American cement plants and the rotary kiln.

In opening the discussion of the paper, Mr. Robert W. Lesley stated that when the cement industry was started in America and American cement and American mud were synonymous with many possible purchasers, the "Proceedings" of the Society of German Cement Manufacturers formed the bible of the American manufacturer. After a long day in the works or with callous customers, it was necessary to put in a long evening with the hard German words of these reports, for in them alone could be found the information needed to establish the industry on this side of the Atlantic. Speaking as one of the original manufacturers of Portland cement in this country, he desired to put on record the fact that these volumes of the German society won for him and his associates in those early days a large part of the success which ultimately came to the first American mills.

While he was willing to acknowledge that in one sense the American cement maker was less interested in pure science than in the pure dollar, it could no longer be said that the technical aspect of the cement industry was not receiving due attention. It was everywhere acknowledged that the scientific side of the business must be developed, and he was convinced that one of the best methods of so doing was to continue the presentation of technical papers before the Association of Portland Cement Manufacturers. He desired to emphasize the facts stated by Mr. Newberry concerning the German organization, but to supplement them as well by pointing out that in one year the American society included in its membership a producing capacity approximately as great as that of the older body across the Atlantic, which had been in existence nearly thirty years. In the one year of the American society's growth it had accomplished a great deal with the railroads, it had secured representation with the engineering societies of a national character on joint committees investigating technical aspects of the cement trade, and he hoped very soon to see it reaching out to establish a great foreign market for American cements. Mr. Joseph Brobston spoke briefly on the importance of technical papers at the meetings of the society, for the benefit of those who were mainly interested in the operation of works. In his opinion such papers and discussions would prove of much value to the companies, which would be warranted in sending their technical staff to the meetings to acquire the knowledge which can only be gained by such an interchange of ideas. This view was approved by the members, and will doubtless receive full consideration in the programs of future conventions.

After passing votes of thanks to Vice-president Gerstell for his work as presiding officer, and to Mr. Lesley for the reception already mentioned, the Society adjourned subject to the call of the executive committee.

FIRE PROTECTION has been studied with special care by Messrs. Ballinger & Perrot, the Philadelphia architects and engineers, in their designs for the new Gilmore theatre in that city. This will have a frontage of 89 feet on two streets, of 141 feet on a third street and the fourth side will be on an alley. In addition to the main entrance 28 feet wide, there will be three exits on each side of the parquet, three on each side of the balcony and four on each side of the gallery. The exits from the balcony and tower in each case lead to tower fire escapes at each of the four corners of the auditorium, and each tower contains separate stairways for the people from the gallery and balcony. The stage is 38x65 feet, and will be separated from the wing containing the actors' dressing rooms by a firewall with double tin-lined doors. Over the stage are two metal skylights of one-eighth the stage area, arranged to open automatically in case of fire. Special provision has been made for exits from the dressing rooms to the tower escapes. The floors will all be made of incombustible material, no wood being employed for the purpose. The electric wiring has been so designed that in case the auditorium is dark during the performance, the body of the theatre can be lighted by means of a separate switch in the front of the building. There will also be separate circuits for the red lights indicating exits which burn during the entire performance.

THE USE OF WATER METERS in Brooklyn has been strongly opposed by many of the leading citizens of that borough and for this reason it is the more pleasing to notice in the Brooklyn "Eagle" the following excellent article: "The great reduction of water in the city's reservoirs this week is a repetition of the experience of every winter in which there is a prolonged cold snap. Cold weather endangers water pipes and to save plumber's bills thousands of householders throw open their faucets and let the water run to waste at full head. The waste of 30,000,000 gallons in one day is scandalous and at that rate it becomes a serious menace to the city. It is also evidence of a widespread moral obtuseness. Turning on a faucet is easy and it costs the householder nothing. The remedy is to make it cost something to the man who permits the waste. This recklessness with water in winter is the best reason for the general introduction of water meters. Their use in stores and factories has checked waste and their use in houses would have the same result. The lavish American disposition objects to any possible restriction in the use of water, and the idea of meters in houses has not been popular. Such reckless waste as this, however, may compel a resort to them. The tariff could be so arranged that the ordinary household consumption would come within the present rate while extra charges were made for use above a liberal limit. That would end the all-night-open faucets in winter or summer. Householders ought to have a high enough sense of responsibility to stop the practice without a penalty, but the morals of a man concealed in a crowd are always low. The meter singles him out from the crowd and makes him instead of the whole city responsible for his own conduct." This is the right position to take and if the other newspapers of the city would also adopt it the people would soon come to regard water meters with as little disfavor as gas meters.

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The International Engineering Congress.

There seems to be some misunderstanding concerning the nature and scope of the international engineering congress to be held at St. Louis during the first week in October, under the auspices of the American Society of Civil Engineers. It has never been intended by the authorities of the Louisiana Purchase Exposition or the committee of the Society having it in charge to have the proceedings overlap in any way the congresses of other engineering bodies, but rather to carry out a program similar to that which the Institution of Civil Engineers has adopted with marked success in its engineering conferences. In the preliminary announcement it was distinctly stated that the purpose of the congress was to review, in a general way, the engineering work of the past decade and obtain an authoritative epitome of present practice. The more elaborate discussions of details of practice in the various specialties are left for consideration by the congresses of engineers devoted to those branches. With this object in view the Society's committee having the affair in charge was selected to represent every branch of the engineering profession, as the following list of its members indicates: Henry S. Haines, chairman; G. Bouscaren, vice-chairman; William Metcalf, Benjamin M. Harrod, Elmer L. Corthell, Robert W. Hunt, George W. Melville, George B. Post, Palmer C. Ricketts, George S. Davison, William P. Craighill, M. T. Endicott, Joseph Ramsey, Jr., L. B. Stillwell, M. L. Holman, Joseph O. Osgood, George H. Pegram, Alfred Craven, Hunter McDonald, Chas. Warren Hunt, Secretary; Joseph M. Knap, treasurer. The members of this committee have prepared a list of thirty-seven branches, covering all fields of engineering which can be handled in a broad manner, and have invited eminent specialists to present reviews of the progress in each of them during the last ten years. These papers are to be printed and distributed in advance of the meetings so that it will be unnecessary to read them at the sessions.

In order to indicate how little the character of the proceedings will trespass on the fields of the meetings of other engineering societies, a few of the papers already promised may be mentioned: "Locomotives and Other Rolling Stock," by George Gibbs; "The Substitution of Electricity for Steam as a Motive Power," by James G. White; "The Manufacture of Steel," by William Metcalf; "Pumping Machinery," by Irving H. Reynolds; "Electric Power—Generating Stations and Transmission," by L. B. Stillwell; "Engineering Education," by Robert Fletcher and Calvin M. Woodward. These few titles are selected from a much longer list recently made public, because they indicate the general character of papers representing the special fields of other national engineering societies. It seems safe to say at this writing that many contributions will be received from England, France, Holland and other countries, as well as the United States.

All engineers are invited to become members of the congress, to attend its sessions and to take part in the discussions or send written communications on any of the subjects for consideration, a list of which will be sent on application to Mr. Hunt, whose address is 220 West 57th Street, New York. The membership fee will be $5, which entitles the member to participate in the congress and to receive a copy of the publications in which its proceedings are printed. All members of the American Society of Civil Engineers are members of the congress without any fees or other formalities.

This congress deserves careful consideration by engineers because it bids fair to be representative of the best work in all branches of their profession. The progress in most specialties in the last ten years has been so varied, and so diverse in different countries, that it is eminently desirable to have a union gathering at which there will be an interchange of information concerning the most marked advances all along the engineering line. The information will be furnished in each case by men who have been responsible in no small degree for it, and what they say will therefore be authoritative and free from the detail which less experienced men might wrap about the subject. It is unquestionably true to-day that every engineer must be a specialist, but it is just as true that no engineer can achieve the highest field of usefulness who does not keep in touch with the leading steps of progress outside his specialty. An international engineering congress is a clearing house of such data as are needed for a good understanding of the present resources of the profession, and there is no reason why it should not receive the support of all engineers, irrespective of their specialties.

Costs of Transportation by Rail and Water.

It is a matter of some difficulty to make a precisely accurate comparison between costs of transportation by rail and by water, at least in many cases, for the reason that some elements of the problem cannot be fairly stated or determined for such a comparison. This is particularly the case in comparing the cost of transportation by rail with the cost of transportation by a public waterway such as will be the enlarged Erie Canal whose construction has just been undertaken. It is entirely feasible, however, to make at least some interesting and useful comparisons and draw from them safe conclusions as to those features of either class of transportation which tend to decrease rates. It is perfectly clear, for instance, that if the train-carrying capacity of a railroad is throttled or limited at certain points on its line by heavy grades and sharp curvature so that the train-load is relatively small, the cost of transportation will show high rates per ton-mile. Similarly, an antiquated waterway like the present Erie Canal with its small boats of 240 tons capacity cannot show rates comparable with those of the canal whose accommodations are sufficient for boats four times that capacity or those of the modern admirably adapted and equipped railroad line. It is, or ought to be, obvious that the question of artifical water transportation, such as that afforded by a canal, must be settled by assuming that its facilities have been developed to the same degree of excellence as the transportation upon the modern railroad which parallels it. If the cost of transportation per ton-mile on the enlarged Erie Canal with its increased size of prism and improved methods of propulsion can compare favorably with that of the New York Central Railroad running alongside it, for the same class of freight, it will justify its construction but not otherwise. The same general observation may be made as to natural lines of water transportation such as those of our Great Lakes.

These general features of the comparative costs of the two classes of transportation have been well set forth by Mr. K. W. Blackwell in his presidential address before the Canadian Society at the end of January of the present year. He commented at the beginning on the greater economy in transportation attained in this country than in England or in Europe generally and confined his remarks to the freight rates in Canada and the United States. The lowest rates must necessarily be found in connection with such bulky materials as grain, coal, iron ore and similar products. During 1903 the all-rail routes, from Chicago to Portland, Chicago to New York, and from Brandon to St. John, New Brunswick, ranged from 0.31 cent to 0.37 cent per ton per mile, while the all-rail rate on coal from the Spring Hill Mines, of Nova Scotia to Montreal, averaged ¼ cent per ton per mile. The effect of water transportation upon the average freight rate was shown by stating the combined lake and rail rates between nearly the same points to be 0.21 cent to 0.26 cent per ton per mile. Even with the present condition of the Erie Canal the rate on grain from Chicago to New York by lake and canal was only 0.15 cent per ton per mile, and from Chicago to Montreal 0.23 cent per ton per mile. The exceedingly low rate of 0.09 cent per mile covered iron ore shipments from Duluth to Cleveland. These rates were typical of all. No attempt was made by Mr. Blackwell to give isolated or unusual cases, but to exhibit figures which fairly represent the ordinary or average "every day freight rates." Of course it is understood that no such low rates would apply to mixed freight with short hauls.

The rate of less than 1 mill per ton-mile for the lake haul of iron ore is exceedingly interesting and clearly representative. The transportation of such freight is usually made in boats from 400 to 450 feet long and of 50 feet beam, with a carrying capacity of 6,000 to 7,000 tons or more, the approximate value of such a boat being about $280,000 as given by Mr. Blackwell. He makes a further statement, which is familiar where the circumstances of the lake business are well known, that such boats have made profits with iron ore when the rate was as low as 0.06 cent per ton per mile, which, Mr. Blackwell observes, is less than one-tenth of the average freight rate paid to the railroads of the United States and Canada. Such rates when compared with those paid to the railroads for the same class of freight service thirty or forty years ago are no less interesting than remarkable. The substantial reduction in freight rates has, of course, been but an incident in the great industrial development of the country, but it constitutes a remarkable tribute to the alert and sagacious management of its great railroad properties. As has been stated before in the columns of this journal, the rapid and judicious development of modern railroad transportation in this country has probably never been equaled in the history of the world for energetic efficiency or business wisdom in connection with the industrial development of civilized communities. It may probably be stated within reason that even the low inland water rates of this country are due largely, though perhaps indistinctly, to the unsuspected influence of the low freight rates attained by the railroads rather than the reverse, although there has doubtless been a mutually stimulating effect between the two classes of transportation.

Mr. Blackwell points out the fact that the part of the public directly interested in transporting freight are paying on an average in this country and in Canada about 7 mills per ton per mile, although an enormous volume of mineral and grain traffic shows a rate less than half the preceding. Indeed, the Bessemer & Lake Erie Railroad carrying the greater part of the iron ore reaching Pittsburg from the Great Lakes exhibits an average freight rate of about 4 mills per ton per mile and illustrates what a well-designed road may accomplish in the way of transportation with low grades and easy curvature. The average southbound train load of freight of this railway for the year 1903 was a little under 1,480 tons, while the average for both north and southbound was 913 tons. Roughly speaking, the average train loads of some of the principal freight-carrying railroads in this country for the same year 1903 ranged from less than one-quarter to a little under one-half of these amounts.

These observations have a direct bearing upon the wisdom of the great canal enlargement upon which the State of New York is about to enter. The investigations which were conducted by various committees and commissions preliminary to the State's decision to undertake the work indicated that bulky freight like grain could be carried by the 1,000-ton barge canal at a rate materially less than 1 mill per ton per mile, indeed, at perhaps 0.6 or 0.5 mill per ton per mile. It was also stated at that time that it was exceedingly unlikely that the freight rates of the competing railroads would ever fall so low as 1 mill per ton-mile. The rates which have been quoted and which are based upon the railroad returns for the year 1903 give little ground for believing that the railroads, at least for a great many years to come, can bring their freight rates down anywhere near to those of even such restricted canal navigation as that existing at the present time. In short, so far as the situation can now be gauged it would seem reasonable to expect that the low rates anticipated when investigating the general question of enlargement of the Erie Canal will be at least realized when that enlargement is completed and hence that the State is entering upon a judicious work.

The Union Engineering Building.

The project for a union engineering headquarters in New York has fortunately suffered no setback from the decision of the American Society of Civil Engineers to remain in its present home. Those who are responsible for the management of the undertaking must be relieved that all uncertainty regarding the parties to the joint enterprise is now ended, and the situation so cleared up that it only remains to carry out the details of finance and organization. Mr. Carnegie has confirmed his intention of giving the necessary funds for building purposes in the following note, dated March 14, and addressed to the "Gentlemen of the Mechanical Engineers, Institute of Mining Engineers, Institute of Electrical Engineers, Engineers' Club of New York:" "It will give me great pleasure to devote, say, one and a half million of dollars for the erection of a suitable Union Home for you all in New York City." It is thus settled that the money for the building will be forthcoming as soon as the committee in charge of the work is ready to proceed with construction.

Attention is particularly drawn to the wording of the letter giving this sum, for it should set at rest certain assertions frequently made that this donation is coupled with all the conditions that have rendered unacceptable Mr. Carnegie's gifts of libraries to a number of municipalities. In those gifts the donor has incorporated requirements regarding the unincumbered ownership of the land for the buildings and the annual appropriation of large sums for library purposes. In the present case it would appear that no such conditions have been made, although it is of course possible that certain business details of the gift may have been kept secret for the present for perfectly proper reasons. This is a matter which is entirely in the hands of the gentlemen in charge of the negotiations, and as they are responsible for the outcome, it is at present nobody's affair but theirs how they discharge their onerous duties. It is apparent, however, from various statements made public by the committee that Mr. Carnegie is proceeding with the union engineering home in a very generous manner, assisting the committee in securing the necessary land for the building and urging them to prepare their plans on a broad scale in keeping with the national and professional nature of their respective organizations. These facts clearly show that the undertaking is not to be carried out along the lines of Carnegie libraries in all respects.

It is announced that the building for the engineering societies will probably be a twelve-story structure with a frontage of 125 feet, and will be designed to harmonize with the structure for the Engineers' Club. The following semi-official statement concerning its character has been issued: "There will be four or five auditoriums of different size, notably one to seat 1,200 to 1,500 persons; and all will be appropriately equipped for scientific meetings, lectures and demonstrations. Above all, there will be an engineering museum and a noble library hall, where all the libraries concerned will be grouped and consolidated, yet each section administered by its respective Society librarian and each adding to its own specific literature, so as to avoid duplication of outlay for books or periodicals. It is proposed, moreover, to co-operate intimately with the New York Public Library, nearby, along these lines of work, so that nowhere else in the world can the student or practitioner find thus freely available the whole literature of engineering and technical industry. The three libraries assembled in this manner will even at the outset include some 50,000 volumes, many of them great rarities of inestimable price."

The three organizations which will occupy this building have at the present time approximately nine thousand members, while a number of smaller organizations of a technical and scientific nature have applied for the use of certain of the facilities which the building will afford. These minor organizations are stated to have a membership of approximately five thousand. With about fourteen thousand professional men and scientists on whom to draw annually, as well as the host of men interested in their work and willing to assist with contributions toward the purchase of land for a great technical headquarters, the financial management of the enterprise is one which can present no difficulties to the gentlemen who have managed the business affairs of the three engineering societies and the Engineers' Club so satisfactorily to those organizations in the past.

The Utilization of the Waste Heat from Rotary Kilns.

At the present time there is no question about the interest shown by the men engaged in the cement industry in all changes in plant and methods of production enabling them to reduce the cost of manufacture. When cement is sold at prices but little if anything above the cost of making it in many plants, and with a very slack demand even at such prices, the manufacturer has ample time and incentive to consider every new suggestion for improvements. For this reason attention is drawn to an interesting article in the "Sibley Journal of Engineering" for the current month, in which Professor R. C. Carpenter gives the results of trials of a boiler plant operated in part by the waste heat from rotary kilns. Recent issues of this journal have mentioned the valuable investigations by Professor J. W. Richards of the heat balance in such kilns, and Professor Carpenter's tests are a most interesting supplement to them.

The trials were made at the plant of the Cayuga Lake Cement Company, which is equipped with four sixty-foot rotary kilns. A Wickes vertical water-tube boiler with 3,000 square feet of water-heating surface was installed in connection with each two kilns, and the tests were made with one of these boilers and the connected rotaries. The gases from the latter contain so much carbon dioxide that the boilers were fitted with an external firebox, to furnish any necessary heat in addition to that from the kilns, so located that the combustion would be perfected at a point where the burning fuel would not come in contact with the flue gases. It might be added that these gases contain enough dust to make it necessary to blow off the heating surfaces with a steam jet every five hours, which will be avoided in future plants by a modification in the boilers and their setting. From the boilers the gases pass to an economizer. The details of the trials need not be given in detail in this place, as they are fully reported in Professor Carpenter's paper. It is enough to state that they showed the boiler to be giving 407 boiler horse-power, of which it was calculated that 264 horse-power was produced by the waste heat from the two kilns and the remainder from the coal burned on the grates. When the second boiler was tested, the first received only the heat from the kilns, no coal being used; during this time a measurement of the feed water indicated that the heat from the waste gases was sufficient to produce 254 boiler horse-power, which checks the previous result fairly well.

While this feature of the plant is thus shown to have reduced the losses of operation incident to the waste heat, another novelty did not prove so successful. At the time of the test, the air not used in blowing the powdered coal into the kilns was forced by a blower through the hot clinker into the rotaries. In this manner about four-fifths of the air supply was heated to 480 degrees Fahrenheit and approximately seven per cent. of the heat furnished by the powdered coal was thus saved. As a heat-saving device this system was successful, but it made it difficult to keep the clinker elevators in order and forced dust into the kiln room, in addition to taking up valuable room, and was soon abandoned. This experience is mentioned because it is a good example of the many trials which weary anybody who attempts to introduce improvements in an industry so beset with practical preventatives of theoretical betterments that many who formerly undertook them with confidence are now perfectly willing to let someone else continue the experiments.

It will be noticed that both Professor Richards and Professor Carpenter confine their remarks to kilns using dry raw materials. It is unfortunate that their investigations have not been extended with equal thoroughness to kilns in wet-process plants. It is well known that the latter engineer has made some very important changes in the kilns designed by him for wet raw materials, and it is to be hoped that he will make a test of them and publish the results. In the Great Northern plant, for example, he has made no attempt to use the heat from the rotaries in boilers, but has lengthened the kilns instead to 120 feet and utilized the upper part as a dryer, following much the same plan that has been adopted successfully in another Michigan plant. In the wet process it is sometimes necessary to evaporate from the slurry from 900 to 1,500 pounds of water per barrel of finished cement, and it is manifest that in such evaporation there is a fine field for the utilization of the waste heat about the works. It is this water which must be driven off that forms the greatest source of extra expense of the wet process as compared with the dry, and it has received much careful study of late that might very well be outlined in papers before the Association of Portland Cement Manufacturers or some similar organization.

Notes and Comments.

Tunneling will shortly find its most important exemplifications in the vicinity of New York. The work for the New York Rapid Transit Railroad Commission under the East River to Brooklyn has already been described in this journal, and the same is true of the twin tunnels across the North River from the vicinity of the Hoboken ferry station on the Jersey shore. The north tunnel of this latter undertaking is now practically finished and parties have crossed below the river in it, although the construction of the approaches remains to be done. Then there are the twin tunnels under the same river to the neighborhood of Cortlandt Street, on which nothing has yet been done. More important than any of the others, however, will be the Pennsylvania Railroad tunnels under the North and East rivers and across Manhattan island. It was announced last week in this journal that the contract for the construction of the North River section had been awarded to the O'Rourke Engineering Construction Company. Since then the East River section has been awarded to S. Pearson & Company, Ltd., which has already been connected with such work in the vicinity as contractor for a part of the Hoboken tunnel. Mr. E. W. Moir, who was lately in New York with Sir Weetman Pearson organizing his forces, was in charge of that work, and since then has been connected with some of the most important tunneling operations in Great Britain. Finally, there will be the important connecting work of this sort across Manhattan island, which, it is understood, will be carried out by Mr. William Bradley. For variety of difficulties, magnitude of operations and interest to the public, the tunneling about New York has never been approached, and the young men who find employment in it have reason to be congratulated on their good fortune in having such an opportunity to secure valuable experience.

The New York High-Pressure Water-Works, described elsewhere in this issue, in a report by Mr. Nicholas S. Hill, Jr., chief engineer of the Department of Water Supply, Gas and Electricity, differ from other projects in a marked manner. In the first place Mr. Hill proposes to use in the pumping stations multi-stage centrifugal pumps driven by electric motors, thereby saving about two-thirds of the land needed for a gas-operated station and greatly reducing the cost of the installation, according to the figures he gives. In the second place he contemplates using fresh water from the large street mains to feed the pumps, instead of using salt water, although provision is made for employing the latter whenever it is necessary. He states that there is plenty of fresh water available for the purpose, which is fortunate because the salt water about the New York wharves is so polluted that when employed in the past for sprinkling streets its odor was too gamey for even the longshoremen and its use is correspondingly undesirable. At the present time about one-tenth of one per cent. of the water furnished the city is employed for extinguishing fires, which indicates how small an influence fire protection has on the amount needed annually. The third important feature in which Mr. Hill's report differs from others of recent date is in his very conservative recommendation to investigate all possible sources of a high-pressure supply before adopting any plans calling for such works as those outlined by him. Although nowhere so stated, it is evident that he has in mind the admirable fire protection which will be afforded by the works recommended by the Committee on Additional Water Supply. It goes without saying that those works will be ideal for all purposes. But it will be many years before they are constructed, while the plans Mr. Hill has suggested can be executed within a year at a cost probably within 4 per cent. of the direct loss in the Baltimore fire. In view of the reduction in premiums which such a fire-protection system would bring about, with the increased security of conducting business in the most important section of the city, the immediate construction of the works is manifestly desirable. They should be installed as a temporary expedient until the new system for an additional supply is completed, which will probably be ten years hence at the earliest estimate.

The Northern Securities Decision of the U. S. Supreme Court on Monday of this week proved conclusively in an indirect manner how far from its once proud position of the nation's financial barometer Wall Street has now drifted. For months the reports emanating from that region have been tinged by the shadow of this famous litigation. As the price of stocks slipped lower and lower, the explanation was that the investors of the country were afraid of the action of the court on this case and were hanging off until the decision was made. The judges at Washington have declared the holding company scheme illegal, but the only result of the decision was, strange enough, to run up the quotation of Northern Securities shares somewhat. There has been no change in the financial system of the country, the Northern Pacific, Great Northern and Burlington trains are running just the same as they did last week, and while the men in charge of the financial problems of these great railways certainly have some hard work cut out for them, the country at large is not affected at all. Down in Wall Street it is now recognized that another bogie man must be discovered to explain the failure of the public to speculate at the bargain counters of the brokers, for it would never do to say that business conditions are now in a sane condition and the average man has learned that he will be better off and sleep easier by minding his own business than by fooling with indigestible securities. Just as a matter of record it may be added that this decision establishes three facts: First, the authority of Congress over interstate commerce is subject to no other restrictions than those set forth in the Constitution and is not reviewable by the courts. Second, any agreement by which the operations of two or more parallel and competing railways engaged in interstate commerce are controlled by a single corporation is a combination in restraint of trade and contrary to the Sherman anti-trust law. Third, actual restraint of trade need not be shown; possession of power to commit a prohibited act is equivalent to the commission of it. There are many other important decisions in the majority report, but these three are the fundamental rulings.

An American Steam Thresher made a triumphal march through Damascus recently, according to U. S. Consul Ravndal. It was imported by Abdul Rahman Pasha, superintendent of the annual pilgrimage to that city, who owns a number of large estates which he is endeavoring to administer on modern lines. On its way from the city into the country, the thresher broke down many bridges, but pulled itself and its train out of the creek beds beautifully, and eventually had the honor of being started in the presence of the governor-general of the province, the field marshal of the fifth army corps and many other distinguished men.

The U. S. Steel Corporation's Report for its second year shows a falling off in all its work in 1903 as compared with 1902. The tonnage statistics are as follows:

	1903.	1902.
Ore mined	15,363,355	16,063,179
Coke produced	8,658,391	9,521,567
Pig iron	7,123,053	7,802,812
Steel ingots	9,167,960	9,743,918
Finished products	7,635,690	8,197,232

Orders on hand at the close of 1903 were for 3,215,000 tons as against 5,349,000 tons the previous year. It is important to bear these figures in mind when considering the various stories in circulation about the corporation's affairs. It is absurd to expect any company to make as much money when business is at its normal amount as during boom periods. This corporation is proceeding about the binding together of its vast interests in a methodical manner, and while it is not doing as well now as it might had its organization developed like that of the Standard Oil Company, for example, it is altogether too healthy to warrant anybody shying any bricks of sarcasm at it.

Kirtland Street Pumping Station of the Cleveland Water Works.

By Charles Goffing, C. E., assistant engineer in charge of construction and repairs of buildings and machinery.

The city of Cleveland, Ohio, having built a new water supply tunnel, descriptions of which have appeared in various issues of this journal, it became necessary to provide an entirely new pumping plant. This plant is on the lake shore at the foot of Kirtland Street, about three miles east of the mouth of the Cuyahoga River. This location was chosen because it is about in the center of distribution in an easterly and westerly direction, and the land possessed the further advantages of being but a little above the lake level and adjoining the tracks of the Lake Shore & Michigan Southern Railway, 38 feet above the grade line of the finished grounds. The station has been built large enough to contain four triple-expansion pumping engines with the necessary boilers, auxiliaries and coal supply. The building contains at present two new Holly pumping engines and two old Knowles pumps moved from another station. The accompanying drawings give a general plan and section of the station, showing arrangement of machinery.

Kirtland Street Pumping Station, Cleveland, Showing Trestle for Coal Cars and Temporary Trestle for Unloading Pumping Machinery.

Station Buildings.—The engine house is 150 feet in length and 65 feet in width inside, excepting the central portion which is 75 feet wide. As the excavation for the foundation was in soft clay and extended to a considerable depth below the lake level, it became necessary to construct a heavy coffer dam surrounding the site of the building. The coffer dam was made of 12x12-inch tongued and grooved pine sheet piling 24 feet long. The enclosed area having been excavated, oak piles varying in length from 25 to 40 feet were driven by steam hammer to the total number of 1,280, forming the supports for the building walls and also for the engine foundations. These piles were capped with 12x12-inch oak timbers secured by drift bolts. The spaces between the grillage timbers were filled with Portland cement concrete extending down 2 feet below the tops of the piles. The engine foundations are of shale brick 5 feet thick capped by a course of sandstone 2 feet thick. The building walls were started upon a sandstone footing 18 inches thick laid upon the timber grillage and were carried up with shale brick to a point 8 feet above city datum. Above this point sandstone was used, forming the rock-faced foundation courses showing on the exterior of the building above the grade line. The foundation walls of the building have been made exceptionally heavy as they have to act as retaining walls against a bank of soft clay and made ground 21 feet high. The distance from the bottom of the engine pit to the main floor line is 24½ feet, and from the main floor line to the ceiling is 53 feet. The roof has steel trusses covered with I-beam purlins, upon which are placed wooden rafters. The roof covering consists of 1⅛-inch matched sheathing, upon which are laid Ludowici roofing tiles. The bottom chords of the roof trusses support a ceiling made of Georgia pine laid off in panels about 16 feet square, by means of false beams built around the bottom chords of the trusses.

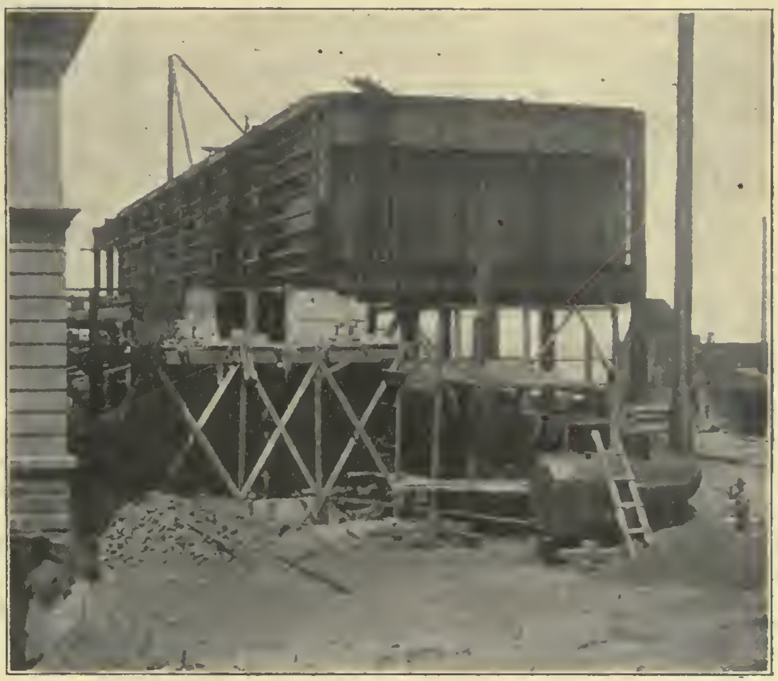
The exterior of the building is faced with Darlington gray pressed brick up to a stone belt course, above which it is faced with Darlington brown pressed brick. The trimmings are of blue Amherst sandstone. On the interior the walls are faced with white and brown enameled brick for a height of about 7 feet above the engine room floor, and above that with Darlington buff face brick. The trimmings on the interior are of terra cotta of the same shade as the brick. The main floor of the building has a frame work of I-beams carrying brick floor arches leveled up with the concrete and finished with white vitreous floor tiles. In order to prevent the transmission of vibrations, the floor has no connection whatever with the engines. To admit light and air to the basement, large openings or well-holes are left in the floor. All openings are enclosed by polished brass hand rails secured to polished steel stanchions. The engine beds and the openings in the floor are surrounded by cast-iron plates. At a level 21 feet above the main floor there is a balcony surrounding the entire interior of the building, and there is a second balcony around the interior of the building 10½ feet below the main floor. This balcony affords access to the three passageways connecting with the boiler house and to the discharge pipes from the engines; it also carries two small rooms, one of which is used as a lavatory and the other as a dressing room. A third balcony, 7 feet above the level of the engine pit, furnishes a crossing over the 48-inch suction pipes running from the engines through the building walls and connects with the balconies in the water ends of the Holly engines and the balcony surrounding the two Knowles engines. To provide drainage from all points of the engine pit, gutters were cut into the concrete between the engine foundations and covered with cast-iron gratings. These gutters terminate in a sump well from which the water is removed by a bilge pump and discharged into the sewer. The building is equipped with a 25-ton hand-power traveling crane built by the Brown Hoisting Machinery Company, of Cleveland. The steelwork used in the roof trusses was furnished by the Variety Iron Works Company; the steelwork for the floors and balconies, together with the hand railings, was furnished by T. H. Brooks & Company; the foundations of the engine house, boiler and coal storage house and chimney were built by the C. H. Fath & Sons Construction Company, and the superstructures for these buildings were erected by John Gill & Sons, all the contractors mentioned being Cleveland concerns.

The boiler and coal storage house is a building 171 feet long and 82 feet wide, interior measurement. This building can be considered as divided longitudinally into two parts, the westerly portion being occupied by the boilers and the easterly portion being constructed of a heavy frame work of steel columns supporting the coal bin and the track for the coal cars. As the excavation for this building was shallow the sheet piling used for the coffer dam was only 6 inches thick. There were 1,224 oak piles from 35 to 38 feet in length driven in this excavation to support the building walls, the piers for the coal bin and the boiler foundations. The piles supporting the building walls and piers were capped with 12x12-inch timbers and surrounded by concrete, the same as in the engine house. The piles driven in the area covered by the boiler foundations were not capped with timbers, but were surrounded and covered with concrete. The building walls and piers were built of shale brick and sandstone, the same as described above for the engine house. The walls of the superstructure are faced on both sides with pressed brick.

There is a basement under the main floor of the boiler house extending under the entire building, which contains the stoker engines, line shaft, track for ash cars and main steam pipes. The smoke flue, faced on the outside with buff pressed brick, extends the entire length of the boiler house and is carried upon lattice columns above the main floor. The main floor consists of I-beams supporting brick arches, leveled up with concrete with cement finish. The roof of this building consists of steel trusses upon which trussed purlins are laid. The purlins support tee irons spaced 24 inches center to center carrying book tiles 3 inches thick. The roof is covered with Ludowici roofing tiles, the same as the engine house. The steelwork for the boiler house and coal bin was furnished by the Van Dorn Iron Works, of Cleveland.

The coal storage bin has 6-inch Z-bar columns carrying the bin floor, the floor supporting the track for the railroad cars and the latticed columns supporting the roof trusses. The bin floor is made of plate girders riveted to the main columns and supporting 15-inch I-beams covered with 5/16-inch steel plate. The sides of the bin are made of I-beams supported by the main columns and lined with 5/16-inch steel plate. The track floor is made of plate girders, built into the main columns, carrying track stringers of 24-inch I-beams, across which 7-inch I-beams spaced 2 feet 8¼ inches apart are laid and support steel deck plating and track rails. The space between the rails and for 2 feet 3 inches each side of the track is covered with a grating of steel bars spaced 3 inches from center to center. The coal is delivered in hopper cars, which are switched into the building over a steel trestle connecting with the Lake Shore & Michigan Southern Railway, the track floor being at the same elevation as the railroad. As nothing but slack coal is used at the station, it must all pass through the grating mentioned above. The cross-section of the bin is rectangular, as it was desirable to obtain the maximum amount of storage capacity in the available space. The bottom of the bin is provided with hoppers terminating in spouts leading to the magazines of the chain-grate stokers.

Header for the Discharge Pipes from the Pumps.



The Coal Storage Bin during Erection.

The side-track trestle connecting the boiler house with the railroad tracks is built on a curve and consists of three plate-girder spans carrying a double track. There are two concrete piers built on pile foundations supporting two steel towers. The plate girders are 6 feet in depth, and there are four girders to each span. The solid floor placed upon the plate girders consists of troughs made of 8x5/16-inch plates filled with cinder concrete. Stone ballast is placed upon this floor carrying the ties and rails. The substructure for the side track was built by John Gill & Sons, and the superstructure was built by the Variety Iron Works Company. The concrete abutment was built on a pile foundation at the foot of the slope from the Lake Shore railway. The side track from the abutment to the railway is carried on embankment.

The brick chimney is 9 feet in internal diameter and 200 feet high from the ground line. It is supported on 169 oak piles averaging 35 feet in length, and is faced on the exterior up to a stone belt course with Darlington gray pressed brick and above this with Fallston brown pressed brick. The chimney has a core wall extending to the top and is lined with fire brick to a height of 70 feet. The top of the stack is covered with a heavy cast-iron cap. The chimney was built by the C. H. Fath & Sons Construction Company.

A sea wall guards the station grounds on the lake side. The site consisting mostly of made ground directly on the lake front, it became necessary to build a jetty into the lake to form a protection from the seas. The jetty is built of two closely driven rows of oak piling 10 feet apart. These are capped with timbers and tied together with timber and iron rods. The jetty is filled with small pieces of limestone and is protected on both sides with large riprap stone laid on brush mattresses. The jetty extends into the lake for a distance of 220 feet beyond an old pile sea wall; then an angle of 90 degrees is made and it extends easterly for a distance of 550 feet. The space inside of the sea wall will eventually be filled with the ashes from the boilers of the station. The jetty was built by the Standard Contracting Company.

Aqueducts, Screen Well and Pump Wells.—The shore shaft of the lake tunnel sunk in 1896 was not in a convenient location to connect with the suction pipes of the engines, and so another shaft, called shaft No. 5, was sunk on the line of the tunnel 163 feet from shaft No. 1. From this shaft an aqueduct 7 feet in diameter was built with its flow line at an elevation of 27 feet below city datum, connecting with four pump wells containing the suction pipes for four engines. This aqueduct was built by tunneling, and is lined with three rings of shale brick laid in Portland cement mortar. A sluice gate 7 feet in diameter, made by the Michigan Brass & Iron Works, of Detroit, Mich., was placed on the line of the aqueduct in a gate shaft adjoining shaft No. 5 A screen well 12 feet in internal diameter was placed immediately beyond the sluice gate. This shaft contains screens of copper wire secured to wooden frames 4 feet high and 12 feet 6 inches long. The aqueduct connects with the pump wells by branches 4 feet in diameter. The pump wells are 12 feet in internal diameter, and their bottoms are 27 feet below city datum. The pump wells and the screen well are built of four courses of shale brick inside of riveted steel shells provided at their bottom edges with cutting shoes. The wells were settled into place by excavating in the interior, and weighting them with pig iron. Each of the four pump wells is provided with a 48-inch sluice gate placed on the connection with the aqueduct and bolted to the steel shell surrounding the well. Each gate is operated by means of a vertical hand wheel from a platform placed inside of the well. These gates were furnished by the Kennedy Valve Manufacturing Company, of New York. Vulcanite Portland cement was used for all concrete and mortar in the station, aqueducts and wells. The aqueduct and wells were built by the C. H. Fath & Sons Construction Company.

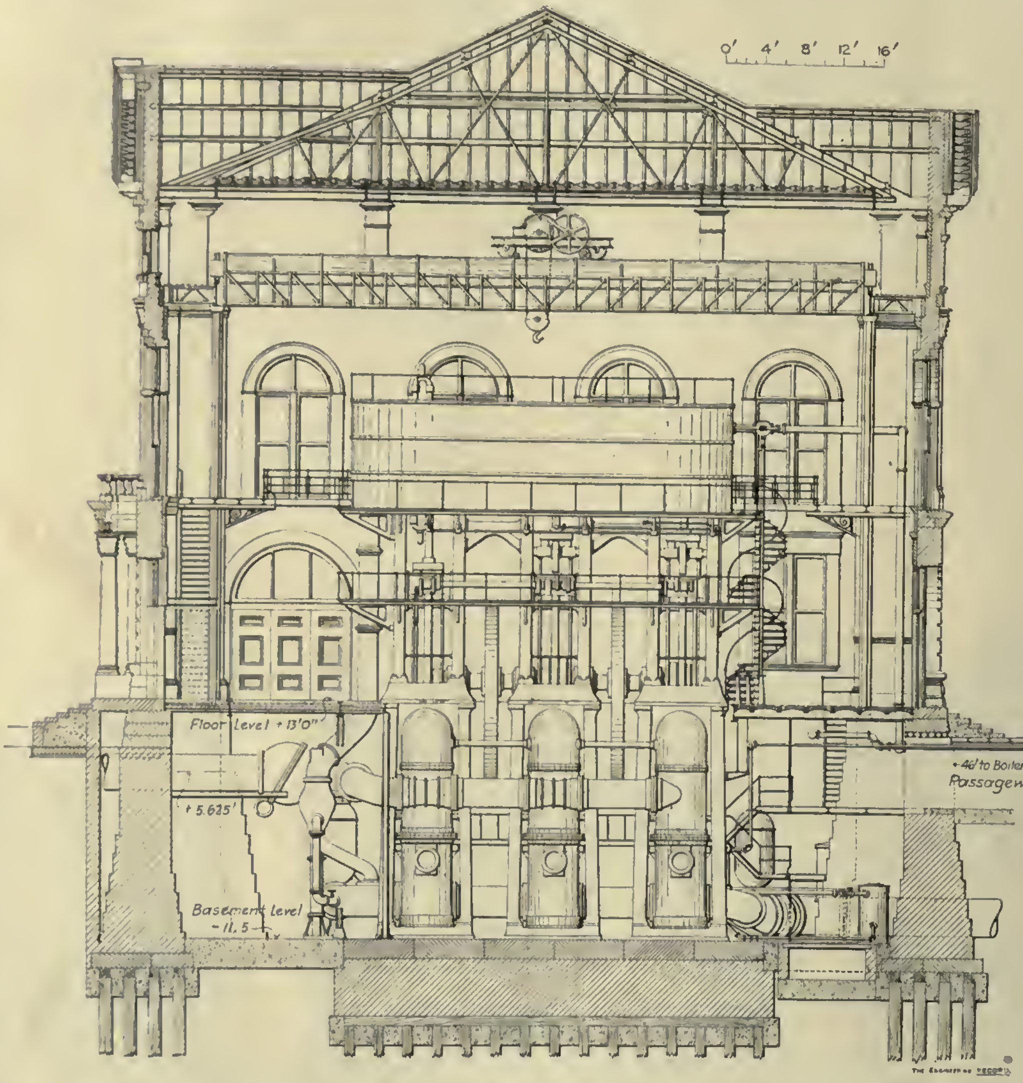
Pumping Engines.—The engine house has been provided with four foundations for vertical, triple-expansion pumping engines of 25,000,000 gallons daily capacity each. In the year 1900, a contract was made with the Holly Manufacturing Company for two such engines. The engines are of the self-contained type, the main engine bases resting partly upon the valve chambers and partly upon heavy iron legs, or A-frames. The legs, valve chambers and pump barrels are supported upon heavy cast-iron subbases. Each of the three pump barrels of each engine has two valve chambers. The water valves are all placed in separate valve cages, there being six cages to each valve deck. The plungers are 36 inches in diameter and the stroke is 60 inches. The main shafts of the engines are made of fluid-compressed steel and are 17½ inches in diameter at the bearings. Each engine has two fly-wheels 20 feet in diameter. The three steam cylinders are 32, 60 and 90 inches in diameter, respectively, both the barrels and the heads being provided with steam jackets. The valves are of the Corliss type, excepting the exhaust valves of the low-pressure cylinders which are poppet valves. The engines will be run with steam of 150 pounds pressure superheated from 100 to 150 degrees Fahrenheit. The average total head of water against which the pumps will have to operate is about 82 pounds. The engines are fitted with jet condensers taking the cooling water from the suction pipe. The air pumps discharge the water into a 24-inch cast-iron pipe running lengthwise of the building, connecting with all the engines and extending to the lake. The suction pipe of each engine is 48 inches in diameter. The suction pipe as it approaches the engine is divided into two lines by means of a Y, one line connecting with the valve chambers on one side of the engine and the other with the valve chambers on the other side. The suction pipes are again connected at the further end of the engine and provided with a large air chamber, and there is another air chamber on each suction pipe between the engine and the pump well. There are two discharge pipes 30 inches in diameter each, connecting the chambers on one side of each engine, the two being combined beyond the engine into a 42-inch pipe provided with a check valve. One of these engines was put into service pumping water from the new tunnel on February 1, 1904; the other engine was started on February 28. Duty trials on each engine will probably be made some time this spring.

The average daily consumption for the city is in the neighborhood of 60,000,000 gallons, whereas the combined capacity of the two Holly engines is 50,000,000 gallons. As it became very desirable to obtain the entire water supply of Cleveland from the new tunnel at as early a date as possible, it was decided to move two Knowles horizontal direct-acting duplex pumping engines of 15,000,000 gallons daily capacity each from the old Division Street station and place them on the two unoccupied foundations in the new engine house. This was done because it would have taken several years to complete the equipment of this building with modern engines the same as the two Holly engines now installed, whereas it consumed only a few months to move the old engines. The two Knowles engines are placed upon brick piers about 8 feet high above the engine pit. These engines require steam at but 60 to 70 pounds pressure. The steam as furnished by the boilers at 150 pounds is passed through a 5-inch Foster reducing valve for each engine. One of these engines was started on February 5.

Boilers and Steam Piping.—The boiler house is provided with foundations for ten boilers, six of which have been installed in three batteries of two boilers each. The boilers are the water tube type, furnished by the Babcock & Wilcox Company. Each has 2,700 square feet of tube heating surface. The tubes are of seamless steel expanded into forged steel headers. Each boiler has a set of superheating tubes suspended below the drums. The boilers are fitted with Babcock & Wilcox chain-grate stokers, having a grate area of 60 square feet for each boiler. There are passageways 9 feet wide between the batteries. The brick walls of the boiler settings are faced on the exterior with Kittanning buff pressed brick of the same shade as those used for the interior finish of the building. The ashes discharged from the chain grates accumulate in steel hoppers, and in the basement are drawn from these hoppers by means of valves into steel side-dump ash cars of about one cubic yard capacity. The ash cars are elevated to the level of the ground by a hydraulic elevator placed in a pit just outside of the boiler house. The ashes are used to make additional land for the pumping station grounds.

Each boiler has two steam outlets, one directly from the drums and the other from the superheater. These two outlets are combined through two 8-inch angle valves into a single 8-inch outlet. These two valves afford a means for regulating the amount of superheat of the steam, as any amount of saturated steam can be mixed with the steam from the superheater. The 8-inch outlets are provided with 7-inch Foster non-return emergency hand stop valves, arranged so as to close automatically in case of the bursting of a boiler tube or the rupture of the steam main at any point. The steam after leaving the Foster valves passes through large U-bends of 7-inch extra heavy pipe to a steam header placed below the main floor of the building and supported upon latticed columns. Owing to the high temperature of the steam an unusual amount of expansion had to be allowed for. The steam header was therefore divided into a number of sections and provided with Wainwright corrugated expansion joints, each section of pipe being held rigidly at one point by a strong anchor bracket. From the header in the basement of the boiler house the steam is carried to the engines through four 8-inch steam lines passing through the covered passageways connecting the two buildings. These lines also are provided with expansion joints and anchor brackets. The pipes to the engines are connected with the header in the boiler house at such points that the steam output of any battery of boilers may be separated by means of valves from that of the remaining boilers for making tests and for other purposes.

The feed water is taken from the air pump discharge of each engine and passed through 500-horse-power Cochrane open feed-water heaters. From the heaters the water is pumped by means of independent feed pumps to the feed-water system. There are four heaters and four feed pumps. The feed pumps are controlled by pump governors placed in the steam supply to each pump and are also controlled by the feed water pressure. The amount of water fed to the boilers is controlled by six Squires feed-water controllers. All the feed piping to the boilers is of extra heavy brass. All the exhaust from the feed pumps, air compressors and electric light engine is discharged into an exhaust main connecting with all the feed-water heaters. The returns from the steam jackets and from the heating system of the building are also taken to the feed-water heaters. As the amount of exhaust steam available at the station will not be sufficient to heat the water in the feed-water heaters to a temperature necessary to precipitate impurities, a connection is made to each heater for admitting live steam. The steam piping was furnished by the Cleveland Steam Fitting & Supply Company.

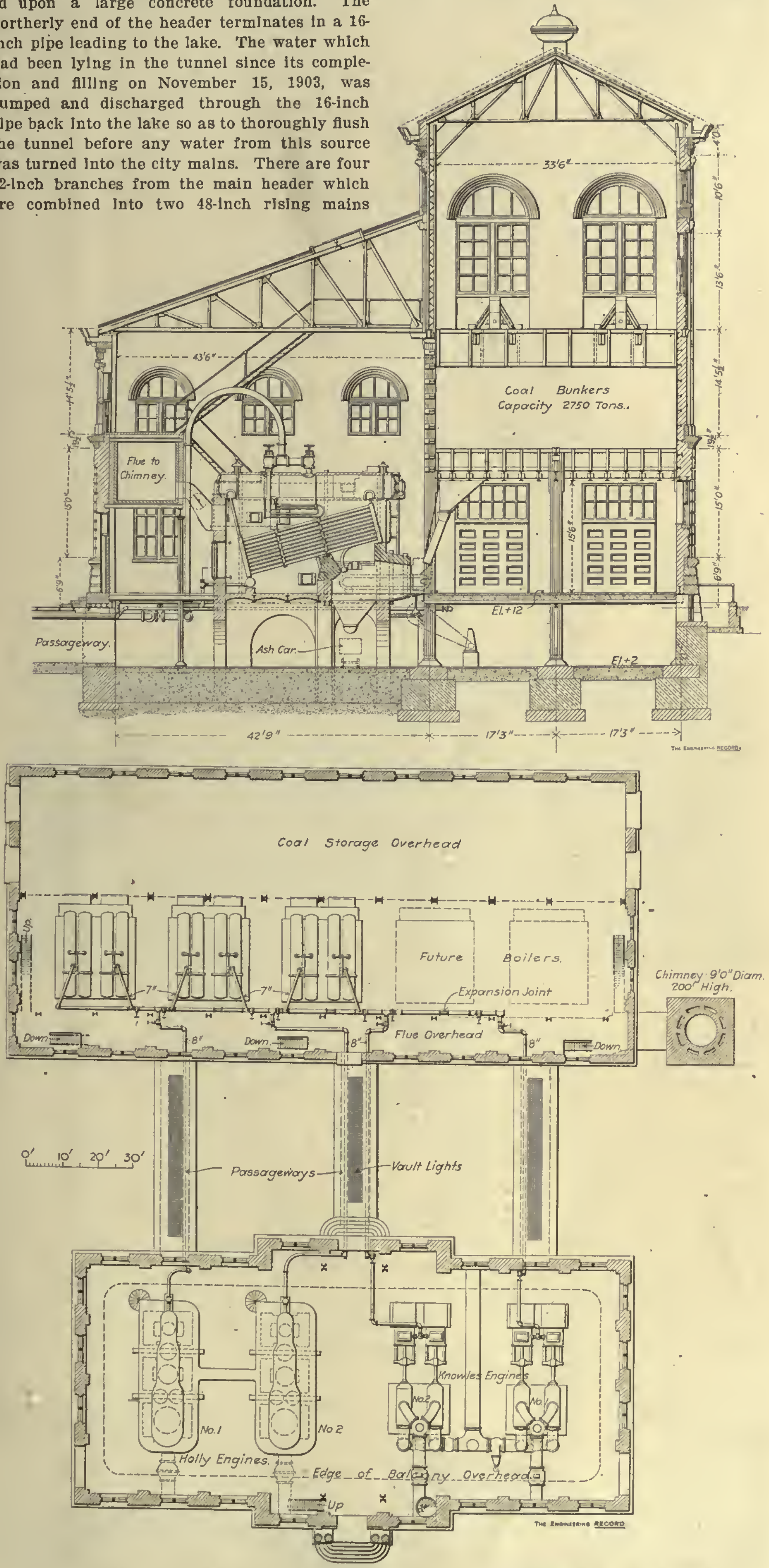


Section through Engine House, with Passageway to Boiler and Coal House, Shown Opposite.

Lighting Plant.—It is the intention to install two direct-connected units of 50 kilowatts capacity each to furnish power for lighting the station. At present, however, the power is furnished temporarily by a direct-connected unit of 25 kilowatts capacity placed upon the main floor of the engine room. A marble switchboard adapted for use with the two 50-kilowatt units to be installed later on and provided with the necessary distributing switches is placed on the main floor near the generator. All the wiring of the station is placed in iron conduit. The lighting of the engines and basements is accomplished by means of incandescent lights hung from the balconies. The general illumination of the engine house is by means of ten arc lamps placed close to the ceiling and twenty-two clusters of five incandescent lamps each, placed on the brackets supporting the balcony surrounding the interior of the building. The lighting of the boiler house will be accomplished partly by arc lamps and partly by incandescent.

Discharge Mains.—The discharge pipes from the four pumps are combined on the outside of the building into a header 48 inches and 42 inches in diameter. The header, a portion of which is shown, is of cast-iron, and all the joints are made by means of flanges bolted up with thin lead gaskets. The header is supported upon a large concrete foundation. The northerly end of the header terminates in a 16-inch pipe leading to the lake. The water which had been lying in the tunnel since its completion and filling on November 15, 1903, was pumped and discharged through the 16-inch pipe back into the lake so as to thoroughly flush the tunnel before any water from this source was turned into the city mains. There are four 42-inch branches from the main header which are combined into two 48-inch rising mains leading up the slope and into the supply system of the city. These mains are made of riveted steel pipe on the hillside and for a distance of 290 feet beyond the Lake Shore & Michigan Southern Railway. This construction was used so there might be no rupture of these mains at this point. Any break occurring on one main would cause a very serious washout, and as the two mains are laid parallel and only 32 feet apart, it might settle the other main and also cause it to break, which would mean the shutting down of the entire station. Both discharge mains are equipped with recording gauges so as to obtain a continuous record of the water pressure. All cast-iron pipes and specials were furnished by the United States Cast-Iron Pipe & Foundry Company. The riveted steel pipe was furnished by the Cleveland Steam Boiler Works. All this pipe was laid by the water works department.

The total cost for the construction of the station, not including the lake tunnel, is about $900,000. Professor Edward W. Bemis is superintendent of the water works. The design and construction of the station has been in charge of Mr. C. F. Schulz, first assistant engineer, and the writer. The construction has been supervised by Mr. E. C. Cooke, resident engineer.



Plan of the Kirtland Street Pumping Station, Cleveland Water Works.

A Concrete-Steel Floor Test at Cincinnati.

An unusual test of a concrete-steel floor was made in Cincinnati on March 5 at a building which is in course of construction for the American Brick Company by the Ferro-Concrete Construction Company of that city. During a recent cold snap, the surface of the concrete floor of the second story of the building was frozen and the top quarter of an inch scaled off. Doubt was expressed concerning the ability of the remaining concrete to fulfil the requirement in the specifications which calls for a sustaining capacity of 200 pounds to the square foot, so the floor was tested with the results given below.

The floor system is a continuous slab of reinforced concrete 2⅞ inches thick, supported on reinforced concrete beams 7½ inches wide, 18 inches deep below the ceiling and 16 feet 2 inches long in the clear, spaced 5 feet 8 inches on centers. About 2 inches above the bottom of each beam there are two twisted bars, one 17 feet long and 1¼ inches square, and the other ¼ inch square and 10 feet long. Stirrups are used in each end of the beam. The floor slab is reinforced both laterally and longitudinally with ¼-inch bars, those parallel with the floor-beams being untwisted and the others twisted.

To ascertain the condition of the concrete a bottomless box 68x17½ feet was built around the portion in dispute. This box was filled with dry sand 3½ feet deep. The loading was started on February 26 and was practically completed during the following day. Heavy rains for several days materially increased this weight, which had already reached 320 pounds to the square foot, 120 pounds more than the requirement. The total weight of the sand was a little over 188 tons, to which should be added that of the water, possibly a ton more.

Wooden uprights 2 inches square were placed in line on the center of the floor and a transit was set up to take the deflection, a bench mark being established on one of the column rods projecting above the floor. The floor showed a deflection, when the total load was applied, of about ⅛ inch, but it was then discovered that the transit was slightly out of adjustment. As the bench mark and the post at which this deflection was taken were approximately the same distance from the transit, the results were practically correct. As a check, two deflectometers were placed under the floor when it was loaded and remained under during the time the floor was being unloaded. These instruments showed a difference in elevation of 3/32 inch between the loaded and unloaded floor.

The Canadian Pacific Railway Shops at Montreal.

PART I.—POWER-PLANT, ELECTRIC INSTALLATION, TRANSPORTATION, WATER SYSTEM, HEATING, GENERAL CONSTRUCTION AND EQUIPMENT.

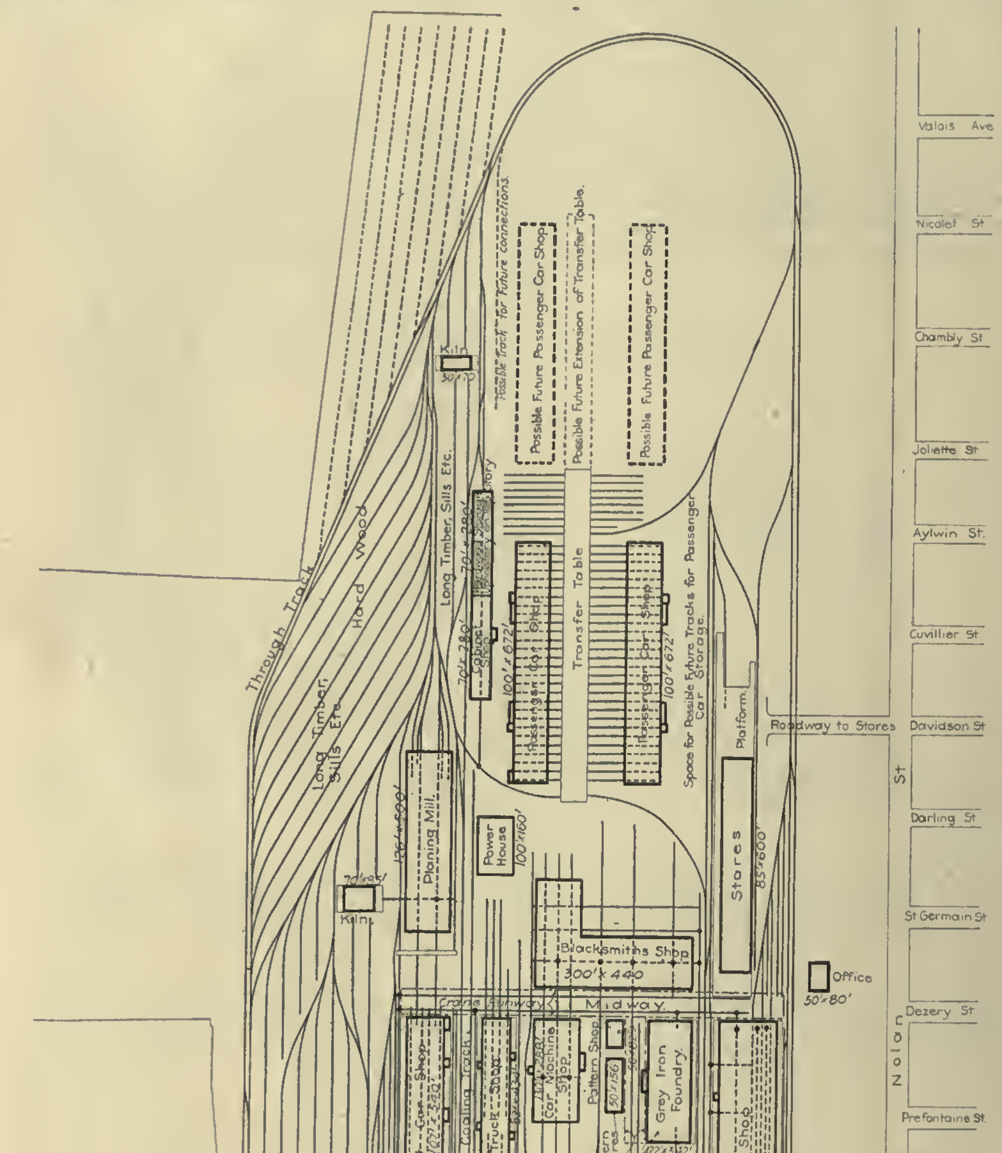
About twenty-five years ago the Canadian Pacific Railway established its principal construction shops at Hochelaga, which was then a town about 2½ miles from the Montreal station. Cars and some locomotives were built in these shops, but after a time they became inadequate for the new and repair work on the rolling stock for the company's system, which now aggregates about 12,000 miles of track and has approximately 900 locomotives and many thousands of passenger and freight cars in service. The design of an entirely new plant was, therefore, intrusted to Mr. Henry Goldmark, M. Am. Soc. C. E., and the construction is now being carried on by him under the general direction of Mr. E. H. McHenry, chief engineer of the Canadian Pacific Railway. The plant and storage yards occupy a site of about 200 acres on high ground in Hochelaga ward, Montreal, 1½ miles from the old shops, which will be dismantled, the best machinery being transferred to the new buildings. There will be in all about twenty principal buildings, with a total roof surface of 20½ acres. The new works will have a capacity to repair 400 or 500 locomotives in service and to build about 100 new locomotives, 500 new passenger cars and 7,000 new freight cars a year. Employment will be given to about 5,000 men.

An important feature in the design of this plant is that it will be able to produce the full output as soon as it is put in operation; for although the buildings have liberal space around them and may be considerably extended, they are being made complete at the outset and are adapted for a volume of work determined by experience at the existing shops. The construction was planned to be durable and to withstand the severities of the climate The principal features have been carefully adapted and combined from large existing plants studied by the designer. The main lines of transportation, the crane girders, the apparatus for heating and light, and the hydraulic and pneumatic systems, however, were determined by the designing engineers.

The main features of the plant were decided and the preliminary studies and designs were commenced in the early part of 1902. Ground was broken in September, 1902, and, at the date of this writing, all the principal buildings are under cover and the installation of machinery has been commenced in many of them. A total expenditure of about $4,000,000 will have been made when the plant is fully equipped. It is intended to make this plant a model for locomotive and car building works and to equip and operate it so as to secure a large output and high grade of work at a cost minimized by convenient arrangement and adequate facilities. That this plant is considered thoroughly satisfactory is attested by the fact that the Canadian Pacific Railway Company has already commenced construction of an exactly similar one of about one-third its capacity at Winnipeg, which will be chiefly used for repair work necessary on the western divisions.

The site is about 4,600 feet long by 1,800 feet wide, and its irregular surface has been leveled. The shops are most of them comparatively long and narrow with their longitudinal axes all parallel to the long side of the site. The main lines to Quebec border one end of the site, to which they are approximately at right angles.

Transportation.—The shops are arranged in two principal groups on opposite sides of a transverse passageway about 80 feet wide, near the center of the site. This street is called the Midway and has no surface tracks, except those which intersect it at right angles and longitudinal lorry tracks. It is commanded, however, by a 10-ton electric traveling crane which spans the full width and has a runway 1,000 feet long intersected near the middle by the 340-foot runway of another 10-ton electric traveling crane at right angles to it. This latter crane travels alongside the gray-iron foundry and serves to transfer heavy castings to the Midway, whence they can be delivered directly to the shops where the heavy work is done, or to the longitudinal surface tracks which will distribute them throughout the yard. The Midway crane serves as a transfer between all surface tracks and enables the heaviest work to be quickly moved from shop to shop. By this system all



General Plan of Montreal Shops of the Canadian Pacific Railway Company.

principal movements are in a longitudinal direction. A transverse movement from shop to shop or from track to track is provided for entirely by the cross-overs and diagonal lines of the surface tracks and by the Midway crane. Both of these cranes were made by the Whiting Foundry Equipment Company, Chicago, and each is equipped with one 25-horse-power and two 8-horse-power Canadian General Electric Company's direct-current motors working at 250 volts. In the locomotive shops there are two 60-ton cranes of 77-foot span, one 10-ton and one 15-ton crane of 56-foot span, all built by the Alliance Machine Company, Alliance, Ohio, and each equipped with four motors. All other cranes in the buildings were installed by the Whiting Foundry Equipment Company and are operated by Canadian General Electric Company's motors. They include one 20-ton 77-foot-span crane in the boiler shop and one 10-ton 50-foot crane in the gray-iron foundry, besides a number of smaller cranes and air hoists in various shops. Between the passenger car shops there is a yard car-transfer table operated by a 20-horse-power, 550-volt alternating-current motor.

The runways for the yard cranes have girders of from 14 to 43-foot spans, corresponding generally to the openings in the adjacent buildings, and varied to suit the passages between shops. The girders all have 36x⅜-inch web-plates and pairs of 6x3½-inch flange angles with pairs of vertical web-stiffener angles from 4 to 5 feet apart. Each vertical post supporting the runway has a batter post latticed to it with zigzag angles and carries a light latticed girder parallel to, and 3 feet distant from, the runway girder. The lower flanges of the two girders are connected by zigzag lateral angles and the top flanges are connected by a 36x5/16-inch continuous cover-plate which projects 12 inches beyond the center of the runway girder. This arrangement gives independent stability and lateral stiffness to the runway girder, and the horizontal plate serves as a foot-walk alongside the crane track.

General View of Plant: Locomotive Machine and Erecting Shops in Foreground.

Power Plant.—The 100x160-foot power building is divided by a longitudinal center wall into a boiler room and an engine room. In the boiler room are four 416-horse-power Babcock & Wilcox boilers for a working pressure of 150 pounds, and one 300-horse-power boiler of the same make for a pressure of 300 pounds to be used in testing locomotives. These boilers are equipped with Neemes's shaking grates and are stoked by hand, but there is also a shavings exhaust system for supplying the boilers with refuse from the planing mill. The induced draught system is operated by two 10-foot Sturtevant fans which make about 200 revolutions per minute and are connected with a steel stack 8 feet in diameter and 70 feet high. Two Green economizers of sufficient rated capacity to serve the five boilers have been installed, and provision is made for the future installation of three more boilers of 416 horse-power each. All the boilers are connected to a 12-inch header, and reducing valves and a by-pass are provided to permit the steam at 300 pounds pressure to be used with the low-pressure battery when the high pressure is not required for testing purposes. Two 12x7x12-inch Northey feed-water pumps built by the Canada Foundry Company, Toronto, have been put in for the 416-horse-power boilers and two 6x3½x6-inch Worthington feed-water pumps for the 150-horse-power boiler. There is also a feed-water heater, made by the Goubert Manufacturing Company, New York, of sufficient capacity for all the boilers.

The ashes are discharged to floor hoppers, from which they are emptied at convenience into cars in a tunnel running beneath the boiler house and terminating at an air hoist for lifting the dump cars to the surface tracks, on which they are run to the spoil banks.

In the engine room there are three 750-horse-power and one 375-horse-power cross-compound horizontal Corliss engines, making 150 revolutions per minute, built by the Robb Engineering Company, Amherst, Nova Scotia, direct-connected to three 500-kilowatt and one 250-kilowatt three-phase 300-volt alternating-current generators. Besides these generators there are two 250-kilowatt 250-volt direct-current dynamos for the crane service. The alternating-current generators, motors for some of the tools and the exciters were built by the Canadian General Electric Company. Air is compressed by machines brought from the old shops and is delivered at 100 pounds pressure through a 7-inch and a 2-inch main leading to the different parts of the plant and connected to one or more receivers in each of the buildings. The engine house is served by a 10-ton traveling crane built by the Whiting Foundry Equipment Company.

A tunnel from the power house was run to most of the important buildings, and carries on wall brackets the live steam pipe for heating at night, an exhaust steam pipe for heating by day, a high-pressure steam pipe for locomotive tests, air pipes for pneumatic service and a return pipe for the drainage of all the heating apparatus, the condensation water from which is saved and used again. All steam and exhaust pipes are jacketed with asbestos air-cell covering wired on.

Electric Installation.—The shops are designed and equipped for work which does not vary greatly in character. Hence the different tools are to be used for a uniform service so that they can, in most cases, be economically operated by constant-speed electric motors, avoiding the complication of variable-speed motors except for a very few machines. The work in the machine shop has been divided into general classes, namely: wheel-finishing; finishing moving parts, such as links, pistons, valves, etc.; heavy turning, boring and planing. Brass-finishing and other light work is done in the gallery and the machining of heavy parts is done in one of the side aisles. In a total of about 200 electric motors only about 15 are of variable speed. The system adopted uses three-phase 600-volt current without transformers and gives 550 volts at the motors. All except the direct-current motors are 10 to 50-horse-power, induction type, three-phase, 550-volt machines made by the Canadian General Electric Company, of Peterborough, Canada.

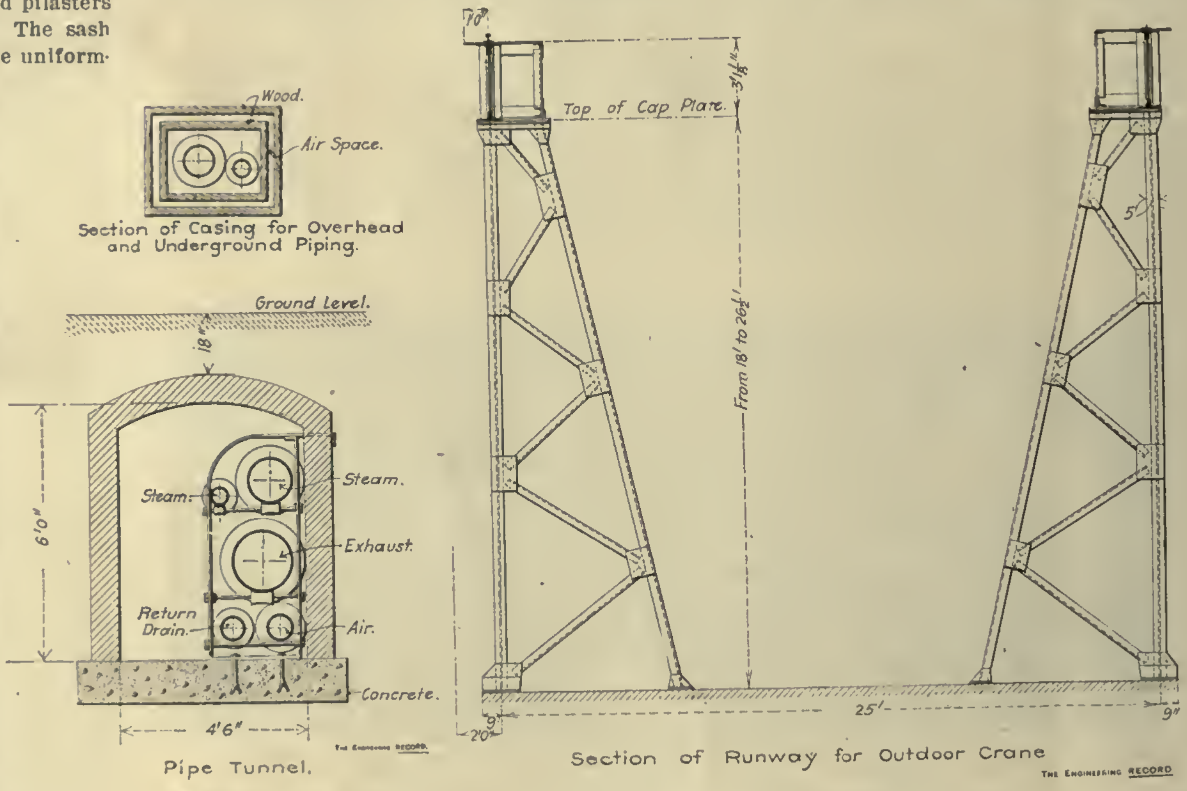
A three-phase switchboard with four generator distributing and exciter panels of the General Electric type has been installed. Outside wiring is done with overhead construction bare-copper main feeders on structural steel poles. In the buildings there is a mixed system of open porcelain cleats and slow-burning waterproof wire on the ceilings, and Richmond conduits and rubber-covered wires on the side walls. Panel boxes are supplied, however, for about every 10 kilowatts of lighting and for every 100 horse-power of motor wire. For shop and yard illumination there are 400 110-volt enclosed arc lamps of the Canadian General Electric make, supplemented by 3,800 16-candle-power incandescent 110-volt lamps. In the passenger car shops the lights are spaced equi-distantly and low tension arc lamps are installed on account of their economy and better results for general illumination. In the yards there are 50 enclosed series arc lamps.

The shops are equipped with a complete telephone system for a 75-drop switchboard and 50 telephones, which are connected to the long-distance wires. The system is equipped with metallic circuit, motor generators for ringing and self-restoring drops. The electric department of the Canadian Pacific Railroad Company is installing all the electrical wiring. The general office at the plant is wired throughout with conduit concealed work, and in every room there is a belt line of wire running around the walls, near the ceiling, behind an oak moulding which can be removed and a light connected at any point without disturbing the line.

In the shops the small machine tools are arranged in groups, which, in most instances, are operated by a motor seated on an overhead platform between the roof trusses. In order to determine the load factor for the groups of tools and for the plant, a series of practical tests was made on a large number of iron and woodworking machines used in similar shops operated by steam power. A small generator and balancer was driven from a countershaft near the center of the shop and operated a small portable motor and controller. The latter was taken to any required machine and belted directly to it or to its countershaft, and the machine worked to its limit under different conditions, thus determining its capacity and maximum horse-power. About 45 per cent. of the aggregate maximum horse-power was used as a basis for proportioning the sizes of the conductor mains.

Character of Buildings.—The buildings are not strictly fireproof, but are of slow-burning construction, special pains having been taken to design them to afford the utmost resistance to fire and to conform to the underwriters' requirements, an attempt which has been so successful that they are pronounced unusually satisfactory by the insurance men and are rated at a very low premium. Generally speaking, the buildings are one story high with simple rectangular plans having considerably greater length than width. The roofs are pitched about 1 in 12 from the longitudinal axis of the building and are in all cases covered with tar and gravel on 3-inch plank. In the power-house they are partly carried by the partition wall. In all other buildings they are supported by one, two or three lines of interior columns, dividing the building into longitudinal aisles which, in several cases, are traversed by traveling cranes or standard-gauge surface tracks, or by both. Most of the principal buildings have small lean-to brick wings on one or both sides for the lavatories, shop offices and fan rooms, several of the latter being spaced at equal distances for the longest shops.

All the principal shop buildings are abundantly lighted by wide and high windows, which generally occupy nearly 50 per cent. of the wall area and cover part of the space in each panel between the buttresses and pilasters provided to support the roof loads. The sash are either balanced or pivoted and are uniformly glazed with 10x16-inch panes of 10-ounce clear glass. Except in the blacksmith shop and foundries, there are no clere-story windows, and most of the large shops have their roofs lighted by transverse monitors about 12 feet wide with double-pitched roofs glazed with rough cast glass ⅜ inch thick. The brickwork, roof boards, trusses, columns and all other parts of the interior are thoroughly whitewashed to promote the diffusion of light, excepting a brown dado 5 feet high on all walls and columns.



Montreal Car Shops: Details of Pipe Tunnel and Outdoor Runway for Crane.

All the exterior walls are of hard red brick laid in 1:3 Portland cement mortar, 12 inches thick at the top and from 12 to 20 inches thick at the base; they are self-supporting and carry, in most cases, the roof girders and trusses. The walls are faced outside with red pressed brick. Most of the doors and all the windows have bush-hammered stone sills and three-course brick arch lintels. Most of the wall and column foundations are continuous and are carried to rock in trenches from 10 to 20 feet deep, in some cases excavated with difficulty on account of the large quantity of ground water. The trenches averaged 3 feet wide at the bottom, and in them 3-foot walls averaging 9 feet high were built of rough flat stones laid dry. On top of these footings 27-inch walls of rubble masonry laid in cement mortar were built to a height of about 1 foot below ground level. On these walls a base course of concrete finished on both faces with 1½ inches of 2:1 mortar was built up to a height of about 30 inches above the ground level and finished with a 9x12-inch base course of cut stone beveled to make the offset on which the brick walls are started. In some cases pile footings were used instead of masonry.

The roofs of the blacksmith shop, wheel foundry, gray-iron foundry, locomotive shop and power-house have steel trusses supported on intermediate rows of riveted columns. The planing mill and freight car shops have combination roof trusses with a center row of steel columns. The pattern storage building, part of the truck shop, and the frog and switch shop have steel I-beam roof girders and steel columns. All other shops have wooden roof beams and wooden columns which, in some cases, are knee-braced. The skylights are generally supported by their side walls, which are of special construction made with crossed layers of solid plank spiked together so as to virtually form plate-girders, which carry the full weight of skylight and intermediate roof surface. The floors are of concrete, of clay and cinder or of 3x10-inch plank. The surface tracks through the buildings are laid on 6x8-inch ties 2½ feet apart ballasted with 18 inches of cinders. The plank floors have a foundation of 12 inches of rammed cinders, in which 4x6-inch sleepers are bedded 4 feet apart. The floors in the smith shop and foundries are made of cinders mixed with sufficient clay to bind them and thoroughly rammed in a layer 12 inches thick.

Drainage from the toilet rooms is discharged into two main lines of brick sewers transverse to the axis of the plant, which empty into the city sewers. The branches to these collectors are vitrified tile pipes from 8 to 21 inches in diameter laid with a minimum fall of 1 to 343. The brick sewers are egg-shaped with a 6-inch radius of invert, 3-foot radius of side walls and 12-inch radius of arch. The invert is a single ring of red brick laid in a solid mass of concrete 3½ feet wide and 20 inches deep on the sides and 12 inches deep in the center. Above the concrete there is a second horse-shoe-shaped ring of brickwork outside. Manholes are built of brick with rectangular cross-sections and tops corbeled in to receive ordinary cast-iron covers at grade.

Water System.—A pit in the pump room contains all the pumps for the fire and general supply service of the plant. There are two Northey's underwriter pumps each with a capacity of 1,500 gallons per minute at 100 pounds pressure, and one Northey pump with a capacity of 25,000 gallons an hour, having their suction pipes connected to a pair of 6-inch artesian wells 550 feet deep and to the high and low pressure city water mains. They discharge normally to the circular concrete storage reservoir for shop service. There is room in the pit for an additional pump with a capacity of 25,000 gallons per hour. All pumps are cross-connected and by-passed so as to be interchangeable in their service and to draw from the reservoir, the wells or the city supply. They deliver to the reservoir, the fire service, the distribution mains or to a 75,000-gallon steel tank on top of a 70-foot tower, which is connected to the mill supply.

Each building is surrounded by a separate belt of fire service pipes laid in the ground and connected to a supply at 100 pounds pressure from the city mains and to the underwriters' pumps. Automatic sprinklers are provided in all the buildings and are generally arranged so that each will serve about 100 square feet of roof surface. Over 13,000 sprinklers have been installed by Messrs. H. G. Vogel & Company, of Montreal and New York, and are connected to the high-pressure system.

Heating System.—A thorough comparative study was made of the different systems of shop heating by direct steam and hot water and by blower methods, the latter being finally adopted as most efficient and economical where the requirements are so severe on account of the large spaces to be warmed, the high proportion of window area and the low external temperature. The appartus was built and installed by the B. F. Sturtevant Company, of Boston. Steam is distributed in tunnels to the different buildings from the central power-house which is about 2,600 feet from the most distant part of the system. The buildings have a combined volume of about 26,000,000 cubic feet, and from ¼ to ½ of the wall surface is glazed, besides which there are skylights aggregating 25 per cent. of the roof surface. The specifications require most of the buildings to be heated to a constant temperature of 65 degrees when the temperature outside is 10 degrees below zero. The radiation for this service contains an aggregate of about 200,000 linear feet of 1-inch pipe, in vertical coils with cast-iron bases, which are coupled up in sections of about 200 feet each. The fans are calculated to have a capacity sufficient to completely change the air in any building in about 20 minutes. In all the buildings they will, however, be used in very cold weather to maintain a closed circulation and return the air in the building to the heaters without receiving any cold air from outside.

In the planing mill the fan engine and heaters are located on platforms between the roof trusses. In most of the other buildings they are located in one or more separate lean-to brick annexes. Each set of heaters is supplied with both exhaust and live steam mains. In the locomotive and blacksmith shops the hot air from the heaters is distributed partly underground through brick conduits; but in the other buildings and in parts of these, the distribution system consists of cylindrical overhead galvanized iron ducts, supported on the lower chords of the roof trusses, having outlets through vertical pipes carried down beside each of the interior columns. Ventilation is provided by the natural outlets through crevices and open doors, by sliding or pivoted sash in the windows, by special doors in the monitors and by 24-inch automatic Aeolian ventilators in every skylight, installed by Messrs. Lessard & Harris. The main windows have been fitted with single sash only, but provision has been made for the use of double sash if the severity of the cold should require it.

The principal contracts for the construction of the plant were awarded as follows: for the freight car shop, planing mill, two passenger car shops, blacksmith shop, and for all plumbing, inside and outside water pipes, sewer construction and the roofing and skylights for all buildings to Messrs. Lessard & Harris, Montreal; for the car machine shop, truck shop, cabinet shop, wheel foundry, gray-iron foundry, general storehouse, power-house, pattern shop and pattern storage building to Messrs. D. J. Loomis & Sons, Sherbrooke, Quebec, Canada; for the locomotive shop, dry kilns and office building to the William Grace Company, Chicago. The contracts for the structural steel work were awarded to the Dominion Bridge Company, Montreal; for the locomotive shop, car-wheel foundry, gray-iron foundry, and the yard crane runways, to the Canada Foundry Company, Toronto.

(To be continued.)

THE IMPORTANCE OF MILITIA ORGANIZATIONS has been recognized by the Vulcan Iron Works Co., of Toledo, which recently posted the following note in its works: "The company will pay full time to any employe who is a member of the Ohio National Guard, when out on parade with his company, at rifle practice, or camp duty or when serving under the governor or sheriff to put down a riot." In view of the valuable services rendered by the militia in times of riots, this action is commendable, to say the least.

The Cranford Plant of the Public Service Corporation of New Jersey.

A building constructed of concrete blocks and a system of piping that includes a steam header 81 feet long without a single valve in it are conspicuous features of the Cranford, N. J., electric railway plant of the Public Service Corporation of New Jersey. It is a 3,200-kilowatt plant in which two 800-kilowatt units are at present installed, and with a load averaging 240,000 kilowatt-hours per month is operating at 3.1 pounds of coal per kilowatt-hour. Direct-connected vertical compound steam engines, equipped with an interesting system of steam circulation for jacketing and reheating, are employed, operated condensing, and horizontal tubular boilers are installed in the boiler room. Jet condensers are used, with water from the Cranford River, and the feed for the boilers is taken from the condenser discharge. The auxiliary steam machinery exhausts in the usual way to a feed-water heater. The plant was designed by Mr. Warner W. McKee, chief engineer of the Elizabeth Division of the Public Service Corporation, which is an organization representing a consolidation of companies owning railway, electricity and gas franchises in most of the towns and cities in Northern New Jersey.

Street Railway Plant at Cranford, N. J.

The plant occupies a site alongside the Central Railroad of New Jersey, so that facilities are afforded for coal delivery, and it is practically on the bank of the Cranford River, which ensures an adequate supply of condensing water throughout the year. The building, which is 127x73 feet in plan, stands some 69 feet back from South Avenue in Cranford, and with a lawn in front, cut by cement walks leading to the building, obtains a setting which enhances greatly the general effect of its architecture.

The site was formerly more or less of a wooded marsh, apparently undesirable for its present occupation, but in boring for the foundations, hard pan was found underlying the muck at a depth of comparatively few feet, so that concrete footings for the walls and machinery foundations were found possible without the use of piling. For the walls concrete blocks were determined on, planned originally to be hollow, largely to secure a reduction in the first cost of the building. The design of the block or the methods employed in its manufacture did not succeed, however, in producing a hollow block that was proof against cracks, and the pattern finally used was the solid. They were made generally with cinders, in the proportion of 1:3:5, with Vulcanite Portland cement, but whenever cinders were not immediately available, crushed stone, 1½ inches and less in size, was substituted, and the resultant cost of the structure, it is estimated, is about what good brickwork would have cost.

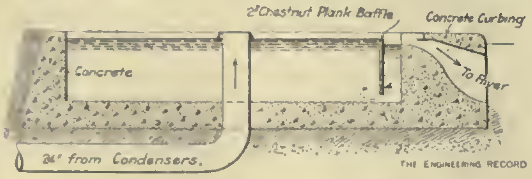
The blocks, which are largely of a 2x4-foot face and 6 inches thick, were placed in the walls as soon as the initial set had occurred and allowed to harden in position. The blocks on their horizontal mating faces were dovetailed together, one block having a tongue parallel with the outside surfaces and the other a groove into which the tongue was fitted. On their vertical jointing faces each block had a groove and the two grooves formed a vertical hole which was filled with cement grout. The joints on all sides were ¼ inch thick, made with cement mortar. The partition wall between engine and boiler rooms is likewise of concrete blocks, and the wall thickness throughout is but 6 inches, except where there are ornamental pilasters or extra thickness blocks around doors and windows. The walls are continued above the roof level, in a cornice or parapet, so that the roof itself is not visible from the street.

The engine-room floor is about 4 feet above the boiler-room floor and under the former the space around the machinery foundations has been excavated forming a basement about 7 feet in clear height, which is lighted by windows and utilized for storage and for electrical apparatus. The engine-room floor is of expanded-metal-concrete construction, suspended between transverse I-beams, and it has a granolithic surface marked off in large squares. The roof trusses, which are of light steel construction, are carried by three rows of light, steel columns, two of the rows on opposite sides of the engine room supporting also the girders for a traveling crane. The roof is of gravel as made by the Commonwealth Roofing Company, laid on planks. The walls and under side of the roofs are painted white, except the bottom 5 feet of the walls which are black, and the roof trusses and crane are a dark red. The columns in their rise through the building are enclosed in concrete as a sort of pilaster. There is a clear height of 25 feet to the under side of the crane, which is a 15-ton hand-power traveling hoist built by the Reading Crane & Hoist Works. There are practically two rows of windows in the outside walls and also a row of clere-story windows in the partition wall above the boiler room, so that the engine room presents a lofty, well-lighted and pleasing interior.

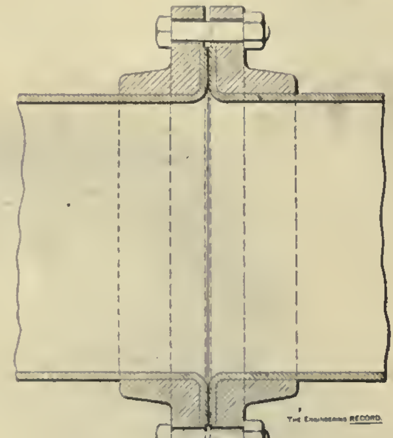
Between the boiler room and the railroad coal siding, which is run on a trestle, there is space for some 3,000 tons of coal; and in the outside wall there are six pairs of large double doors through which coal is carried by a short haul from coal pile to firing space. At each end of the boiler room there is also a large opening closed by a Kinnear rolling door. The floor, which is paved with brick, is at grade level, and to the under side of the roof trusses there is a clear height of 22 feet. In the roof there are seven 24-inch ventilators. Fire hose is provided in both rooms, attached to piping extending from the city water supply.

The boiler plant consists, as stated, of horizontal tubular boilers, each of 72-inch shells with 3½-inch tubes. The room is planned for twelve all told, arranged in two groups on opposite sides of a central, cross gangway, where the feed pumps and feed-water heater are located and where communication is had with the engine room. Three of the boilers are yet to be installed. Those now in place were built by the Stewart Boiler Works, of Worcester, Mass., and have a shell 20 feet long with 86 tubes, so that the heating surface is 1,800 square feet per boiler. Allowing 12 square feet per boiler horse-power, each boiler has a capacity of 150 horse-power, or 1,800 for the whole plant. The floor space taken up by each group of six is 1 2/3 square feet per horse-power, and in the whole room there are about 2.8 square feet per horse-power, with 12 feet firing space and 5 feet between the boilers and the partition wall.

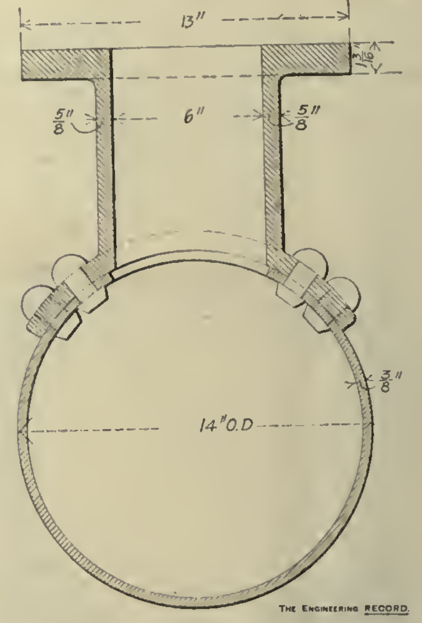
The boilers have 9/16-inch shell and ⅝-inch heads, and were designed for 175 pounds pressure. They are enclosed in a setting built along the lines advocated by the Hartford Steam Boiler Inspection & Insurance Company. The grate area is 33.4 square feet, showing a ratio of heating to grate surface of 53.8 to 1 and a ratio of tube area to grate surface of 1 to 5.7, as bituminous coal is burned. The boilers are hand fired and a record of the coal consumption is kept by means of a street-railway fare register, which is rung up every time a barrowful of coal is weighed and brought into the boiler-room, the barrow being carefully balanced on platform scales with 300 pounds of coal net, each time. The reading of the register is noted at every change of shift. The boilers have the usual overhanging fronts, and each smoke uptake has an area of 5.4 square feet. The breeching is circular in cross-section and at its largest point is 6 feet in diameter, or 80 per cent. of the total tube area of the six boilers served by it. The smokestack rises outside the building in the position indicated, and is of the Custodis radial perforated brick construction, with square base and ornamental top, 8 feet in inside diameter at the top and 150 feet high. A damper in the connection between breeching and stack is arranged for automatic control by means of a Spencer draft regulator.



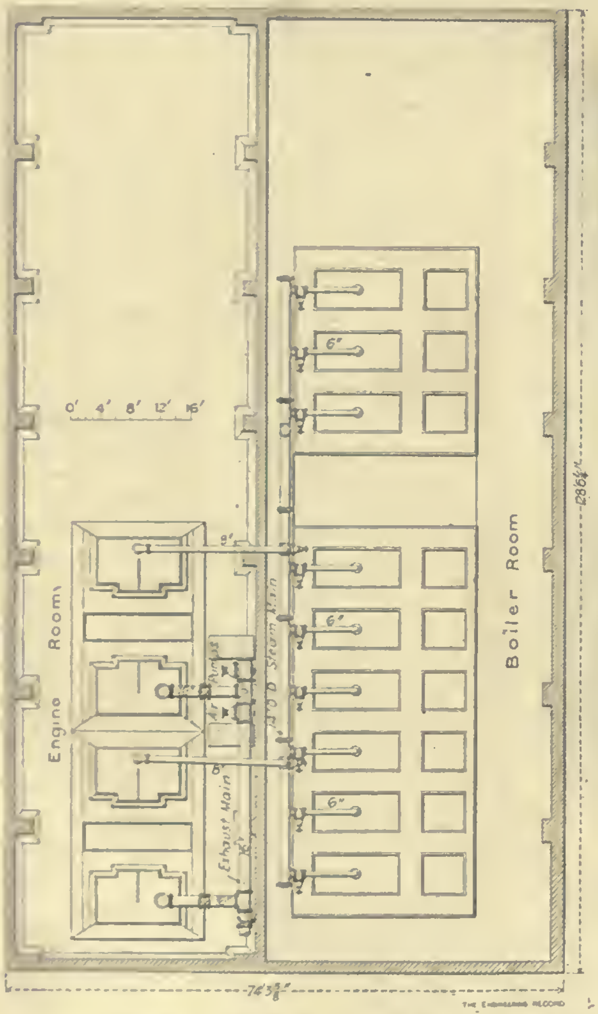
- OIL SETTLING WELL.

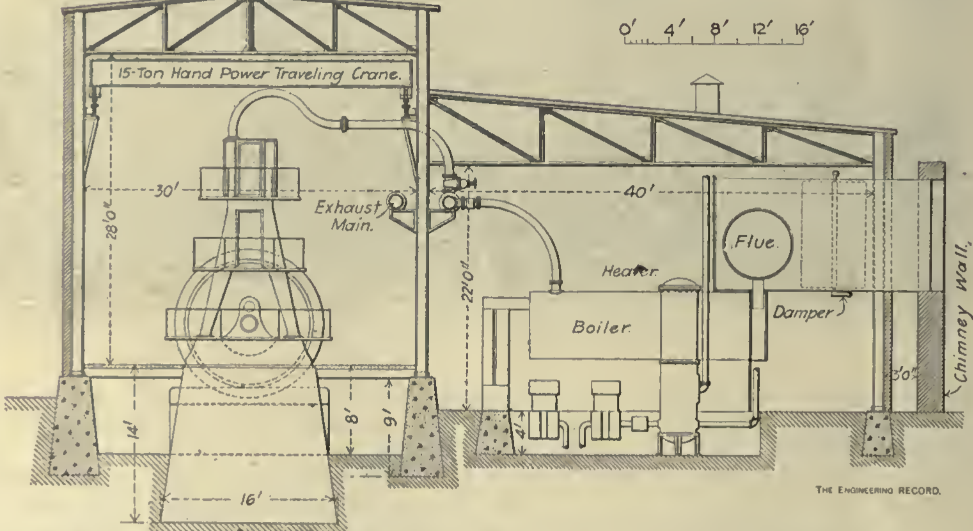


STEAM PIPE JOINT.



RIVETED NOZZLE TO STEAM HEADER.





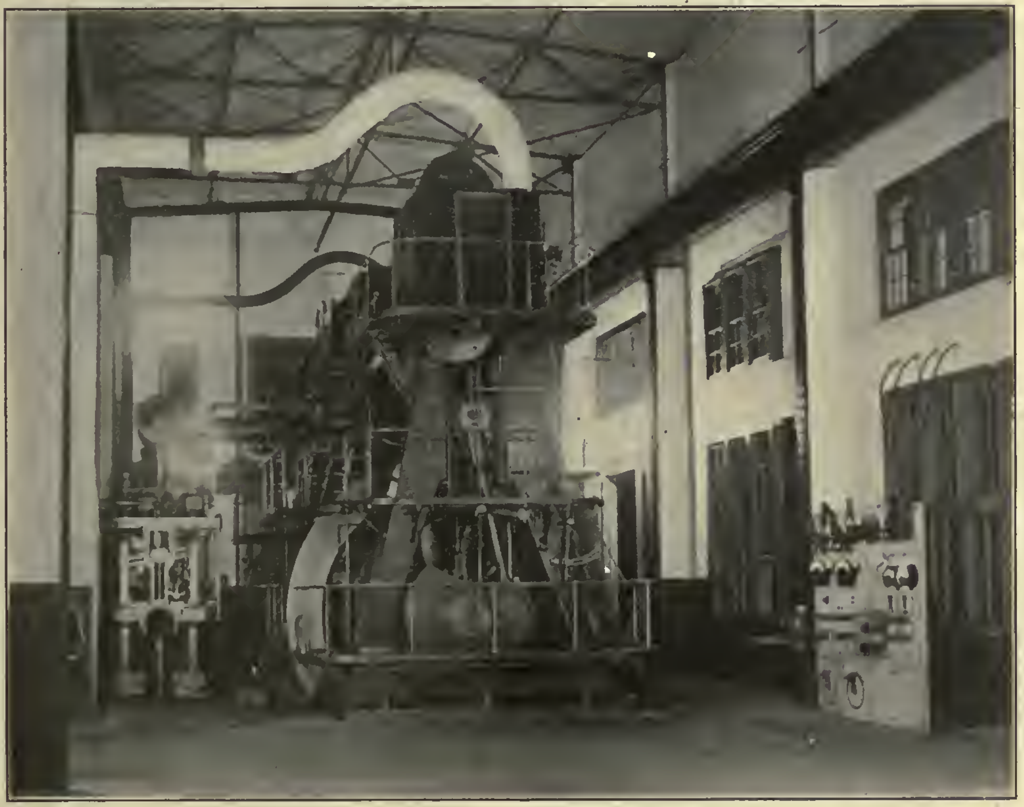
Cranford Plant of the Public Service Corporation of New Jersey: Foundation Plan showing Steam Piping; Cross-section and Details.

The steam piping is quite unusual, particularly in the use of a steam header without valves. The arrangement of the piping is shown in the accompanying illustrations. The boiler connections into the header and the engine supply pipes from it are formed on long-radius bends, in accordance with modern practice of allowing in that way for expansion and contraction changes with an elimination of sharp angles and bends and with a reduction in the number of joints and fittings. The height of the engines with respect to the roof of the boiler-room necessitated an unusual amount of bending in the pipe in the engine room. One valve only is fitted in the pipes to and from the header and these near to it and accessible from an elevated platform behind the boilers. The boiler leads enter the side of the header, so that condensation within them can flow back into the boilers, while the other connections rise from the top and drainage of the header is effected by a system of drip pipes. These are 2 inches in diameter and one is taken from the header below the inlet from each boiler, with a valve near the header. These pipes drop along the rear of each boiler and thence into the water space of the boiler, but each connects en route into a 4-inch header which is carried across the rear of the boilers as an auxiliary steam main and drip line. It will thus be seen that the main steam pipe drainage system provides for returning the water of condensation to the boilers by gravity, while at the same time it furnishes a supply of steam for the auxiliary steam apparatus.

The present steam header is formed of five lengths of 14-inch outside diameter steel piping, ½ inch thick, the lengths ranging from 14½ feet to 19 feet 4 inches. The steam pipes are connected to it by flanged necks of cast steel, ⅞ inch thick, riveted to the header by ⅞-inch rivets. The sections of the header are joined by the recessed lap joints made by Messrs. W. K. Mitchell & Company, of Philadelphia. The rest of the piping is of extra strong steel piping, with the Mitchell joint. In all joints a copper-wire gasket, devised by Mr. McKee, is employed. The main valves are of the Chapman gate type, and the piping is wrapped in R. A. Keasbey 85 per cent. magnesia pipe covering, 2 inches thick.

The engine room contains at present two 800-kilowatt direct-connected direct-current railway units with space for two more of the same capacity, which, however, may be alternating-current units, in case it is desired to provide for long-distance transmission. In that event it is proposed to install rotary converters as a means of connecting the direct and the alternating-current ends of the plant, so that an excessive demand on the one system can be met by the other through the use of the converter. The space occupied in the engine room is 1.18 square feet of floor space per kilowatt of rated output, or 0.88 square feet per horse-power. Taking the whole building into consideration, there are, not including the chimney, 2.17 square feet of ground space per horse-power of rated output and 71 cubic feet of building per horse-power.

The generating sets now in operation consist of Williams vertical compound engines, with 21½ and 43-inch cylinders and 36 inches stroke, built by the Quincy Engine Works, and Westinghouse 600-volt railway generators, operated at 120 revolutions per minute. The engines were furnished under a guaranteed steam consumption of 13½ pounds of steam per indicated horse-power per hour, with steam at 150 pounds pressure, a vacuum of 27 inches and the speed above given. They are equipped with an interesting system of reheating, including a jacket for the high-pressure cylinder and a reheater between cylinders. The live steam in the jacket passes from it through a coil in the reheater, and the outlet of the reheating coil is then connected, after the condensation has been trapped off, to operate the steam cylinders of the condenser air pumps, the pipe thus serving as a convenient method of supplying the condenser units but principally as a means of creating a steady flow of steam through the reheating coils. Such water of condensation as forms later reaches the feed-water heater through the exhaust from the steam pump.



Engines and Condensers in the Cranford Power Plant.

The engines are operated with a fixed cut-off for the low-pressure cylinder, so that with varying load the receiver pressure is variable, and the latter is accordingly equipped with a safety valve of the Crane type, set to blow off at about 60 pounds. The receiver is 36 inches in diameter and about 4 feet, 9 inches high inside and contains sixty 2-inch brass pipes, 3 feet 8 inches long, connected at top and bottom by return bends to form a continuous coil. The bearings and guides of the engine are water cooled and lubricated from an oil circulating system which employs a storage tank on the upper engine gallery. The head under which the oil is circulated is thus not more than a few pounds at the oil spouts, the purpose being to furnish the oil through these outlets in comparatively large globules or streams to avoid the clogging of smaller outlets which might otherwise have been necessary. The oil from the bearings is caught and drained by a system of piping to a Burt "Cross" oil filter in the engine-room basement. Filtered oil from the reservoir is pumped to the elevated tanks by means of a small steam pump operated a few minutes as the tanks above become empty.

The condensing system is noteworthy for the directness of the piping system and the location of the air pumps on the engine room floor, behind the engines readily accessible to the room attendants. The exhaust pipe from each engine, 16 inches in diameter and of wrought-iron, is 11 feet long to the 20-inch main exhaust, and each of the two pumps takes from the main through a pipe 8 feet long. As indicated in an accompanying drawing, the usual relief connection is provided, with a Blake relief valve discharging through a short horizontal pipe extending through the end wall of the building. The pumps are of the vertical twin pattern, made by the Warren Steam Pump Company, and are 10x25x18 inches in size. Each is calculated large enough to serve both engines and the connections are made so that either one or both may be operated. They deliver into a concrete reservoir outside the building, the chief purpose of which is to afford means for the oil or grease to separate from the water before its final discharge into the river. As shown in a sketch herewith the water flows out of the reservoir over a weir in one side, reaching the weir under a baffle, so as not to disturb the surface water where the grease may rise and collect. As little cylinder oil as possible is used in the engines and thus far no systematic skimming has been necessary. The reservoir is 24 feet in diameter and 5 feet deep.

Water for the boilers is taken from a pocket in the condenser discharge main within the power-house, the pocket being located in the bottom of the pipe to minimize the chances of getting oil in the water; and this water, without treatment, except heating in the feed heater, is pumped into the boilers. The boilers are cleaned in turn after being in use four weeks and the sediment is a soft mud easily washed out. There are two 10x6x12-inch Warren feed pumps, installed in duplicate and placed on one end, taking a vertical position with minimum floor space. They deliver first through a Union meter, by means of which the record of the boiler evaporation is kept, and then through the feed heater, which is a Wainwright water-tube heater with corrugated tubes. Under normal conditions the feed to and from the heater is 100 to 110 and 200 to 210 degrees Fahrenheit, measured by Standard thermometers with dial faces. The heater is rated at 3,000 horse-power and contains 144 1½-inch tubes, 124 inches long. The exhaust from the various pumps is led to it and the condensation is drained to an open barrel near the feed pumps, this barrel serving the same purpose as the concrete reservoir. Considerable oil is recovered in this case and is skimmed off for utilization over again in the pump cylinders.

The station is entirely a street railway one, subject to the variations of demand peculiar to this class of service. It is at present an adjunct of a 1,300-kilowatt street-railway plant at Elizabeth, and while located centrally for the suburban lines to Plainfield, to Elizabeth and to Boynton Beach, is frequently called on to send current to the Elizabeth system, a distance of 5½ miles over a 1,000,000-circular-mil feeder. The station is 9½ miles from the center of Plainfield and 10 miles from Boynton Beach and furnishes the current necessary to operate all the cars along the line and at Plainfield as well as Elizabeth.

For the control of the electric system there is a standard switchboard with two panels for the generators, a totalizing panel and the remainder feeder panels, two feeders per panel, each feeder protected as usual with a circuit breaker. The totalizing panel carries a recording wattmeter, which is one of the instruments read with changes of shift in the power-house, in connection with the records kept of the plant performance.

The plant is run daily except between 2 and 5 in the morning. The average load throughout the day is 800 amperes, but at the peak, between 5:30 and 6:30 P. M., the current demand averages 1,200 amperes, fluctuating between 800 and 1,600. Steam, however, is kept up at all times, and the steam pressure is varied proportionately to the load, the idea being that more economical steam distribution is secured in the steam engines at the light loads with reduced steam pressure. The pressure ranges from 60 pounds during the early hours of the morning to 150 pounds at heavy load times, or 160 in the case of an unusual demand. In the accompanying table is given the record of the coal consumption in seven months' running:

Record of Seven Months' Operation.

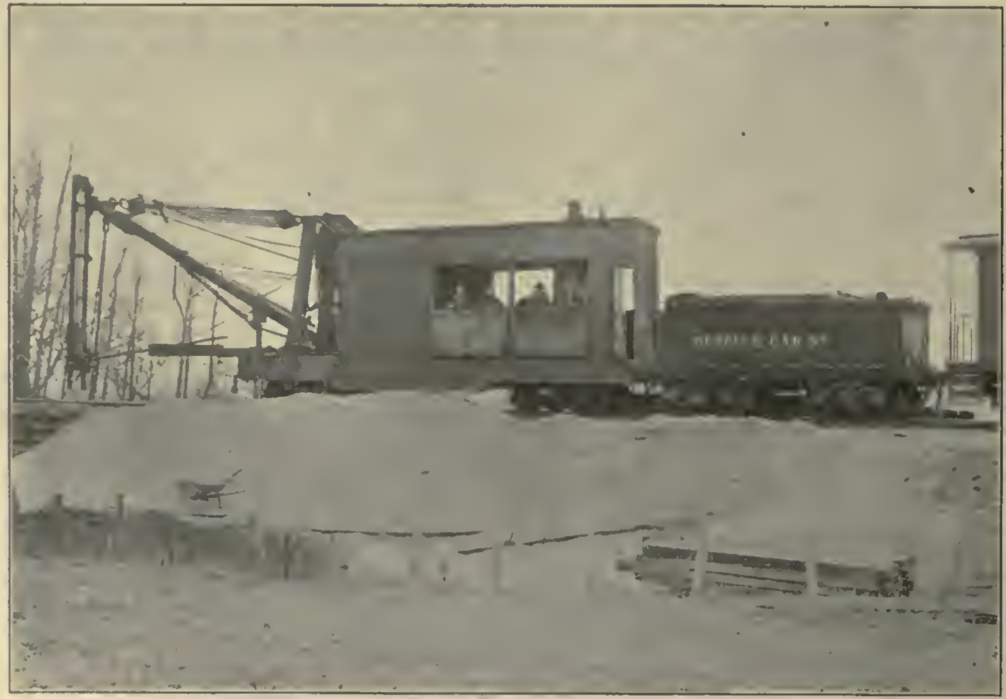
Month.	Kilowatt-hrs.	Coal per Kw-hr., lbs.
June	......	3.97
July	......	3.4
August	......	3.37
September	......	3.4
October	......	3.44
November	210,000	3.4
December	240,000	3.1

The evaporation of the boiler plant, on the basis of the water meter and for the actual continuous performance, day after day, is 9½ pounds of steam per pound of coal. On the basis of the December output, it will be found that 29½ pounds of steam were consumed per kilowatt-hour including the engines, condenser and feed pumps.

The Products of Combustion from steam boilers fired with bituminous coal should not carry less than 14 per cent. of carbonic acid, in the opinion of Mr. J. B. C. Kershaw in a paper presented to the Liverpool Engineering Society. Lower percentages are due, he says, largely to excessive draft, and he figures that the loss represented by the difference between 14 and 8 per cent., this the average accredited by some authorities, with the gases at 560 degrees Fahr., is equivalent to 10 per cent. of the fuel burned. He believes boiler houses should be planned so that the firemen can always see the chimney top, reflecting mirrors being provided if necessary.

Improved and Combination Collapsible Pile Drivers for Railroad Work.

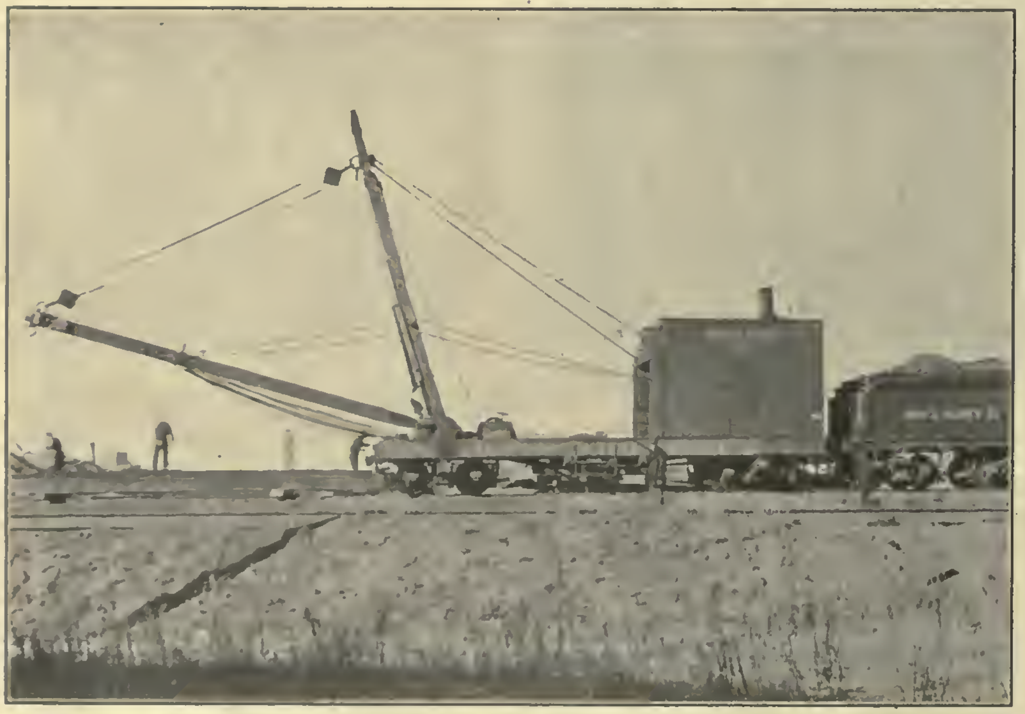
A special type of wooden pile driver has been designed and used by Mr. O. J. Travis, superintendent of bridges for the Illinois Central Railroad Company. It is a simple machine without turntable or telescopic extension. When in transit it is lowered to clear tunnel roofs and overhead and through bridges, and projects over the floor of a platform spacer car coupled in front of the pile-driver car. It has a fixed short vertical transverse A-frame over the forward truck. The top of this frame is braced to the rear of the car, and between the inclined posts there is a short vertical mast with top and bottom gudgeons and a 12x12-inch boom 27 feet long, operated by a hoisting engine in the house on the rear of the car, which serves as a counter weight for the derrick loads. The machine is considered very satisfactory for use as a wrecking derrick and to erect heavy plate girders and truss spans up to 150 feet long.



Illinois Central Railroad Pile Driver with Short Fixed A Frame.

Pile-driver leads from 18 to 24 feet long, made of pairs of 6x6-inch angles back to back, can be suspended with an offset hinge from the point of the boom and folded up underneath the latter when the machine is in transit. In service the leads are braced by an adjustable horizontal strut hinged to the foot of the boom and revolving with it. The strut consists either of a telescopic pipe or of overlapping timbers extended and withdrawn by a rack and pinion, thus allowing for different heights of the boom. A pair of horizontal cantilever 9-inch I-beams, with their forward ends connected by a cross piece which engages the strut, slides in guides on the sides of the car and is moved in and out by hand with a rack and pinion. The rear end of the strut is movable on the cross beam and thus provides a brace for the leads when they are inclined to drive batter piles. The boom and pile driver leads can be lowered to any height to be used inside a through span to drive or pull out falsework piles through the floor and has the advantage of being entirely self-contained without requiring any bracing or guying when in use.

Another type of machine designed by Mr. Travis has a much longer A-frame, which is pivoted at the base and has no center mast. In service it is inclined forward and held by back stays to the rear of the car. In transit it is revolved back to rest on the top of the engine house and come within standard vertical track clearance and the boom is lowered on an idler platform car in front, which also carries the leads detached from the boom, to which they have a special connection like that used for the other type of machine.



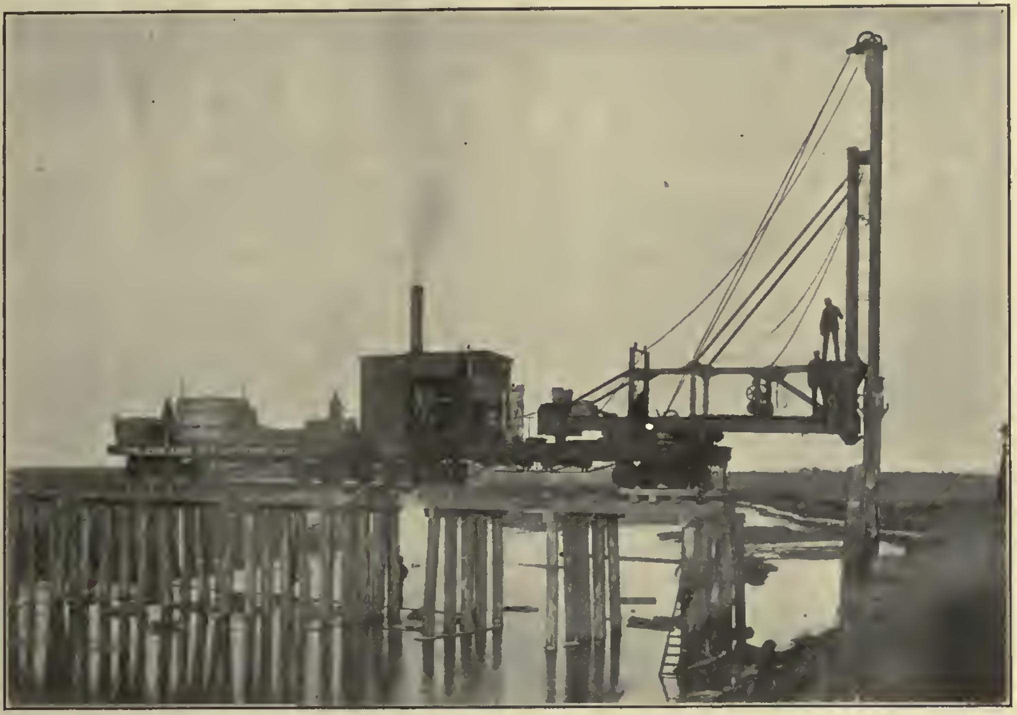
Illinois Central Railroad Pile Driver with Tall Revolving A Frame.

Mr. W. H. Woodward, bridge supervisor, Asheville, has secured very satisfactory results from the revolving extension pile driver built by the Vulcan Iron Works, Chicago. The machine is made of structural steel and has a trussed framework mounted on a turntable bolted to the deck of a flat car. It also rolls longitudinally to give an effective overhang of from 7 to 16 feet in front of the wheel base, and is revolved by hand or by the engine. A vertical bent is pivoted to the top of the forward end of the trusses and from its cap the pile driver leads are suspended from a horizontal pivot, which permits them to be inclined transversely in order to drive batter piles. When in transit the leads and vertical bent revolve down to a horizontal position on top of the trusses and the smoke stack revolves down flat on the engine house roof. The leads are fitted with either a steam hammer or a 2,800-pound drop hammer and Casgrain pile cap. The Warrington hoisting engine is fitted with locomotive gear making the machine self propelling. All operations of swiveling, hoisting driving and locomotion are governed by friction clutches. The machine is mounted on a 38-foot car with a platform 10 feet wide.

A modification of this type differs from it in having the turntable in the center of the car and in having no locomotive gear. The trusses are longer and extend to the rear end of the car, support the engine and boiler and can revolve 360 degrees. The trusses have no longitudinal motion, but both trucks of the car can be moved backwards 7 feet 4 inches so as to give the leads a correspondingly greater overhang beyond the wheel base, thus providing an effective reach of from 13 feet 2 inches to 20 feet 6 inches beyond the wheel base on either end of the car and 28 feet at right angles to the car. Batter piles can be driven with a maximum inclination of about 9 degrees from the vertical equivalent to a slope of about 1:6½.

The pile driver designed by Mr. W. R. Smith, district carpenter of the Chicago, Milwaukee & St. Paul Railway Company, was described in this journal February 17, 1900, but is here illustrated by a more recent photograph. It has a trussed steel framework mounted on a center turntable which is longitudinally movable on the deck of a platform car 45 feet long and 3½ feet high. The leads are pivoted a little above their center to the top of a four-sided tower, 20 feet high above the car deck, with vertical forward posts and battered rear posts. The tower is mounted on rockers in longitudinal vertical planes. They are slightly flattened segments of circular arcs and have notches engaging pins in the deck track to prevent slipping as the tower is revolved backwards by power to a horizontal position when the machine is collapsed for transit. When the tower is in the vertical position, the upper ends of the rockers are braced by inclined struts pin-connected to them at their lower ends and having two-pin joints in the center so that when one pin is removed they hinge there and fold like a jackknife as the tower is lowered, but never entirely release it.

The deck is moved longitudinally by a rack and pinion operated by a sprocket chain from the engine. The turntable is swung by a rack and pinions operated by ratchet levers. The leads are pivoted to the tower so as to revolve in a transverse vertical plane and drive batter piles. The car and machine complete weigh about 100,000 pounds, and in transit the leads are revolved back to a horizontal position on top of the engine house so that no part of the machine projects beyond either end of the car; it can be coupled into any train without an idler or flat car at either end. Piles can be driven by it 18 feet beyond the center of the front wheels and about 23 feet either side of the center of the track.


Vulcan Iron Works Pile Driver with Short Cantilever Frame.

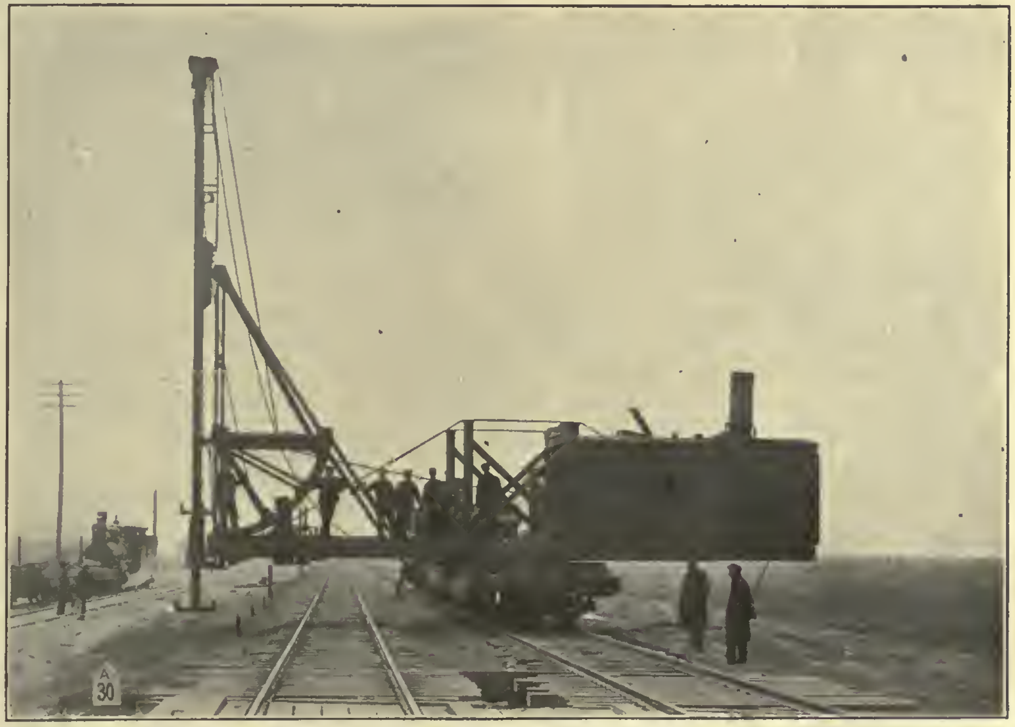
A pile driver used on the Boston & Maine Railroad has a combination bridge with a pair of Pratt trusses about 45 feet long 8 feet deep and 9 feet apart on centers connected by top and bottom transverse braces, laterals and sway braces. The bridge is mounted on a flat car with a center turntable about 9½ feet in diameter, revolved by a rack and pinion operated by a worm gear which always leaves it locked in any position and is driven through friction cones by the hoisting engine. The leads about 47 feet long are pivoted to the ends of the top chords, which project slightly beyond the forward end of the car when the bridge and car axes coincide and the bridge has the minimum overhang.

A 35-foot boom can be pivoted to the leads, and when the machine is in service either as a pile driver or derrick the leads are braced in a vertical position by an inclined post pin-connected to them where the topping lift is attached a little below the top, and pin-connected to the top of the bridge one panel back. In transit the leads are revolved back into a horizontal position on top of the bridge and engine house. The turntable track is bolted to a false deck, which can be moved longitudinally 18 feet in either direction on adjustable transverse rollers on the car frame. When the deck is in the required position the rollers are lowered by vertical screws and the deck takes bearing on the car frame. To drive batter piles the deck, bridge and leads are tilted transversely by screws in the ends of the truck bolsters. For derrick purposes the car can be anchored by eight rail clamps and shores and has a capacity of 20,000 pounds 32 feet from the center of the track. A shorter wrecking boom is provided which has a capacity of 40,000 pounds. The machine can drive piles in a circle 45 feet in diameter without moving the car; it is equipped with a 2,800-pound hammer and a Lidgerwood engine, and weighs complete about 100,000 pounds.

Mr. H. Rettinghouse, superintendent of bridges and buildings, of the Chicago & Northwestern Railway, has satisfactorily driven 1,500 piles with a machine having 45-foot leads suspended from the overhanging end of a combination bridge with a pair of 46-foot Pratt trusses 9 feet deep and 9 feet apart on centers mounted on a turntable bolted to the car frame about 1 foot from the center and about 26 feet from the leads. The leads are counterbalanced by the engine and boiler at the opposite end of the bridge and slide through a special joint at the end of the top chords. This double pivoted connection allows them to be revolved into a horizontal position on top of the bridge, projecting about 12 feet beyond it when in transit, and to be swung into an inclined position in a transverse vertical plane to drive batter piles. While the car is in motion the leads can be raised or lowered in two minutes by an auxiliary drum operated by the hoisting engine.

A pile driver designed by Mr. R. H. Reid, general bridge foreman of the Lake Shore and Michigan Southern Railway Company, was built by Kaltenbach & Greiss, Cleveland. It has a riveted steel truss frame the full length of the flat car, on which it is mounted on a turn table 6 feet from the center of the car and frame. When the frame is reversed so that the long arm overhangs the short end of the car, the leads can drive piles 16 feet from the end of the car and when revolved 90 degrees it can drive piles 20 feet from the center of the track. The leads are pivoted to the frame near the car deck, and can be revolved down to a horizontal position over the top of the engine. One engine with a 35-horse-power boiler raises or lowers the leads in 3 minutes, handles the piles and hammer and propels the car at a speed of 10 miles an hour. The leads can be rigged with a derrick boom, with which a 105-foot span truss bridge has been completely erected alongside the main track.

Mr. A. S. Markley, superintendent of bridges and buildings, Chicago & Eastern Illinois Railroad, has driven 436 piles at an average cost of $0.044 per linear foot with a Bay City Industrial Works pile driver. This machine has 47-foot leads pivoted to the tops of a pair of short vertical posts on the extremities of two queen-post trussed horizontal 15-inch I-beams. The I-beams are mounted on a turntable over the forward truck of a flat car and can be moved longitudinally across it to project a maximum distance of 16 feet beyond the wheel base. The leads are counterbalanced by the engine and boiler and a 5,000-pound scrap box at the opposite end of the beams. They are raised and lowered and the beams extended and withdrawn by a hand windlass. The machine drives piles 14 feet either side of the track center line and is equipped with locomotive gearing which makes it self-propelling at a speed of 8 miles an hour. It is operated by a 30-horse-power engine and supplies its boiler from adjacent streams by a pump on a platform suspended under the car floor. In transit the leads are revolved horizontally and project half-



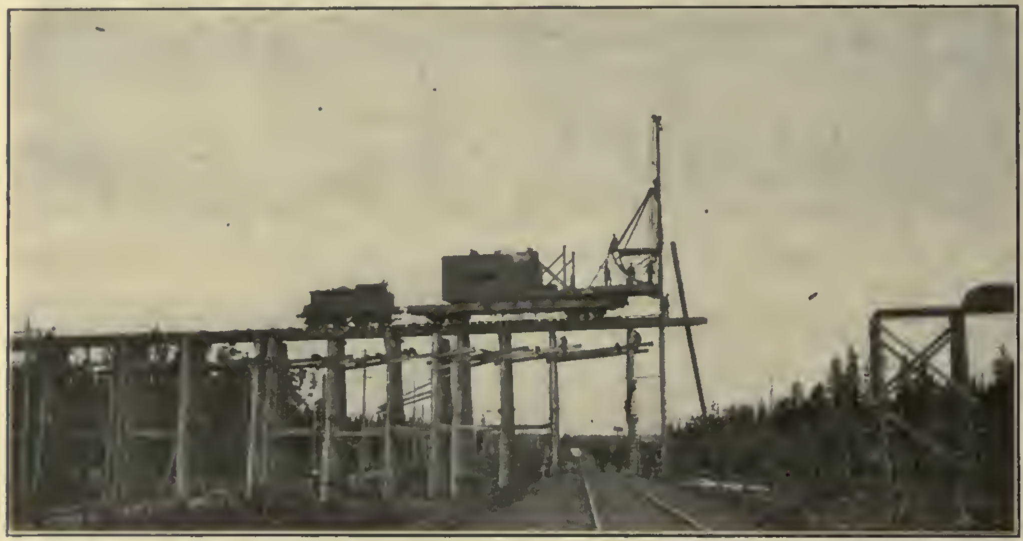
Chicago, Milwaukee & St. Paul Railroad Pile Driver in Transverse Position, Clearing Side Track.

way across a pilot flat car with a tool house on the opposite end. The machine is frequently used for unloading materials and handling masonry supplies.

The Association of Railway Superintendents of Bridges and Buildings appointed a Committee on Recent Practice in Building Railroad Track Pile Drivers and from their report a portion of the foregoing descriptions have been condensed. The committee received twenty-four replies to a circular letter of inquiry about the most desirable requirements for pile drivers, and reports its conclusions as follows: (1) The ideal pile driver should "be able to drive piles of any length and size from either end of car, close to the car, or fifteen feet ahead of wheel base as may be desired; either plumb or at any desired batter (within reasonable limits), and at any point of a circle the radius of which shall be equal to half the length of the car, swinging itself into the proper position for the pile by power from its own engine under the control of both the engineer and signal man at any time during the operation of raising, setting, or driving pile, without interfering with any other part of the work, being at the same time rigid enough to perfectly hold the largest pile used in the heaviest kind of permanent construction and yet sensitive enough to be susceptible of the slightest move at the will of the operator.

"(2) It should be rigged with a boom long and strong enough whereby to handle with ease and safety the heaviest bridge timber, as well as to do all the work usually required of a steam derrick car in the erection and maintenance of bridges, culverts, etc., and should also have a capacity for heavy lifting, making it very useful in clearing up a wreck, pulling out temporary structures and old bridges, and, in fact, doing any kind of work where a strong portable steam derrick is required.

"(3) Its construction should be such as to make all the changes necessary to adapt it to all the various kinds of work required of it in the least possible time with a very small force of men, and so simple that no great amount of special training will be needed to fit ordinary bridge men to handle it successfully, and should not require more than six men, including engineer, for all ordinary work."



Chicago, Milwaukee & St. Paul Railroad Pile Driver Erecting Trestle Viaduct.

A Filtration Plant for Harrisburg, Pa.

For about a year and a half, under the direction of Mr. James H. Fuertes, of New York, as consulting engineer, studies and experiments have been in progress for a filtration plant for Harrisburg, the capital of Pennsylvania, a city of about 60,000 population. Situated on the east bank of the Susquehanna, where the river is broad and has a large volume of flow, the city has for years drawn its supply of water directly from the river, from points about 700 feet off shore, and into the river, at the shore line, has also discharged its sewage. In addition the stream receives sewage from an aggregate population of over 500,000 in other communities above Harrisburg; it also receives the wastes from industrial plants, and, perhaps worst of all, washings from the culm piles of the anthracite coal-mining regions. Just above Harrisburg the Conedoquinet enters from the west, bringing, when in flood, large quantities of yellow clay, while 20 miles farther upstream the Juniata pours in, also from the west, contributing, in freshet times, great quantities of red clay sediment. Consequently, in periods of high water the Susquehanna as it passes Harrisburg is frequently made up of three streams of water of distinctly different color, the black culm-burdened water next to the eastern or city shore, the red water of the Juniata in the middle, and the yellow at the west side. Notwithstanding these capabilities for being very bad, for several months of each year the river is clear as spring water, without turbidity or color, and the numbers of bacteria are generally, at such times, in comparison with many other streams, very low.

As the outcome of the investigations, taking into account first cost, maintenance and local conditions, a filtration plant of the American or mechanical type has been designed, and of the three possible locations the upstream end of Hargest's Island, in the middle of the river, has been chosen. Owing largely to the conditions imposed by this site, the plant will be decidedly unique. Drawings and specifications are now ready for bidders and an invitation for proposals is printed elsewhere in this paper. Bids will be received until April 13. The island selected for the site is crossed by two highway bridges leading from Harrisburg to the west bank of the river and has an area above the northerly bridge of nearly 80 acres.

North of Hargest's Island is Independence Island, and extending southerly below the latter is a long low sand spit between the city shore and Hargest's Island. Advantage has been taken of this formation by locating the raw-water intake for the filters in the channel between the spit and the island; the Harrisburg sewage enters the river close to the easterly bank and therefore ordinarily follows the other channel between the spit and the shore. Geologically Hargest's Island is a formation as old as that upon which Harrisburg is built; it has 12 to 15 feet of hard watertight clay immediately beneath the surface soil and below the clay about 2 to 5 feet of sand and gravel overlying the ledge rock. Occasionally, in flood stages of the river, the island is inundated, the greatest depth above its surface of which there is record having been 11 feet in 1889. The ice floes and jams in the stream also have to be dealt with. These statements make evident the necessity for some special features in the design.

Near the north end of the island a plot of about 2½ acres is to be enclosed by an earth dike 16 feet high above the surface of the island, approximately 1,600 feet long, 10 feet wide on top and having outside slopes of 1 on 2 and inner slopes of 1 on 1½. The outer slope of this dike will be armored against the attack of the ice by a continuous sheet of Portland cement concrete reinforced with ¼-inch twisted square steel rods spaced 12 inches apart in all directions. This concrete will extend from a curb at the top to a depth of several feet below the natural surface of the island. The inner slopes of the dike will be grassed. A large proportion of the materials for the dike will be obtained from the excavations for the filter plant within the enclosure. The filter plant proper will include a low-lift centrifugal pumping station, of 15,000,000 gallons daily capacity, provided in duplicate; a sedimentation basin of 4,000,000 gallons capacity, in one corner of which there will be the coagulating basin; covered filtered-water reservoir of cylindrical arch concrete construction; twelve filter beds of .01 acre area, on top of the reservoir; an operating gallery between the two rows of filters, and above the gallery a story devoted to laboratory and offices and the storage of coagulants. The walls, floors and roofs of the filters will be of concrete steel construction, which will be used also for the operating floor, pipe gallery, coagulating basins, drainage well and various parts of the different structures; the superstructure will be of brick with slate roofs.

The water surface level of the sedimentation basin will be about 5 feet above the natural surface of the island. Raw water will be supplied to it by the centrifugal pumps, but from the sedimentation basin the water will flow by gravity through the filters to the filtered-water reservoir, and from this reservoir through a 42-inch pipe laid under the river to a pump well on the easterly bank. From this pump well the water will be drawn by the pumping engines in the existing water-works station nearby and forced to an existing distributing reservoir having a capacity equivalent to about two days' maximum consumption at the present rate. During six months or more, each year, it will probably be unnecessary to use the sedimentation basin, the raw water being clear enough to be sent directly through the coagulating basin to the filters. Sulphate of alumina will be used as the coagulant and at times soda also will be added to the water before it passes through the centrifugal pumps. A Pitot tube in the rising main of the pumps will be used to indicate the rate of delivery of raw water.

In the design of the filters but one or two novel details have been introduced, the plant in other respects conforming to accepted practice in up-to-date filter construction. Each bed will have a capacity of 1,000,000 gallons per day at a 100,000,000-gallon rate, but results obtained in the experimental filters give assurance that the plant can, during some periods, safely be run at a rate of 170,000,000 gallons per acre per day. Filter sand of satisfactory character can be prepared from the river deposits near the site, but alternative bids are requested for sand furnished from any other satisfactory place. Means will be provided for preparing the local sand.

When in operation, the filters will be washed with air and water, water being used ordinarily and the air whenever the sand becomes sufficiently lumpy to require a scrubbing as a preliminary to the washing with water. The wash pipes in each bed will have the vent holes in their under sides so that the air may be forced out under a positive pressure; the size of the vents and pipes, back to the blower, will be so proportioned that there will be a positive and absolutely controllable pressure on the vents whenever the wash is being used. The pipes in each filter will be surrounded by a 4-inch layer of ¾-inch gravel, on which there will be a layer of fine gravel or very coarse sand passing a sieve having 4 meshes per inch and remaining on one having 12 meshes to the inch. The normal depth of sand will be 30 inches.

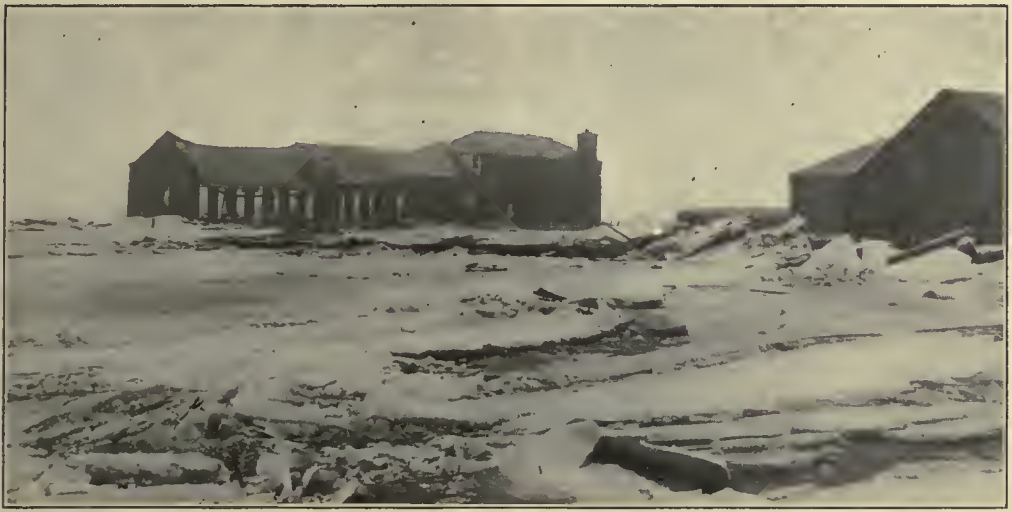
The effluent from each filter will pass through a concrete regulating box 2 feet high with a bronze measuring orifice plate in its bottom. These orifices will be so arranged that they can be changed by the superintendent from the operating gallery so as to regulate the rate of filtration. In case the pumping station should not draw the effluent from the filtered-water reservoir as rapidly as the filters are discharging, the water will rise upon the regulating boxes, thus beginning to reduce automatically the rate of filtration as soon as the water surface gets above the bottoms of the boxes, and stopping filtration completely when the water reaches the tops of the boxes. An automatic device is provided to reduce correspondingly the dose of coagulant as the water rises above the bottoms of the regulating boxes. Each bed has a float gauge to indicate the percentage or reduction of filtration during these periods as well as a loss-of-head gauge similar to those already well known from their use in other plants. The stems of the measuring orifices for the control of each filter are brought up to a stand in the operating room and have pentagonal nuts set flush with the top of the stand so that no one can use a monkey wrench on them or readily meddle with them in any way. The superintendent, however, by means of one suitable key, can turn any stem as desired. All valves in the pipe gallery will be hydraulically operated, the handles for controlling the valves for each filter being located on the operating stand.

PLANS FOR THE MODEL FOUNDRY to be carried on in connection with the St. Louis exposition are now completed and it is expected that the construction of the building will begin soon. President Engler, of the Worcester Polytechnic Institute, has been asked to name a man to take charge of the erection of the building and of the foundry itself, after it is once in operation; and, as has been previously announced, the entire charge of the foundry throughout the summer will be in the hands of the Institute.

Flood Damage to the York Haven Power Plant.

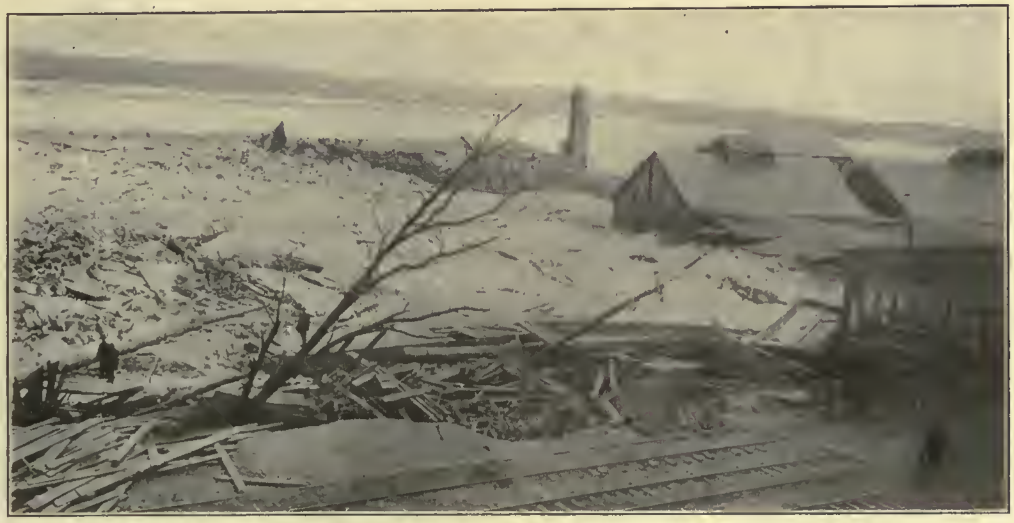
By O. P. Waters.

Though the damage to the $1,500,000 hydroelectric plant, on the Susquehanna River, at York Haven, Pa., described in the issue of March 12, will result in much loss through the delay in the completion of the plant, it is not as extensive as was reported in the newspaper dispatches sent out, while the worst ice freshet in 110 years was tearing down the Susquehanna River on its way to the bay. The plant, which was built by the York Haven Water & Power Company, would have been in operation by next May, had not a mountain of ice been hurled against the big power-house, rendering it a heap of ruins. The building stood well out in the stream and was built high above a massive granite wheelpit sub-structure, 478 by 51 feet.



York Haven Power House after First Damage by Ice.

Mr. T. W. Shock, electrical engineer for the York Haven Water & Power Company; Mr. Thomas Green, the constructor and superintendent of the plant; Mr. J. A. Dempwolf, the architect for the plant, and a number of disinterested experts have made an inspection of the plant, and Mr. Shock has given out the following description of the damage: "Many of the newspaper reports sent out in connection with the wrecking of the power-house were misleading and I do not doubt that in many minds the impression prevails that the entire plant, which was built at a cost of $1,500,000, has been converted into a worthless and irreparable ruin. This is far from the truth. The damage did not extend beyond the power-house, which collapsed, and the wire alley, which was swept away. The sub-structure, the water-wheel equipment, the dam and the transformer house resisted the destructiveness of the flood, proving the success of the plans the engineers and builders who resorted to everything known to engineering science for protection against high water and ice. The greatest loss to the plant will be the delay and extra cost of replacing the building. The cost of rebuilding and repairing the machinery will not exceed $10,000. Much of the material of the ruins will be serviceable in rebuilding. The material of the roof trusses, the brick and the crane girders can be used. As to the machinery we find that the exciter is in good condition. Number 1 and 2 generators are intact. Four generators, which had been set up and one, which was still on the floor, are covered with ice. This was a protection to them as it prevented the debris from coming in contact with the coils and I think the machines will be found to be damaged but little. The switchboard instruments are in fairly good condition and can be quickly repaired. Some of the glass of the switchboard was not even broken. There was scarcely any damage to the switching devices, and the traveling crane is all but intact. In fact, the loss to the machinery and electrical equipment is comparatively small, and about all that will be required will be the renewal of the switchboard and the re-coiling of the generators which were damaged. One generator, of 1,000 horse-power, and one exciter is still at the factory at Pittsfield, Mass. The extent of the damage wrought to the cables will be unknown until the debris is cleared away. Much of the cable will, I think, be serviceable again. In fact, the whole outlook is much brighter now than when the mountains of ice were threatening and playing havoc. I think the worst is over, and, as I said before, the greatest loss entailed will be the delay in the completion of the plant. As the work was progressing prior to the flood, the plant would have been in operation by next May, now its completion will be deferred until next autumn, when, I think, we shall be able to send a 6,000-horsepower current into York at the outset. The experience will probably be of benefit to us as we now know what the Susquehanna River is capable of, and in rebuilding the power-house precautions will be taken against another flood of the kind. The plant was built 9 feet above the highest water mark that had ever been recorded. The water rose 15 feet above that mark. Great jetties will probably be built upstream to turn the ice in future floods into the channel of the river. The great wall, which is a part of the power plant, saved the paper mill from being wiped out entirely. Thus, I think, jetties would be serviceable in protecting the power-house and other departments of the plant."



York Haven Power House after Second Attack by Ice.

The power plant is the project of Mr. Henry L. Carter, founder of the York Haven Paper Mills, also partially wrecked. Twenty years ago, he conceived the idea of building a plant near the Conewago Falls. In 1884, a site and water rights were procured, and three years ago construction was begun.

Foundations of the Rogers Building, New York.

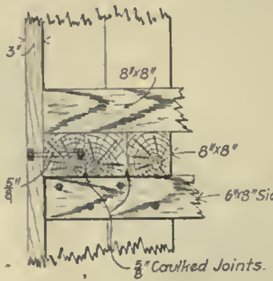
The Rogers Building is a ten-story steel-cage 100x200-foot department store at the southeast corner of Fourteenth Street and Sixth Avenue, New York. The site was formerly occupied by several old brick, iron and wooden buildings used by the R. H. Macy Company for a department store. The site was covered by a concrete cellar floor 8 inches thick, laid on the soft wet earth at about ground water level, 11 feet below the curb. As soon as the structure was removed to this point, a well 8 feet square and 30 feet deep was sunk near the center of the lot, and the water which collected there was pumped out with a No. 9 Cameron pump having an 8-inch discharge which branched to two sewers on Sixth Avenue, neither one of them having sufficient capacity for the entire quantity of water. The excavation was carried to a uniform depth of about 26 feet below the curb, and at Sixth Avenue and Fourteenth Street encountered, at a depth of 14 feet, rock which sloped rapidly to a maximum depth of nearly 60 feet at the Thirteenth Street side of the lot.

The sidewalk vaults on the Fourteenth Street and Sixth Avenue fronts were not disturbed and their inner walls were in some cases left intact and underpinned as the excavation was carried down adjacent to them. In other cases the walls were removed and the sides of the excavation were heavily sheeted. On the Thirteenth Street side the excavation was carried to the curb about 15 feet beyond the building line, and this side of the pit was protected by heavy sheet piles driven down by hand as the excavation progressed and braced with three lines of 12x12-inch rangers and heavy inclined shores. A sidewalk bridge was provided on the Sixth Avenue and Fourteenth Street sides, but as there was little pedestrian traffic on Thirteenth Street, no bridge was provided there.

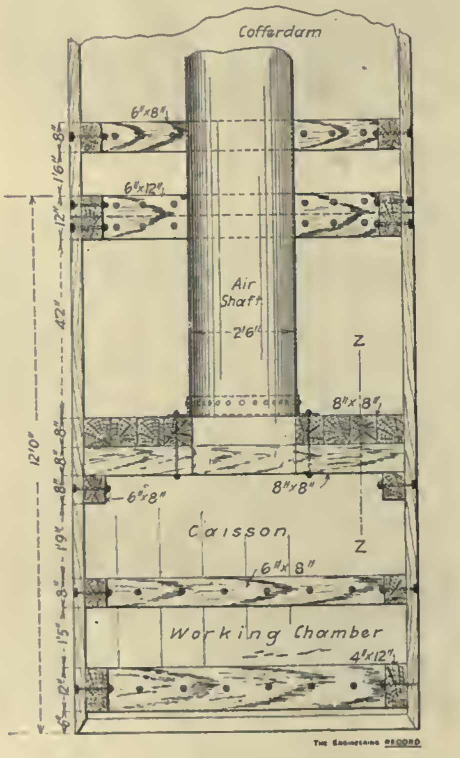
On the side opposite Sixth Avenue the George A. Fuller Company had also contracted for a separate and adjacent building and therefore was not required to sheet the sides of the excavation, but carried it down alongside the old wall and afterwards excavated for the other building. As soon as rock was encountered, sixteen Ingersoll-Sergeant rock drills were installed and were driven by steam from a battery of two locomotive boilers, afterwards increased to three and finally to four. The earth was found wet and soft and was excavated wholly by pick and shovel and carried off in two-horse wagons. The wagons were drawn by horses to the foot of a plank incline, where they were attached to a steel cable which passed through a snatch-block secured to a 12x12-inch vertical post at the top of the slope and thence led through the adjacent lot to the drum of a Lidgerwood hoisting engine in Fourteenth Street. The loaded wagon with the horses hitched to it was assisted to the top of the first incline by the hoisting engine, the wire rope was detached, removed from the snatch-block, hooked on again and pulled the wagon up to the street, thus permitting the loads to be much larger than could have been pulled out of the pit by the teams.

As the excavation progressed, the single sump was found inadequate and so two more were dug at the ends of the lot and the three were connected together by a line of valved 6-inch pipe. Separate pumps were attached to them and discharged the water to different sewers in the streets and avenue, the flow being greater than could be disposed of in a single sewer. Steam siphons were set wherever needed at different parts of the excavation to keep the pit dry, but large quantities of water were encountered and the digging was difficult and disagreeable. The steam boilers were set on transverse and longitudinal horizontal timbers at the original cellar floor level. As these were undermined by the excavation, they were supported by vertical shores, which were replaced by successively increasing lengths until they were finally carried by braced trestles supported at the new grade.

As the excavation progressed, sheeted pits were dug for the column piers. These were easily carried to rock at the Fourteenth Street end of the lot, but as the rock became deeper and deeper towards Thirteenth Street, the difficulties of sinking open pits and draining them increased until finally it was determined to build a number of the piers with pneumatic caisson footings, and the contract for this work was awarded to the Foundation & Contracting Company, under the condition that the first caisson should be ready to sink in 10 days after the contract was signed. In 9 days after the contract was signed, the first caisson was sunk to rock and sealed and the last caisson was finished 29 days later.



Detail of Roof at Z-Z.



Cofferdam and Caisson for Interior Column Pier.

The building has fifty-eight main columns arranged in eleven transverse and five longitudinal rows from about 16½ to 24½ feet apart. Twelve of these columns on the Thirteenth Street side of the lot and towards the adjacent building have piers built in caissons. The caissons were made entirely of timber with wooden horizontal rectangular frames made of 6x8-inch and 6x12-inch timber halved and lapped at the ends. The sheathing was of 3-inch vertical pine planks, 11½ inches wide, dressed on all sides and secured to the horizontal timbers with two ⅝-inch bolts at every intersection. The joints were calked outside with oakum and served with tar. The planks were countersunk on the outside to receive the heads of the bolts and the nuts were screwed up against washers flush on the insides of the timbers. The cutting edges were made without steel plates or angles, simply by beveling the lower ends of the planks to a thickness of 1 inch, and were reinforced by 4x12-inch horizontal timbers 6 inches above the edge. The working chamber had a clear height of 6 feet and had a roof made of two solid courses of crossed 8x8-inch timbers. The ends of the lower course were supported on 6x8-inch horizontal timbers bolted to the sides to form cleats, and the side timbers were bolted to the sheathing planks and had continous curves rebated in the middle of the inner vertical face to receive the nuts of the bolts and allow them to clear adjacent timbers. The sheathing projected above the roof of the working chamber so that the upper part of the caisson walls virtually formed one section of the coffer dam. The coffer dam was like the caisson, except that it had neither cutting edge nor roof. At the joints between the sections of the coffer dam and between the coffer dam and caisson the ends of the sheathing plank were cut square and abutted on the center line of an inside frame of 6x12-inch timber, which was bolted to both sections and served as an inner connecting flange.

The caissons were made in lengths of 12 and 20 feet and the coffer dams were made in regular lengths of 14 feet varied as necessary to suit the different depths. A drawing was made of the standard vertical section through the caissons and coffer dam and roof plans were made for the different sizes of caissons, thus much reducing the number of drawings required. Detail drawings exactly corresponding to the shop drawings for steel work were made of all the different timbers of the roofs and frames. These were sent to the planing mills and all of the timber was cut, planed and bored to correspond, and shipped to the site framed ready for immediate assembling. By this means the work was done quickly and accurately and time was saved in the delivery, and the trouble and expense of handling the bulky and heavy completed caissons through the crowded city streets by large trucks and 8 or 10-horse-teams was avoided. The vertical corners of the caissons were rounded and the outer faces were well smeared with grease. The caissons were sunk in the usual manner with heavy loads of kentledge and a maximum air pressure of 17 pounds. Each caisson was assembled in the position in which it was to be sunk, and the materials were handled by two large boom derricks seated on towers located so as to command the entire area of the lot. The dimensions of the caissons varied from 8 feet square to 6 feet 9 inches by 14 feet 6 inches, and they were sunk to depths of from 28½ to 60½ feet below the curb. In some places the surface of the rock sloped so steeply that one caisson was sunk 15½ feet deeper than an adjacent one, only 17½ feet from it. The caissons for the wall columns on the side opposite Sixth Avenue were made large enough for the piers of the Rogers Building and for those of the adjacent Siegel Building which was being constructed by the same contractors.

The excavation for the Rogers Building was much deeper than that for the Siegel Building and the column footings were carried down correspondingly, after which partitions were built in the coffer dams and the space on one side was filled with concrete to carry the pier up to a considerably greater height for the columns of the Siegel Building. The contract for the caissons was received and the plant was shipped to the site on August 7. The caisson timber was shipped August 11, the first caisson was ready to sink August 14, air pressure was put on it August 15 and air pressure was removed from the last caisson on September 12.

The bottom of the excavation was leveled and covered with 1 foot of concrete. On this was laid a 3-inch protection course of 1:2:5 concrete made with fine broken stone, then an asphalted felt waterproof course, then 12 inches of concrete and the asphalt floor. The concrete piers were capped with two 20-inch courses of cut granite which, in the larger piers, had grillages of 20-inch I-beams to receive the column shoes. For the smaller piers the shoes were seated directly on the granite. The steel framework was erected by the two large derricks shown in the illustration, and the bricklayers, plasterers and carpenters followed the erectors and were all working on the lower stories before the roof was erected. The total force employed consisted of a maximum of about 450 men, divided in three eight-hour shifts. Included in these there were at one time 150 men shoring and underpinning.

Messrs. Cady, Berg & See are the architects, and the George A. Fuller Company is the general contractor, Mr. H. Harvey, superintendent. The caisson work was done by the Foundation & Contracting Company, Mr. L. L. Brown, superintendent. Messrs. Southard & Company were contractors for razing the old buildings.

Excavation below Old Cellar Floor; Incline for Spoil Wagons.

Rogers Building: Completed Excavation; Derrick Tower, Braced Sheeting and Caissons.

The Measurement, Consumption and Waste of Water in the Boston Metropolitan District.

The Metropolitan Water and Sewerage Board recently presented to the legislature of Massachusetts a report on the measurement, consumption and waste of water in the Metropolitan water district as an aid to determining "the manner in which waste may be prevented and as to the manner in which the consumption of water may be considered in the apportionment among the cities and towns of the annual assessment required for the construction and maintenance of the Metropolitan water works." This report was made pursuant to a special act of the legislature of 1902 and embodies the results of a careful investigation and extended observations by Mr. Dexter Brackett, engineer of the distribution department of the Metropolitan Water Works, whose long experience and studies in this field of water works practice have made him one of the highest authorities on these questions and give more than passing value to the document, extracts from which are given below. Hitherto the assessments for the Metropolitan Water Works have been distributed among the cities and towns of the district according to a scheme based on valuation and population, stated in previous issues of this journal. For some time efforts have been made to substitute the element of consumption for that of population, and the act authorizing the present report also empowered the Board to provide means for measuring the water supplied to each of the cities and towns in the Metropolitan water district. These measurements have been provided for by the installation of forty-nine Venturi meters ranging in size from 8 to 48 inches, as described in The Engineering Record August 1, 1903. Some of these meters have been in use since January, 1903, and all since June 26, 1903. Results of complete measurements of the quantities supplied to the eighteen communities connected with the Metropolitan works for six months, could, therefore, be embodied in the report.

The total consumption of the district, as given by the meters, is about 2½ per cent. less than the consumption as measured by the displacement of the pump plungers at the pumping stations. The difference includes the quantity used in all of the pumping stations and the leakage from the Metropolitan mains and reservoirs. This use and leakage is estimated to be not less than 500,000 gallons per day.

The term "domestic use" will, for the purposes of this report, be understood to include not only the strictly household use, but also the water used for private stables and watering lawns. The best information regarding the quantity used for these purposes is obtained from the records of the cities and towns where all or a large percentage of the water takers are supplied through meters. In the towns of Belmont and Milton every service pipe is metered; in Watertown, 89.5 per cent.; and in

	Number of consumers. 1902.	Gallons per day. 1902.	Gallons per day per consumer. 1902.
Belmont	3,900	66,630	17.1
Malden	22,550	450,160	20.0
Milton	7,450	143,500	19.3
Watertown	10,250	152,900	14.8
	44,150	813,190	18.4

Malden, 63.4 per cent. The experience in other cities and towns where meters are in general use on domestic services corroborates the results obtained in the Metropolitan district.

	Estimated No. of consumers.	Per cent. of services metered.	Gallons per consumer per day. Domestic.	Manufacturing.	Totals.
Brockton	37,800	90.6	13.2	6.5	*21.8
Fall River	107,650	96.0	15.5	5.2	*22.2
Newton	35,400	86.0	23.1	4.6	*34.0
Ware	7,690	100.0	25.4	1.1	26.5
Woonsocket, R. I.	34,474	86.7	11.6	10.5	22.1
Wellesley	5,147	100.0	25.6	.1	25.7
Worcester	119,330	94.5	16.1	17.8	*36.3
Yonkers, N. Y.	51,000	98.7	19.7	22.0	*42.7
	398,491	...	16.7	...	...

*Includes water used for public purposes.

The manufacturing and trade use in the Metropolitan water district is centered in Boston, although the per capita use for these purposes is quite large in several other cities and towns. The greater portion of the water used for manufacturing and trade in the Metropolitan district is supplied through meters, and for the year 1902 was 19.47 gallons per capita per day.

Careful estimates of the quantity of water used for these purposes, which is not metered, indicate that the amount is not more than 5 gallons per capita in Boston and from 2 to 3 gallons per capita in other cities and towns in the district, with an average of about 4 gallons for the whole district. This quantity, added to the quantity supplied through meters, gives about 23.5 gallons per capita per day required at the present time for manufacturing, mechanical and trade purposes in the Metropolitan water district.

The principal uses of water for public purposes are for public buildings, for public fountains, for sprinkling streets, for flushing water pipes and sewers, and for extinguishing fires. Under the head of public buildings are included schools, fire engine houses, State House, city and town halls, hospitals, asylums and jails, churches and theatres, and all other national, State, county and municipal buildings. The total for public buildings is as follows [based in part upon meter measurements and in part upon careful estimates]:

	Gallons.
Schools	.70
National, State and county buildings, metered	.58
Hospitals, asylums and jails, metered	.50
Churches, theaters and clubs, metered	.40
Public buildings, other than schools, unmetered	1.00
Total for public buildings	3.78

The estimated quantity of water used by 139 public drinking fountains, located in the several cities and towns supplied by the Metropolitan Works averages 664,640 gallons per day, equivalent to .74 of a gallon per capita of the population supplied. In the greater proportion of the drinking fountains the water runs continuously, and it follows that the greater part of the water is wasted. The average use in 18 fountains of this class in Boston, as determined by measurement, was 14,000 gallons per day each. Thirty-three of the drinking fountains for animals used in Boston are so arranged that during the six summer months the flow into the trough is controlled by an automatic valve, and no water is wasted; during the winter season the flow is continuous. Meters attached to two of these fountains showed that the use during the summer was at the rate of 1,250 gallons per day, and during the winter, when less water is needed, 6,250 gallons, or five times the summer use. In the city of Boston there are 20 ornamental playing fountains, and the total quantity discharged is estimated to be 237,000 gallons per day for six months, equivalent to .2 of a gallon per capita for the whole year. The combined use for drinking and ornamental fountains is about 1 gallon per capita per day.

For sprinkling streets throughout the Metropolitan district in the year 1901 the quantity used is estimated to have been nearly 700,000,000 gallons, equivalent to 2.13 gallons per capita per day for the year.

Although large quantities of water are at times drawn from the pipes for extinguishing fires and for flushing water pipes, the use continues for but a short time, and the total use during the year is comparatively small; the per capita yearly use probably does not exceed .20 of a gallon.

The quantity required for public purposes may be summarized as follows:

	Gallons per capita.
Public buildings	3.78
Drinking and ornamental fountains	1.00
Street sprinkling	2.13
Flushing water pipes and sewers and extinguishing fires	.20
	7.11

From the preceding statements the total quantity actually required for legitimate use in the Metropolitan water district at the present time is shown to be less than 60 gallons per inhabitant per day, divided as follows:

	Gallons.
Domestic use	25.0
Manufacturing, mechanical and trade use	23.5
Public use	7.0
	55.5

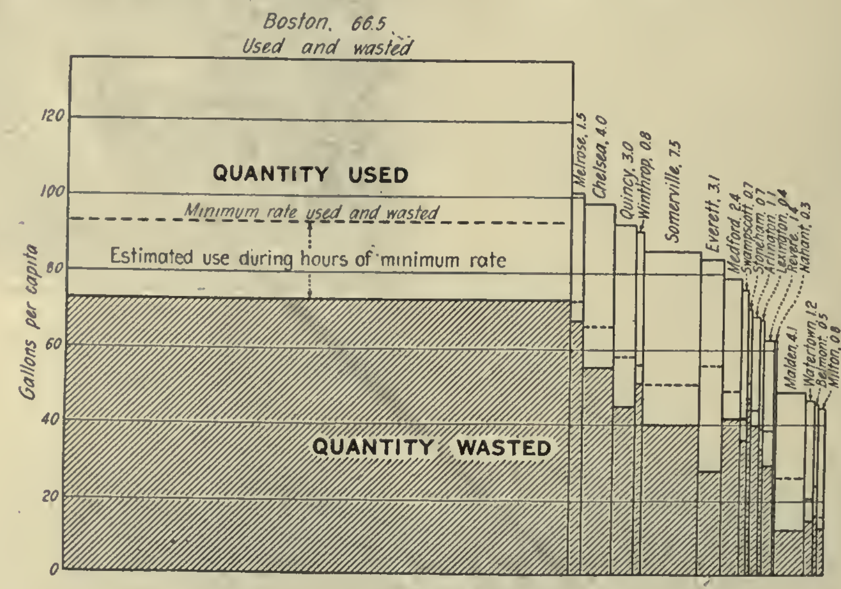
If, as has been stated, the actual requirements for domestic, manufacturing, trade and public purposes in the Metropolitan district do not exceed 60 gallons per inhabitant, while the total supplied to the district is nearly 120 gallons, it is evident that one-half of the water furnished must be wasted either from the street mains and service pipes, or from the water fixtures and piping on the premises of the water takers.

Both the daily per capita and night rates of consumption vary widely in different districts, even where the takers are of the same general class. Where the rate for twenty-four hours is large, the night rate is in almost every case excessive. It is also noticeable that the lowest rates of consumption are to be found in those districts where water meters are in general use. Take, for example, the rates of consumption during the night in Milton, Watertown, Belmont and Malden, as compared with those in Medford, Melrose, Winthrop and the high-service districts of Brighton and Chelsea. The

Diagram No. 1

Diagram showing the per capita quantity of water used and wasted in the several cities and towns supplied by the Metropolitan Water Works.

Figures following names of cities and towns show percentage of total population of district



Consumption of Water, Metropolitan Water Works.

population of each of these groups is about 60,000. They are districts in which the manufacturing use is very small, and there appears to be no good reason why the legitimate use of water between the hours of 1 and 4 A. M. should not be very small in every case. In the first group the rate varies from 13.4 to 25.5 gallons per capita, with an average of 18 gallons; while in the second group it varies from 43 to 71.4 gallons, with an average of 58.3 gallons. The difference between 18 and 58 gallons is unquestionably preventable waste.

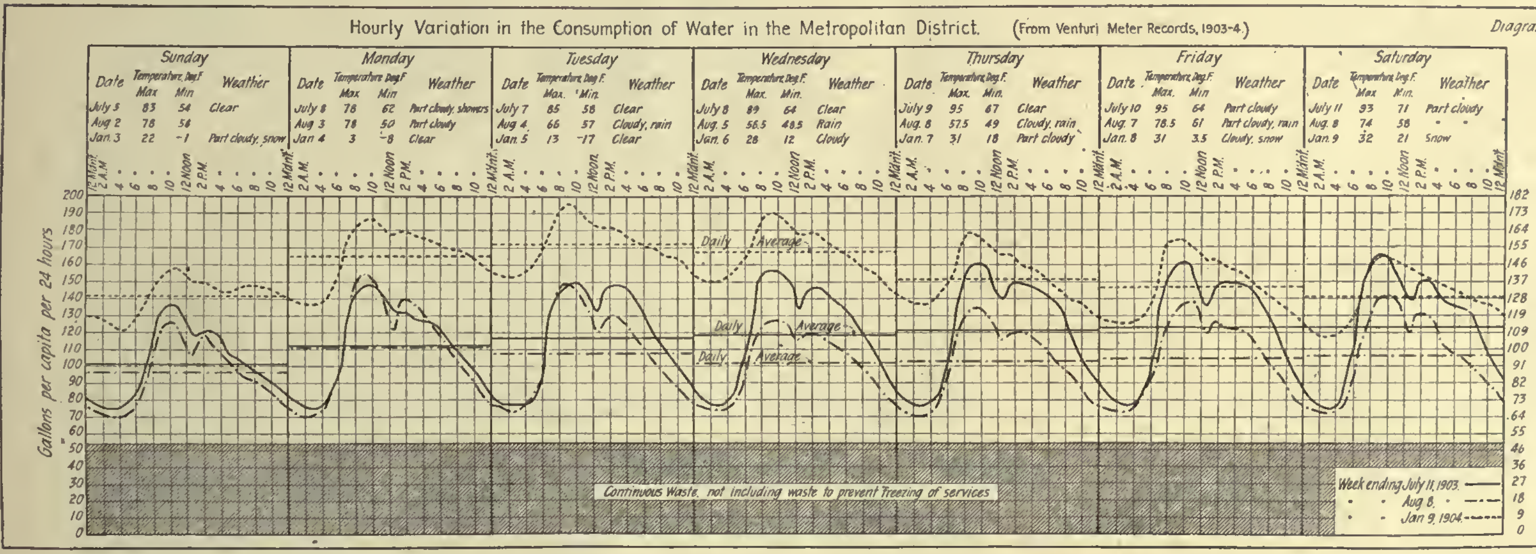
Considering the whole Metropolitan district, the legitimate draft during the night is very small, when compared with 77 gallons per capita, which was the average minimum rate during the last six months of the year 1903. Nearly all of the water used for manufacturing, mechanical and trade purposes is metered, and the total is but 23.5 gallons per capita, of which the greater part must be used during the day. It is not probable that the legitimate use for all purposes during the hours of minimum consumption is more than 17 gallons per capita, in which case 60 gallons must be wasted.

Diagram No. 1 shows graphically the comparative volume of water used and wasted in the several municipalities, the cities and towns being arranged in order of per capita use.

Diagram No. 2 shows the rate of consumption in the whole district supplied by the Metropolitan Works for each hour during three weeks, as measured by Venturi meters. During the week ending July 11, 1903, the weather was hot and dry, especially during the latter part of the week; during the week ending August 8 the weather was comparatively cool, with showers and little sunshine; and during the week ending January 9, 1904, was extremely cold. On Monday, July 6, .42 of an inch of rain fell, making street sprinkling unnecessary until Tuesday afternoon. For this reason the use during Monday, July 6, was very nearly the same as on Monday, August 9. During the last four days of the week ending July 11 the maximum temperature was from 89 to 95 degrees, and a large amount of water was used for sprinkling streets and lawns. The consumption for these days was from 14,000,000 to 17,000,000 gallons per day more than during the corresponding days of the week ending August 8, when frequent showers and cool weather made both street and lawn sprinkling unnecessary. During both of these weeks the minimum rate of use was about 75 gallons per capita.

The amount wasted from the street mains and service pipes is a much larger percentage of the total consumption than has been generally estimated. This fact is proved by the results obtained where water supplied to individual takers is measured, and can be compared with the total quantity supplied to the city or town. In the Metropolitan district in the town of Milton the water supplied to every taker is metered, including that used for street watering and other public purposes. In Belmont all supplies are metered, and a careful record is kept of the number of loads of water used for street watering. The total quantity of water delivered into the pipes of each town has been measured by means of Venturi meters, and, if the meters through which water is supplied to individual takers record accurately the water passing through them, the difference between the quantity recorded by the local meters and that delivered into the pipes of the town must represent the leakage from the street mains and service pipes. In both of these towns meters have been used but a few years, and it does not seem probable that the loss in registration of the meters can be more than 2 or 3 per cent. Similar results have been obtained in every city and town where the water supply to individual takers has been metered.

	Gallons per day. Delivered into pipes of town.	Gallons per day. Metered to consumer.	Gallons per day. Unaccounted for.	Per cent. unaccounted for.	Gallons per day unaccounted for per mile of pipe.
Milton, April, May, June	325,100	216,300	108,800	33.5	3,110
Milton, July, August, September	328,000	199,100	128,900	39.3	3,680
Belmont, March 15 to May 15	171,500	135,300	66,200	38.6	3,710
Belmont, May 15 to September 15	230,500	145,000	85,500	37.1	4,780



Day	Date	Temperature, Deg. F. Max.	Temperature, Deg. F. Min.	Weather
Sunday	July 5	83	54	Clear
	Aug 2	78	54	
	Jan. 3	22	-1	Part cloudy, snow
Monday	July 6	78	62	Part cloudy, showers
	Aug 3	78	50	Part cloudy
	Jan 4	3	-8	Clear
Tuesday	July 7	85	58	Clear
	Aug 4	66	57	Cloudy, rain
	Jan. 5	13	-17	Clear
Wednesday	July 8	89	64	Clear
	Aug. 5	56.5	48.5	Rain
	Jan. 6	28	12	Cloudy
Thursday	July 9	95	67	Clear
	Aug. 6	57.5	49	Cloudy, rain
	Jan. 7	31	18	Part cloudy
Friday	July 10	95	64	Part cloudy
	Aug. 7	78.5	61	Part cloudy, rain
	Jan. 8	31	3.5	Cloudy, snow
Saturday	July 11	93	71	Part cloudy
	Aug. 8	74	58	" "
	Jan. 9	32	21	Snow

	Delivered into mains. Per cent. of taps metered.	Delivered into mains. Daily average (gallons).	Delivered into mains. Gallons per consumer.	Metered to consumers, or otherwise accounted for. Gallons.	Metered to consumers, or otherwise accounted for. Gallons per consumer.	Per cent. unaccounted for.	Gallons per day unaccounted for per mile of pipe.
Brockton	90.0	1,362,470	36.0	902,120	22.0	32.3	6,200
Ware	100.0	338,160	44.0	203,430	26.5	39.8	11,200
Worcester	94.5	8,094,840	68.0	4,331,030	39.0	46.5	20,800
Wellesley	100.0	257,000	50.0	150,000	29.0	41.5	3,450
Yonkers, N. Y.	100.0	4,540,900	89.0	2,463,490	42.7	45.7	23,340
Fall River	96.0	4,365,060	40.5	3,430,300	32.0	21.5	10,000
Woonsocket, R. I.	86.7	989,420	28.6	762,380	22.0	23.0	4,370

In the Metropolitan water district there are 1,457 miles of pipes, on which there are 750,000 leaded joints from which leakage may occur. Leaks of considerable magnitude often remain undiscovered for months, the water escaping into the ground or into a brook or sewer. Several years ago, while Deacon waste-water meters were being used in Boston to detect leaks, several 4-inch and 6-inch cast-iron pipes were found broken, from which the water was escaping unseen into the sewers. In a number of instances this leakage was at the rate of 24,000 gallons per day, and in one instance 100,000 gallons per day were found to be running into a sewer from a 6-inch pipe which was broken entirely off.

A very forcible illustration of this source of waste has been furnished in the town of Stoneham. During the first six months of the year 1902 about 800,000 gallons per day were supplied to the town. As this quantity appeared larger than was needed for legitimate use, an investigation was instituted for the purpose of learning where the water was used, with the result that four leaks in the street mains were found, which gave no surface indications. After these were repaired the consumption of water fell to 330,000 gallons per day, indicating that 470,000 gallons per day had been wasting from a few unseen defective pipes.

Tests have been made in Melrose to determine the amount of water leaking from the mains and services, by measuring with a meter the rate of flow into the pipe supplying certain streets while all the stop cocks on the house services were closed. These tests were made during the night, when the legitimate use was very small. The total leakage from less than 2 miles of pipes was 3,490 gallons per hour, or at the rate of 43,770 gallons per mile of pipe per day.

Several years ago a blow-off valve was carelessly left open in Boston, and water ran for several days into a sewer at the rate of 3,000,000 gallons per day. In flushing water pipes and sewers much larger quantities are often used than are necessary for accomplishing the results desired, but it is not thought that the aggregate amount wasted in this way is large.

The tests which have been made in the several municipalities of the Metropolitan district tend to show that the leakage from the street mains and services is very large, and that from 10,000 to 15,000 gallons per mile of street main escape each day into the ground or into some underground channel. If this estimate is correct, the total leakage from the mains and services is from 15,000,000 to 22,500,000 gallons per day—equivalent to from 16.5 to 25 gallons per inhabitant.

To a greater degree than in the case of the street mains does the leakage from water fixtures take place from a very large number of small openings which permit of a constant flow. Few persons realize that sufficient water will flow, in twenty-four hours, through an orifice of no greater diameter than an ordinary lead pencil, under the average pressure which exists in the pipes throughout the Metropolitan district, to furnish an ample domestic supply for 360 persons; and that in the same time more water will leak through an orifice the size of an ordinary pin than would be used by a fairly economical family of five persons.

The legitimate use of water is no larger during the winter season than during the months of November and April, but the actual use in the Metropolitan district is much larger during cold weather than during any other season of the year. In the cities where meters are in general use, waste of this character does not occur to any great extent, as each property owner is pecuniarily interested so to arrange the plumbing in his buildings that it does not become necessary to allow water to run in order to prevent it from freezing. The effect of cold weather upon the use of water is illustrated very forcibly on Diagram No. 2, on which is shown the rate of consumption from the Metropolitan Works during each hour of the week ending January 9, 1904. On Tuesday and Wednesday, which were the coldest days of the week, the consumption was about 60,000,000 gallons per day greater than during corresponding days in the month of August; and the lowest rate at which water was drawn from the pipes during the night was 150 gallons per capita—an amount greater than the maximum rate of use during the corresponding days in August. The cities of Malden and Chelsea have approximately the same population. Malden uses meters on 69 per cent. of its service pipes, Chelsea on 2 per cent. The per capita use in

	Daily average (gallons). November and April.	Daily average (gallons). December, January, February and March.	Difference wasted to prevent freez'g of water in pipes (gals. per day)	Daily No. of gals per cap. wasted (y'rly average).
1900-01	90,322,000	104,878,000	14,556,000	5.74
1901-02	99,317,000	111,417,000	12,100,000	4.61
1902-03	104,950,000	121,589,000	16,639,000	6.16

Malden on August 4 was 41 gallons, and in Chelsea 88 gallons. On January 5, 1904, when the average temperature for twenty-four hours was 2 degrees below zero, the per capita use in Malden increased to 57 gallons, and in Chelsea to 211 gallons. In Malden the increase caused by cold weather was about 16 gallons per capita, and in Chelsea 123 gallons.

The most certain means of detecting waste, and the most effectual means of preventing the extravagant use and waste of water, is that of measuring the water supplied to each municipality, district or individual water taker, and obliging each municipality and individual to pay for water in proportion to the quantity used. Differences in climate, in character of business and in location, as affecting the available supply of water, often have a marked effect upon the consumption in different cities; but in the following table an attempt has been made to eliminate these differences, as far as possible.

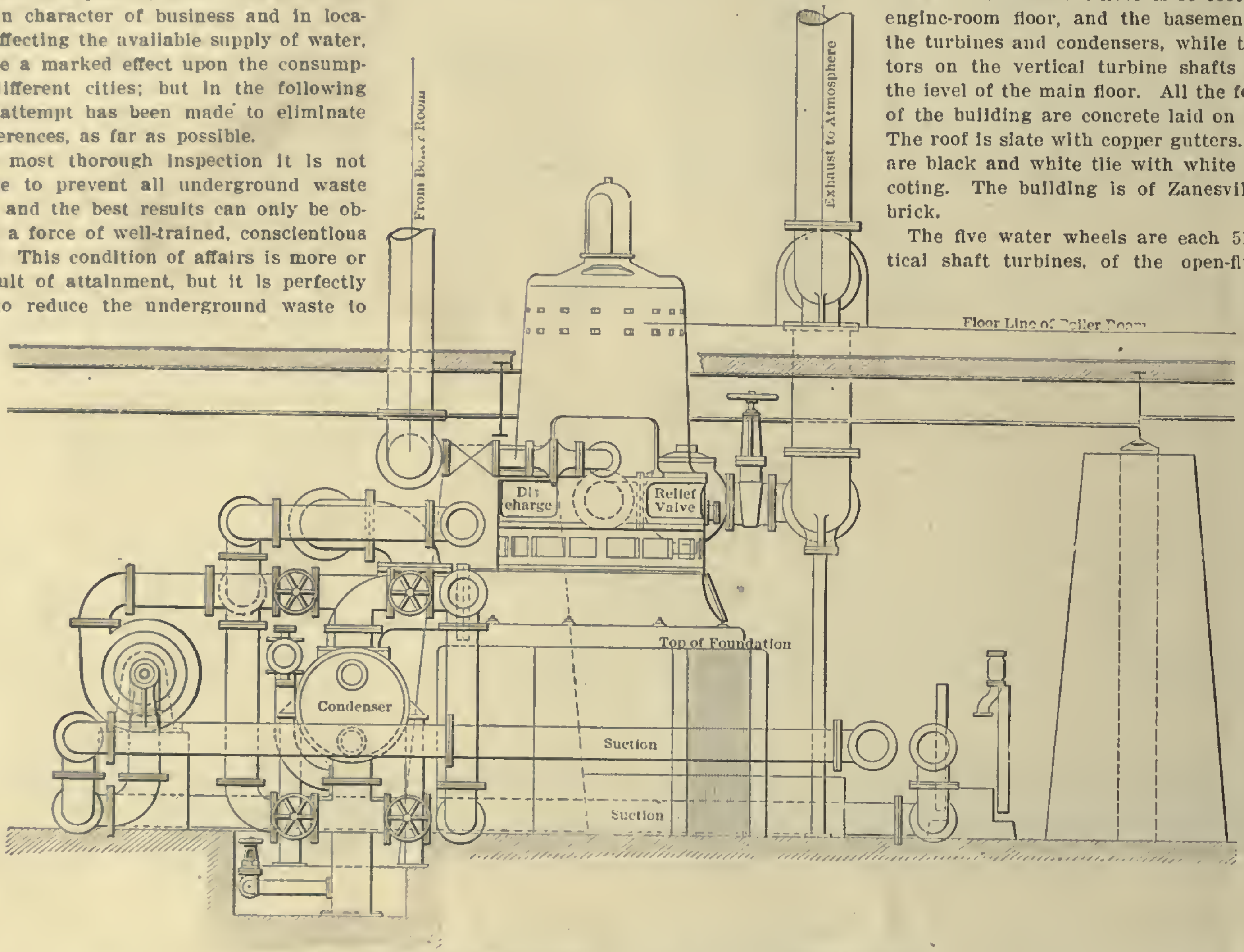
By the most thorough inspection it is not practicable to prevent all underground waste of water, and the best results can only be obtained by a force of well-trained, conscientious employes. This condition of affairs is more or less difficult of attainment, but it is perfectly feasible to reduce the underground waste to from 10 to 15 gallons per capita, and the total waste, including that in buildings, to from 15 to 20 gallons.

	Number of consumers.	Per cent. of services metered.	Consumption (gallons per day per consumer).
Milwaukee, Wis.	308,000	80.0	81.0
Providence, R. I.	198,400	84.5	58.0
Worcester	119,330	94.5	68.0
Fall River	107,650	96.0	41.0
Lowell	100,000	65.0	57.0
Lawrence	65,000	83.0	53.0
Brockton	37,800	90.0	36.0
Newton	35,400	86.0	54.0
Woonsockel, R. I.	34,474	96.0	29.0
Ware	7,630	100.0	44.0
Wellesley	5,147	100.0	49.0
Reading	4,385	100.0	33.0
Buffalo, N. Y.	360,000	2.0	324.0
Indianapolis, Ind. ...	169,100	6.0	79.0
New Haven, Conn.	108,000	2.6	150.0
New Bedford	61,000	18.0	104.0
Cambridge	94,150	15.0	85.0
Haverhill	37,200	10.0	95.0
Lynn	74,000	25.0	63.0
Waltham	24,550	6.0	99.0
Salem	36,250	3.0	79.0
Montague	6,150	2.0	73.0
Dedham	7,500	2.0	83.0
Braintree	5,980	1.0	91.0

The report contains many other statements, tables and diagrams of interest, but limitations of space prohibit more liberal extracts.

A Central Station with Steam and Water Turbines, Zanesville, O.

A central electric station including in its equipment five 275-horse-power water turbines and two 500-horse-power steam turbines has been built at Zanesville, O., for the Zanesville Railway, Light & Power Company. Formerly the varied service maintained by the company was distributed from a plant consisting mainly of high-speed, simple, non-condensing engines with a conglomeration of belts and line shafting for transmitting the power to generators, but during the past eighteen months the property has been undergoing an extensive reconstruction looking to the abandonment of the old installation. The opportunity to utilize a water power led to the adoption of the water-wheel machinery, but the variable output of the natural power made it necessary to provide in addition for the full capacity in steam-driven units.



Arrangement of Steam Turbine and Piping and Condenser System.

The new plant is located on the bank of the Muskingum River, between the river and a canal maintained by the Government. To divert water to the canal, a wooden crib dam is maintained in the river by the Government, just above the power plant. The only expense connected with the development of the water-power has thus been the building of the station itself. As regards the effect of the location on the operating facilities of steam plant, it may be stated that below the power-house is a bridge, and from the street railway tracks on this bridge a spur is run to the power-house for carrying coal and other supplies. A side track of the Baltimore & Ohio Railroad also reaches the plant at one end. The power-house is located on a solid ledge of rock.

The water passes under the down-stream end of the building. The boiler house is located over the head race and the generators on opposite ends of the horizontal shaft to which the vertical shaft turbines are geared by means of wooden beveled gears. The ordinary level of the tail water is 13 feet below that of the head water. This head disappears in times of freshets, as maximum high water comes very nearly to the top of the concrete foundation wall, which is carried up to the level of the engine and boiler-room floors. The coal siding is located at the right directly over the ice racks and in front of the boilers. The steel structure supporting the boiler room is covered with concrete, as it is exposed to the water. The up-stream end of the station contains the steam-turbine units. The basement floor is 13 feet below the engine-room floor, and the basement contains the turbines and condensers, while the generators on the vertical turbine shafts are above the level of the main floor. All the foundations of the building are concrete laid on solid rock. The roof is slate with copper gutters. The floors are black and white tile with white tile wainscoting. The building is of Zanesville pressed brick.

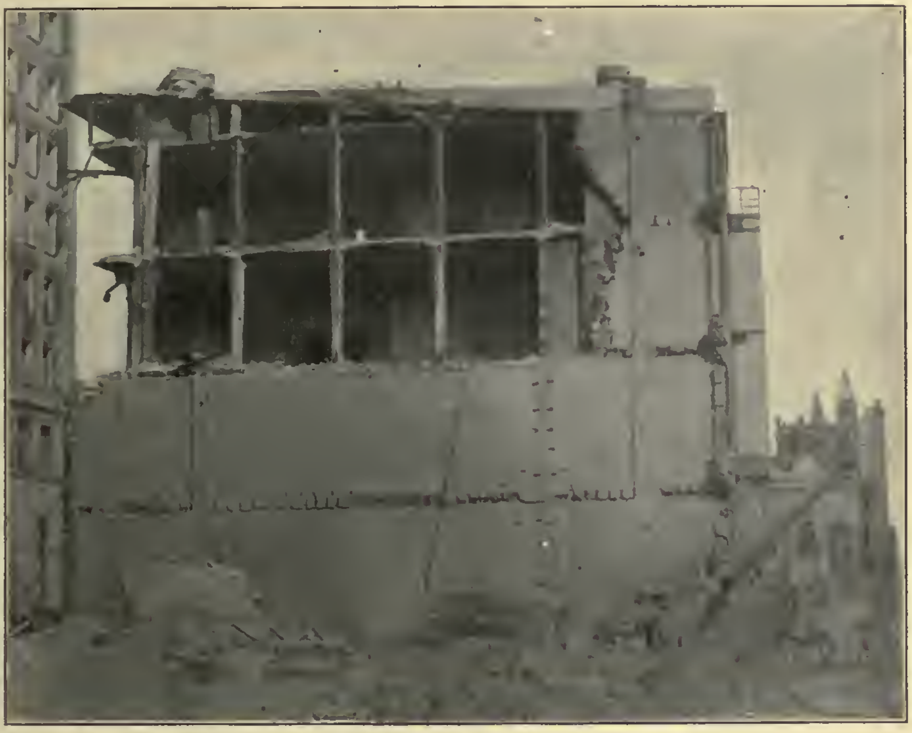
The five water wheels are each 51-inch vertical shaft turbines, of the open-flume type, made by the Stilwell-Bierce & Smith-Vaile Company. They run at 80 revolutions per minute and are geared through bevel gears to a line shaft running 200 revolutions per minute. On each end of this line shaft is a 375-kilowatt General Electric, 60-cycle, 2,300-volt generator. The wheels are controlled by Lombard governors, and the speed can be varied from the switchboard by means of a direct-current motor at the governor. The shaft house is partitioned off from the generators at either end.

In the steam turbine room are two 500-kilowatt Curtis steam turbines, designed to operate at 180 pounds steam pressure, in connection with Stilwell-Bierce surface condensers. The centrifugal circulating pump is motor driven. Provision has been made in the generator room for two more steam turbine units of this size. Rotary converters are also in this room. The accompanying drawing shows in dotted line the future condenser connection.

In the boiler room resting on a concrete floor over the head-race are two 380-horse-power Heine water-tube boilers, with two Stilwell-Bierce feed pumps. The boilers are hand-fired. Coal is shoveled directly from the cars on the siding into the space in front of the boilers. Provision has been made for doubling this boiler capacity.

About 25 per cent. of the load of the station is supplied to alternating-current lighting circuits. The remainder is used in rotary converters to give 550-volt current for railway use and 110 volts for the three-wire direct-current network for general use.

Both the railway and lighting rotary converters are supplied from the same generators. This has been made possible by connecting in multiple with the railway bus-bars, 256 cells of chloride accumulator. This storage battery is connected in series with a differential booster, which causes the battery to take the fluctuations of railway load and leave a practically steady load on the generators. The cells of this battery are type G, with 17 plates per cell. The tanks are large enough to allow 50 per cent. increase in plate service, and the differential booster was selected for the ultimate capacity of the cells. This battery is rated at 640 amperes at the one-hour rate of discharge. The value of a battery was forcibly demonstrated last winter during the holidays. The maximum railway load amounted to 660 kilowatts. If there had been no battery, this would have been beyond the capacity of the water supply which was then available for use. The average load was only 220 kilowatts. The battery took the fluctuations so that the plant was operated with one wheel at full gate and one wheel at sixteenth full gate.



Annex of United States Fidelity & Guaranty Building, Baltimore.
Showing Reinforced Concrete Columns and Floors.

No exciters have been provided for this station for the present. In case all the direct-current machinery should be shut down, current for excitation can be obtained from the battery. The battery room is on a floor above the generator room. It has the regular floor now commonly employed in storage battery rooms, consisting of tile laid in asphaltum, and is drained with lead-lined iron pipes. The high-tension switchboard in the gallery was furnished by the General Incandescent Arc Light Company, and has G. I. hand-operated oil switches.

The economies effected by the reconstruction are in a few particulars already known. In the old plant, for example, seventeen men were required for operation; in the new, six suffice. The old plant used 12 pounds of coal per kilowatt-hour, while the Curtis turbine units are guaranteed to operate at 20 pounds of steam per kilowatt-hour, so that with an assumed evaporation of 8 pounds of steam per pound of coal, it is expected to operate with less than one-quarter the amount of coal with the same power output. Coal costs $1.40 per ton delivered.

Hon. F. A. Durban, of Zanesville, is president of the company; Mr. H. M. Byllesby, vice-president and engineer; Mr. W. A. Gibbs, general manager and assistant treasurer; Mr. W. D. Breed, of Messrs. Rudolph Kleybolte & Company, bankers, of Cincinnati and New York, secretary and treasurer. Mr. Gibbs had been in charge of the properties under the former management for several years. Messrs. H. M. Byllesby & Company, of Chicago, were retained for all the engineering work in connection with the rebuilding of the property. Mr. Gibbs, together with Mr. E. C. Braun, one of the engineers of H. M. Byllesby & Company, had charge on the spot of the reconstruction of the property.

Reinforced Concrete in the Baltimore Fire.

An interesting example of a building with concrete-steel framework and floors, which was exposed to the flames in the Baltimore fire, is the four-story basement and attic annex of the United States Fidelity & Guaranty building at 111 East German Street. It occupied a 25x67-foot lot and was six stories, or about 78 feet high, including the basement and attic. It had flat-arch floors of 9-foot 10-inch clear span carried on six transverse girders supported on two rows of longitudinal wall columns 20 feet apart in the clear. The columns vary from 8 inches square at the top to 14 inches square at the bottom and, together with the girders and floor slabs, were made on the standard Hennebique system. The floors were designed for live loads of 200 pounds per square foot and were made with flat arches 4 inches thick at the crown and 6½ inches thick at the skewbacks. The girders were 8 inches wide and 22 inches deep including floor thickness. The hand-mixed 1:3:5 concrete was made with Lehigh cement and ¾-inch broken trap rock.

The end columns and floorbeams were one-half panel back from the front and rear walls, and the floor slabs cantilevered beyond the beams to the building lines where their extremities took bearing in the walls. The roof construction was the same as the floors, except that the surface was pitched longitudinally. The concrete construction thus comprised the whole interior of the building and consisted of six platforms supported on vertical columns. It was built about a year ago to replace the wooden interior of the building which had been removed and left the brick walls standing on the rear and two sides of the building. These were of solid brickwork 16 inches thick at the base and 12 inches thick at the top and were laid up with lime and cement mortor. Chases were cut in them 4 inches deep to receive the concrete wall columns which thus had a nominal connection but no satisfactory bonding with the brickwork. The column foundations were of concrete laid in the bottoms of pits excavated in dry clay about 3 feet below the cellar floor and corresponding to the wall foundations.

The front of the building was composed of cast-iron and plate glass. The floor surfaces, doors, window-frames, trim and partitions were of wood, and the rooms contained some furniture and considerable paper. All of these combustible materials were consumed and produced a fire sufficient to melt brass, fuse typewriter machines and produce other evidences of high temperature. The upper two stories of one of the side walls fell and the remainder of the brickwork was so much injured that it all had to be taken down. The front was practically destroyed and buckled out away from the building, but did not completely fall.

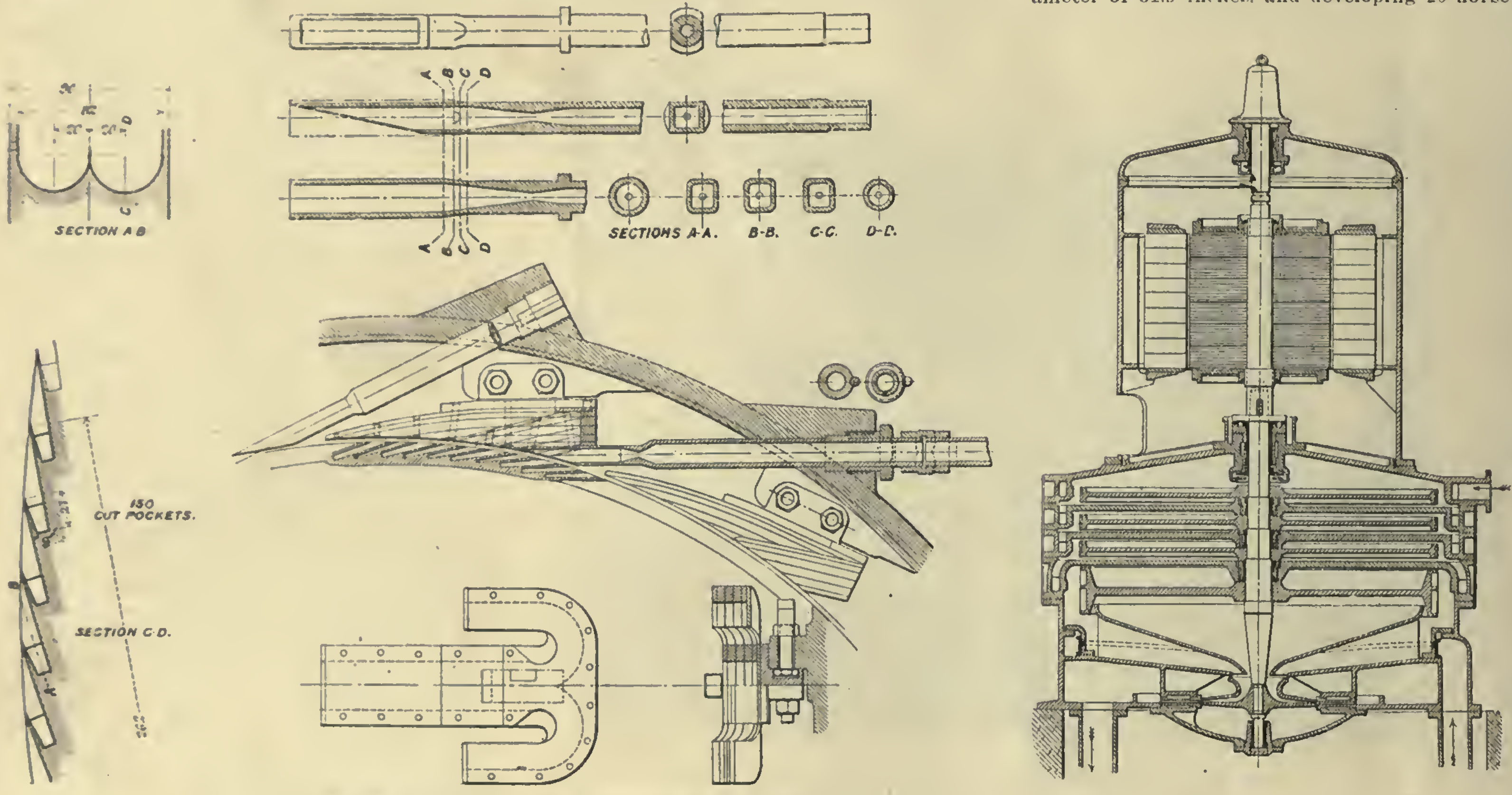
The concrete construction endured the fire practically uninjured, a notable demonstration being the fact that the cantilever extensions of the floors in front and rear remained intact, and the attic floor carried a tier of columns reaching to the roof which it had never been designed to support. These floor slabs showed slight cracks, but were not broken or disabled. Elsewhere in the upper two stories there were a few instances of cracks in the tops of the floor slabs in the middle of the spans, indicating that the concrete had buckled upwards through expansion. In a few cases where the heat was the greatest, fine surface cracks were seen in the beams and ceilings and small portions of the concrete had flaked off, but nowhere sufficient to indicate serious injury to the structure.

This building was the only one which remained standing in that block after the fire, and its endurance was remarked by many engineers and architects, and was considered highly satisfactory by the builders. On March 10 a loading test was made of one of the lower floors. A portion of the full width of the floor, one panel long, extending from the center of one floor slab 10½ feet to the center of the next slab, an area of 210 square feet, was covered to a depth of 3 feet with common bricks piled solid, making a uniformly distributed load of 225 pounds to the square foot on the assumption that the bricks weighed 75 pounds per cubic foot. This load caused a deflection of 1/16 inch at the center point of the beam under the center line of loading. Afterwards a pile of bricks 6 feet wide and 2 feet high reaching from end to end of the first pile was built parallel to the walls of the building and on its center line. The increased load increased the deflection to ⅛ inch at the center of the floorbeam. The load was allowed to remain 24 hours after application and when removed, it was found that there was no permanent deflection and no cracks or perceptible injury to the floor. This test would have been made on the upper floor where the fire had been the hottest, but the building was devoid of elevators or stairways and it would have been difficult to raise the bricks so high.

The building was constructed and the tests were conducted by Mr. Henry Kantmann, C. E., licensed contractor of the Hennebique patents and now engineer of the Ferro-Concrete Company, Baltimore.

The Riedler-Stumpf Steam Turbine.

The Riedler-Stumpf steam turbine was brought into especial prominence about November last year at the Technical Shipbuilding Society in Berlin. Several descriptive accounts have since then appeared in the European technical press, including a discussion of new forms of turbines, in "The Engineer" by Mr. Robert H. Smith. From this and an article in "Engineering" the following account has mainly been drawn. The turbine was designed by Professors Riedler and Stumpf, of the Royal Technical High School of Charlottenburg, to utilize the impulse principle under the following conditions: It was determined to employ a relatively large wheel diameter to obtain a comparatively low rotary speed; to split the fall of velocity, that is, the spending of kinetic energy, into stages, to secure a further reduction of speed, say to 500 or 700 revolutions per minute; and to provide also for a division of the pressure into steps, with the restriction, however, that the number of separate pressure falls must be small.



Sketches of Details of the Riedler-Stumpf Steam Turbine and Section of a Vertical Unit.

As shown in the accompanying illustrations, the rotor contains peculiar oblique pocket buckets. These are milled out of the rim of the rotor and the nozzles are placed obliquely with respect to the rotor, in a ring which surrounds the wheel, directing the steam not at an angle with the plane of the rotor, but, as indicated, against the peripheral surface. The nozzles, which are of nickel steel, in a proportion to resist rusting, are square in cross-section. They are made of round bored tubes; the portion below the stricture, the size of which depends on the desired expansion, is drawn out square and finally cut off obliquely. The type of bucket shown is the divided or double pattern, the impinging steam jet being parted by the partition between the pockets. In a wheel of 6 feet 8 inches diameter, with 3¾-inch width of rim, the pitch between the buckets measured on the outside periphery of the wheel is about 1⅝ inches and the total number of buckets is 150.

Sometimes only one pocket is milled in the periphery of the rotor and sometimes the two taue by side are of unequal size. In the latter of a working steam inpinges on the inner edge of the smaller pockets, sweeps around the semicircle of these pockets outward and finds exit from the wheel with a backward velocity of about 0.7 the original velocity. It flows into a tube guide, which leads it around a semi-circle without doing work and therefore without loss of velocity except through friction, the object of the guide being to change the direction of the jet to approximate parallelism with that of the first jet. The steam then once more impinges on the wheel, driving it forward by sweeping around the semi-circle of the larger of the two sets of buckets. In this type the drop of pressure takes place before discharge from the nozzles and there is thus no provision for steps in pressure fall. The kinetic energy, however, is utilized in two stages, as outlined.

It appears that there is chance for a considerable loss between stages by lateral spraying or dispersion of the jet. To avoid such loss by close guidance of the stream of steam, the reversing guides, as shown, are made up of a group of separated passages, the scheme being that by sub-dividing the stream, each portion is saved from wasteful eddies and cross currents. The reversing guides shown are for an arrangement where the wheel has two rows of buckets.

The main nozzles may be placed at considerable distances apart with the discharge orifices of the reversing guides in between. Where the buckets are of the two-size pattern, with the nozzles directing on the smaller series, the nozzles can, of course, be placed closely together, so that the impinging steam forms a compact undivided ring-stream. With this type, when it is not desired to use all nozzles, it has been found better to block the jets in groups around the periphery.

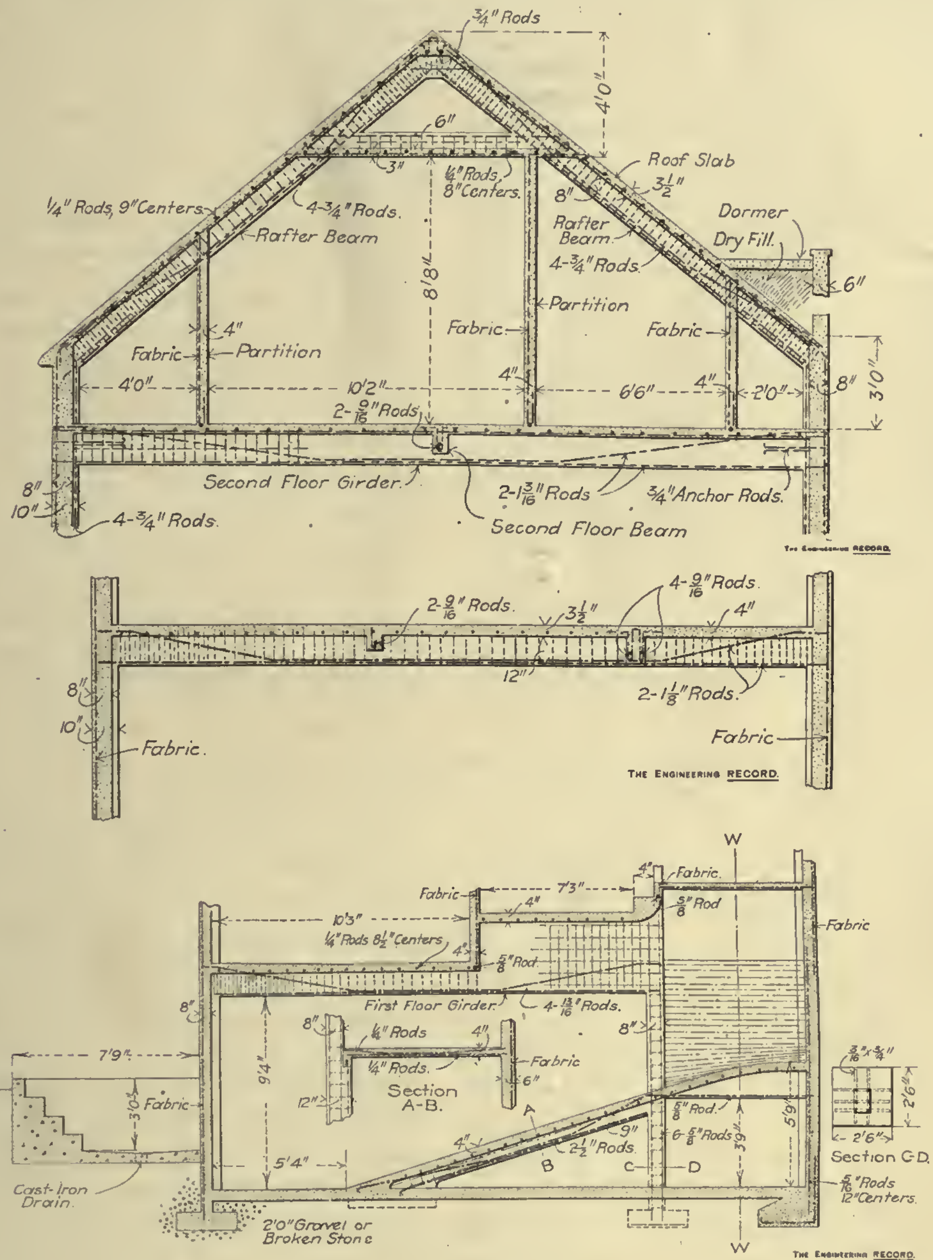
The clearance between rotor and nozzle amounts, in the case of a 2,000-horse-power turbine installed at the electric works at Moabit, a suburb of Berlin, to 0.12 inch measured radially and to 0.39 inch when measured in the axis of the nozzle. The radial clearance has been increased to 0.2 inch without affecting, it is said, the efficiency of the turbine. An interesting point that may be mentioned here is that experimenting first with single-rotor turbines of large diameter, 10 per cent. nickel steel proved suitable. The center of gravity of the rotor was, by contract, to be within 0.004 inch of the geometrical mass center. This condition was fairly well fulfilled, and the center of gravity could afterward be made correct within 0.0004 inch. Under these circumstances the motion of the rotor, running at 3,000 to 4,000 revolutions per minute, is said to be so steady that ordinary observation does not reveal whether the wheel is running or standing.

The Moabit turbine runs at 3,000 revolutions with steam at 188 pounds per square inch and 562 degrees Fahrenheit and with a condenser vacuum of 85 per cent. The rotor weighs 1,875 pounds. It appears that several concessions were intentionally made in this machine for the sake of simplicity at the expense of efficiency. Thus there was a loss of steam velocity in the nozzles, a loss in the buckets and also a loss because the steam was allowed to enter the condenser at high velocity. The steam consumption in the first trials was 19.5 pounds per kilowatt-hour and later 17.6 pounds. Another turbine having one guide-blade ring and a diameter of 31.5 inches, and developing 20 horse-power at 3,500 revolutions without pressure stages, used 37 pounds of steam per horse-power per hour. This was not, of course, a remarkable performance, but without the use of the reversal guide blades, the steam consumption was 57 pounds.

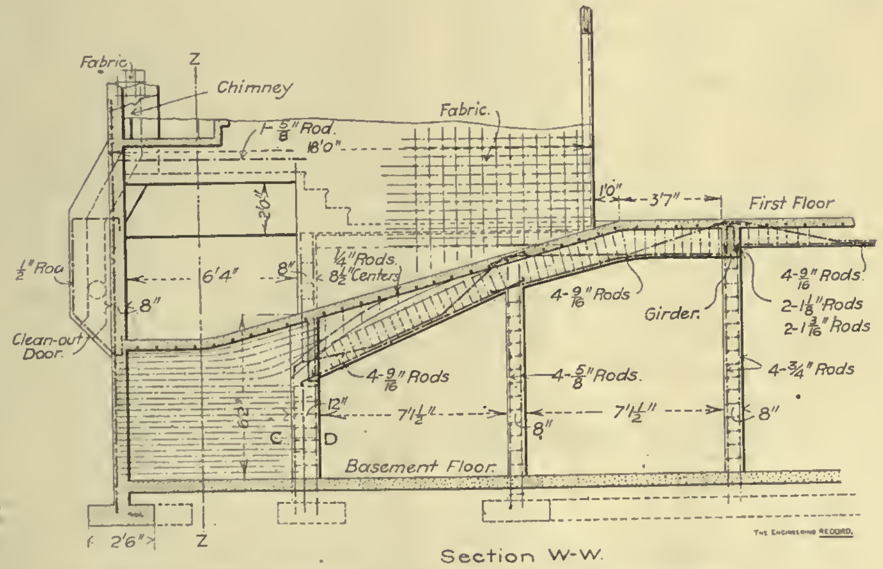
When the pressure fall is broken into stages, the successive turbine wheels are placed in entirely separate chambers. The accompanying cross-section of a unit is to show the general arrangement of a four-stage pressure fall turbine of 500 kilowatts capacity, with wheel diameter 6 feet 8 inches, running at 750 revolutions per minute on a vertical shaft. In each case the kinetic energy is spent in two stages. The steam inlet is opposite the uppermost wheel, and the passages to the successive wheels are indicated. The weight of the turbine is taken by a collar-bearing above the turbine proper, floating on high-pressure oil. At the bottom bearing the shaft drives a centrifugal pump for the condensing water. The inlet for the condensing water is at the lower right of the cut and the outflow at the lower left. The water is thrown into the lowest compartment.

A Reinforced Concrete Stable.

A 25x34-foot two-story and basement stable has just been built of reinforced concrete of the Wight-Easton-Townsend system for Dr. N. B. Van Etten at 177th Street and Anthony Avenue, New York. It is intended to accommodate several vehicles and three horses, and to provide apartments for the coachman besides storage for hay and grain. The original design was for a brick and iron structure at an estimated cost of $7,000. As built the stable does not contain any structural wood, is entirely fireproof and sanitary in its construction and gains a considerable space on account of the thinner floors and walls. The cost is estimated to be less than for any other completely fireproof design, and it is expected that there will be a material reduction of the insurance premiums.



Section Z-Z.



Section W-W.

Roof, Floors, Walls and Stairs in a Concrete-Steel Stable.

The stable is built on a side hill and the lower story, half in excavation, is used for the stalls, with an adjacent vault which is intended for a manure pit. The second floor, at street level, is unobstructed by columns or partitions and is used for harnessing and for storage of vehicles. The third story is reached by an inside stairway and is divided into several rooms for the coachman and for keeping harnesses, stores and the supplies of grain, baled hay, etc. All the walls have concrete footings 30 inches wide and 8 inches thick, most of them without reinforcement, and the basement floor is a 6-inch concrete slab laid on 2 feet of broken stone. The first floor is supported on beams, columns and the exterior walls; the second floor is supported by the exterior walls and the long span beams reaching across the building, and the steep pitched roof, also of concrete, is carried by the exterior walls and by interior partitions and concrete rafters. The roof is proportioned for a total load of 40 pounds per square foot of inclined surface, including wind pressure. The third floor is calculated for a load of 60 pounds per square foot, and the second floor for 100 pounds working load and 700 pounds ultimate strength.

The 1:2:4 stone concrete used throughout the building is made with Trowel brand Portland cement, and is assumed to have an ultimate strength of 52,000 pounds per square foot. The walls are reinforced by vertical ¼-inch rods 12 inches apart which reach from the footings to the second floor level, above that there is a vertical sheet of lock-woven steel fabric embedded in the concrete 1 inch from the outer surface, extending to the roof. In the rear wall the vertical rods are arranged on both sides of the small high stable windows, but there are none in the panels below them where reinforcement is provided by 5/16-inch horizontal rods about 12 inches apart. At window and door openings the steel fabric is bent back on itself to protect both sides of the wall for a short distance and forms loops, U-shaped in horizontal section. At the corners the fabric is bent at right angles to be continuous around both faces and is offset a little and reinforced by a second thickness 2 feet wide on each side.

All reinforcement rods are round steel with an ultimate strength of 80,000 pounds and a maximum working stress of 20,000 pounds per square inch. The main reinforcement rods in beams and columns are securely fastened together by 3/16-inch transverse rods wound around them at the ends and tightly wired at intersections. The spaces between them are about equal to the thicknesses of the columns and vary according to the intensities of the shears which they are calculated to resist in the beams and girders. The reinforcement is accurately arranged and the relative positions of the bars permanently fixed to template by skilled workmen. The steel work for each member is then taken complete and set firmly in the mold so that the bars cannot be disarranged by ramming. The concreters have no responsibility for the reinforcement, its position is not jeopardized by their carelessness and assurance is had that the reinforcement is in accordance with the engineer's design, which is considered one of the most important advantages of the Wight-Easton-Townsend system.

The runway for the horses between the basement stable and the first floor carriage room is made with two inclined planes at right angles to each other, which slope about 1:3 and are connected by an intermediate horizontal landing. The inclines are made, as shown in the sections and details, with a continuous slab of concrete 4 inches thick and 6½ feet wide, which has the upper surface roughened by shallow tranverse grooves to prevent slipping. They are reinforced with horizontal and bent transverse ¼-inch rods in vertical planes 8½ inches apart. One side of the runway is built into and supported by the outer wall; the other side is carried by reinforced concrete beams. The deep upper beam is bent at the upper end and is supported on three columns, one of which carries the upper end of the other beam. All these columns carry first floor loads also and are made with offsets to receive the runway beams intermediate between the first and second floors. An additional pair of vertical rods reinforce that side of the column which forms the beam seat. The lower ends of these rods are seated on the intersections of the flat reinforcement bars in the footing.

The first-floor slab is 3½ and 4 inches thick reinforced with one layer of woven steel fabric and with longitudinal and transverse ¼-inch rods spaced 8½ to 12 inches apart. It has panels of a maximum size of about 10x11¼ feet clear between the longitudinal beams and transverse girders. The second floor corresponds in construction to the first floor and has two transverse girders and one line of longitudinal beams. The coachman's apartments have wood upper floors, and there are removable hard-wood gratings over the basement stall floors which are pitched to drain to gutters. The roof slab has a uniform thickness of 3½ inches reinforced by ¼-inch longitudinal and transverse rods from 8 to 12 inches apart. Theoretically, it is entirely supported by the two pairs of steeply inclined rafters 6 inches wide and 8 inches deep below the under side of the slab, but practically the solid partitions carry an indeterminate portion of the roof load. The stairs have steps 33 inches long in the clear and at their ends are built into the exterior or partition walls. The 8½-inch risers and 10-inch treads are both 4 inches thick and are reinforced by a continuous sheet of lock-woven steel fabric and by a ½-inch transverse rod at the lower edge of each riser.

The hand-made concrete was mixed wet and rammed well in moulds covered with cheese cloth to prevent adhesion and give a uniform texture to the surface which has not been otherwise treated. When the interval between laying adjacent portions of concrete was not more than fifteen hours the old and new surfaces were considered to bond satisfactorily if simply kept clean and made in such a way that there was no stress tending to open them.

The beams and girders are all of the Wight-Easton-Townsend type, corresponding to the typical one here shown, which is the largest in the building. The reinforcement consists of horizontal rods in the lower sides of the beams and of bent rods running from the upper sides at the ends to the lower sides in the center. Both sets of rods have their ends bent at right angles so as to engage vertically the concrete in the walls and secure additional anchorage. These rods are proportioned to receive all the tensile stresses and are connected by 3/16-inch vertical U-shaped rods, with the loops up, spaced about 4 inches apart at the ends of the beams and farther apart in the center so as to resist all shearing stresses, for which they are proportioned and arranged. The largest girder is in the second floor, has a clear span of about 22 feet and is 8 inches wide and 12 inches deep below the floor. It is reinforced with two 1 3/16-inch horizontal rods in the bottom flange and with two 1⅛-inch bent rods in the middle of the bottom flange and at the ends of the top flange. The longitudinal beams are similar to the girders, are flush with them on the upper surfaces, and like the girders are integral with the floor slabs. The depth and thickness of the beams and the dimensions of their reinforcement rods are smaller than those of the girders. The ends of the girders are supported on pilasters 8 inches wide which project 2 inches beyond the inner faces of the walls. The inclined rafters are of the same type of construction as the main transverse floor girders.

Rods 1 inch in diameter are bedded in the second story floor slabs in the planes of the 4-inch partitions and engage the U-shaped loops bent on the lower edges of the lock-woven steel fabric which is bedded in the center of the partitions, thus helping to bond them to the floor. Wherever there is an intersection of any two concrete surfaces, like floors or roof and partitions or walls, the joints are bonded by sheets of steel fabric embedded in both and serving to splice sections of concrete laid at different times. All details are designed to have the concrete act only in compression and steel is provided to take all shearing and tensile stresses.

The moulds in which the concrete was rammed for the main walls, columns and floors were similar to those illustrated in The Engineering Record of January 16, in the description of a concrete factory building in Long Island City. The wall moulds were made in narrow horizontal panels, raised as the wall was built, and those for the beams and girders were made so that the falsework could be easily stripped from them and permit atmospheric action on the surface of the fresh concrete at the same time that protection was afforded against undue deflection before the concrete developed full strength. The falsework and moulds used for the first floor were used over again for the second floor and after the completion of the work much of them were suitable for use in similar work elsewhere. The falsework for the roof had to be cut in short and irregular lengths on account of the steep slope and the numerous partitions, and therefore did not give as much salvage.

The third-story partitions were built at any convenient time after the floors and were not intended to bond with the floor concrete. They are not considered as supporting any part of the roof loads and are intended to act only as curtains, although as a matter of fact they are bonded to a considerable extent with the roof slabs. One side of the mould was first built up complete from the floor to the roof and the studs set for the opposite side which was built up in 3-foot courses of narrow horizontal edged boards laid up to correspond with the filling in of the concrete and its convenient puddling with thin bars.

The roof slab was built from the eaves to the center continuously, but the space was divided by 3 lines of 2x4-inch horizontal strips laid on the bottom of the mould parallel to the ridge into four 4-foot zones so that the soft wet concrete should not exert too great a push at the bottom before setting. On the second day, or as soon as the concrete had the initial set, these strips were removed and the spaces filled with concrete before it was too late for it to bond with that already set. The upper surface of the roof was plastered with a ½-inch waterproof coat of cement mortar.

The doors and the window sash and trim are of oak. The coachman's rooms are finished with oak and a small penthouse roof over the side entrance is tiled. With these exceptions concrete is the only structural material used, about 200 cubic yards of it and 10 tons of reinforcement steel and fabric being required. Mr. Robert W. Gardner is the architect and the Wight-Easton-Townsend Company, of New York, are the contractors.

Presscake From Sewage Sludge Presses has been burned by the aid of coal dust, according to Mr. James Ashton, whose paper on Disposal and Utilization of Sewage Sludge was printed in a recent number of "The Surveyor." He sprinkled about half a hundredweight of coal dust on each ton of sludge cake, but he states that the gases from the furnace should be passed into the flue of a destructor maintaining a temperature of 1,000 to 1,500 degrees; otherwise there will be a nuisance from the chimney.

High-Pressure Water Service for Fire Protection in New York.

Slightly condensed from a report to Commissioner John T. Oakley, by Mr. Nicholas S. Hill, Jr., Chief Engineer, Department of Water Supply, Gas and Electricity.

Pursuant to your request I submit a preliminary report on the proposed high pressure fire service. The data and plans presented are tentative. The location of mains and power stations are subject to change. The estimates may be somewhat modified when time is afforded for more careful consideration. The following conclusions may be safely drawn:

First, It is possible to construct such a system on the general lines herein presented subject to such modifications as a thorough study may suggest.

Second, A high-pressure fire service may be installed with an expenditure not exceeding the limits of the estimates furnished.

I have been somewhat guided by Fire Chief Croker's views in selecting the district in which to install the first section of the proposed service. A large number of factories, wholesale establishments of various kinds, and buildings not fireproof in construction are located within the confines of this area. I understand the losses from fire in this section are heavier than in any other district of equal area in the Borough of Manhattan It is a district containing many buildings similar in character and construction to those situated in the locality where the Baltimore fire originated.

The area outlined is bounded generally by Twenty-third Street on the North; Broadway to Fourteenth to Fourth Avenue and the Bowery, on the East; Chambers Street on the South and the North River on the West.

It is proposed to erect three pumping stations, definite locations for which cannot be fixed until the relative cost of land and other questions have been considered. Each station will be capable of pumping to any part of the distribution system. The sub-division of the pumping plant was deemed advisable on the ground that should any one station be disabled or rendered ineffective during the course of a conflagration, two-thirds of the output of the plant, or double the present capacity of the fire department would be available.

Provision has been made for direct connections to the high-service mains at various points on the water front so that in the event of the total disability of the pumping plant the fire boats may be used to pump into the proposed system. These boats, five in number, have a combined capacity of about 2,400,000 gallons per hour, or 40,000 gallons per minute against a pressure of 150 pounds.

About twenty-five engines respond to a fourth alarm of fire in the district mentioned. Their combined capacity equals about 900,000 gallons per hour against a pressure of 125 pounds. The fire boats directly connected to the high-service mains would more than double the output of the engines.

The present plans contemplate a capacity of 1,000,000 gallons per hour at each of the three stations or a combined capacity of 3,000,000 gallons per hour. The pressure at the station will be 300 pounds. The minimum pressure at the hydrant is estimated at 200 pounds. The following facts are interesting:

The new service will furnish more than three times the water now supplied at one fire by the present fire equipment.

The pressure will be more than double that now maintained. Each station will furnish 32 streams through 3-inch hose with 1¾-inch nozzles. Each hydrant will deliver approximately 2,600 gallons per minute or five such streams.

Two hydrants are proposed for each street intersection giving ten such streams.

From the four corners of a block 40 such streams may be played on a fire within the block. Forty streams are equivalent to about 20,000 gallons per minute or 1,200,000 gallons per hour.

Thirty-three and one-third per cent. more water can be delivered on a fire from the four corners of a block than is now furnished at a fourth alarm fire with the engines widely scattered. Concentration of the fire-fighting force saves time, frictional losses in hose and facilitates the operations of the officers and men.

Ninety-six lines of 3-inch hose not exceeding 350 feet in length may be concentrated on a single fire when the three stations are operating simultaneously.

It has been proposed to put in a system for the combined purposes of fire protection and street cleaning. I consider this ill advised and impractical. The nominal pressure on the system is 300 pounds. The actual pressure may reach 600 due to water hammer and the presence of air in the mains. No hydrant can be built to withstand such conditions and undergo rough usage at the hands of ignorant workmen. The system might fail at a critical moment if used for other than fire purposes. Our experience with the hydrants on the low pressure service of the Croton amply justifies the above statement.

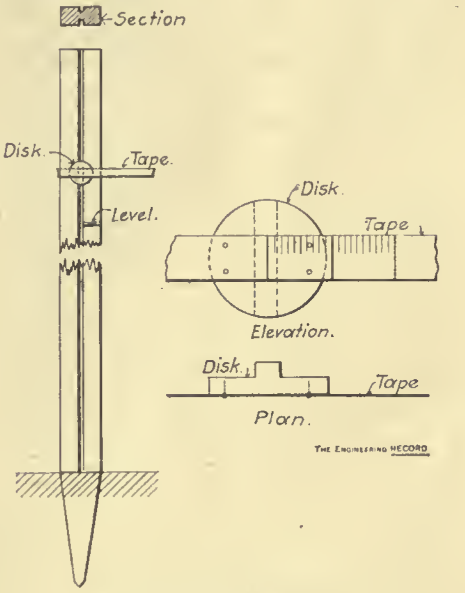
The pressures which will be carried on the fire service are too great for street cleaning. The city should provide proper stand pipes at street intersections, connected with the Croton system for the specific uses of the Street Cleaning Department.

Three sources of energy may be used, steam, gas and electricity. Steam need not be considered, unless absolutely necessary, on account of the high first cost of the plant and the expense of operation. The three stations will probably not be operated more than 240 hours per year. The plants, to be effective, must start instantly upon the stroke of a gong. Steam pressure must be maintained for every minute in the year to accomplish this in a steam plant. Fuel will have to be fed continually, therefore, to maintain stations operating ten days per year. This is not the case with gas or electricity if the energy is procured outside. A gas engine may be started in a few seconds and when closed down is using no fuel. An electric motor may be started by throwing a switch and the current shut off with equal facility. No final arrangements can be made for the supply of current or gas until the project takes more definite form. A careful investigation leads me to believe the electric companies in Manhattan are amply equipped, so far as power is concerned, to give us the maximum amount of current needed at any time if properly constructed cables in duplicate are laid and interconnected to prevent a possible interruption in the supply of electricity. The three plants will require about 15,000 horse-power when working at their full capacity.

The proposition from the gas company's standpoint is rather more difficult. To furnish the necessary gas involves long lines of mains not less than 30 inches in diameter. This entails heavy expenses and special generators to insure the requisite amount of energy at any moment. The additional plant would create an annual expenditure of about $50,000 per year for maintenance and repairs. This may be reduced on further investigation, but I have not considered it safe to figure on less than this amount in the estimate of the cost of operating a gas plant. The cost of the electric current cannot be definitely ascertained until the conditions of operation and the locations of the pumping stations are determined. I have assumed a rate in the following estimates which I feel assured can be obtained. The load factor on the pumping stations is small as the stations are operated approximately ten days per year, so if electricity is paid for, only when used, the question of cost is not great in comparison with other expenses of operation and maintenance. The total cost, therefore, will not be materially affected by any reasonable change from the rates assumed. Allowance has been made for laying the necessary electric cables to connect the pumping stations. If gas is used the company will provide the pipes and plant.

The plant operated by gas has six horizontal engines of 750 horse-power each connected to six triplex single acting plunger pumps or eight 600-horse-power vertical engines connected to the same style of pumps. The electric station is a multi-stage turbine plant, consisting of four units of 1,500 horse-power each. The mechanical efficiency of the gas and electric plants is approximately the same.

In comparing the use of gas and electricity as the probable source of energy it may be well to present the following points in favor of electricity: First, economy in first cost of machinery and buildings; second, economy in space necessary for installation, thereby reducing cost of land required; third, economy in cost of wages, maintenance, repairs and renewals; fourth, simplicity.



Rod for Tape Measurements.

The relative cost of power cannot be stated with accuracy until the price for which gas can be had is determined. Following is a statement of the comparative cost of one pumping station operated either by gas or electricity, an estimate of the probable operating expenses and fixed charges per annum, a similar summary for the three stations and an estimate of the total cost of high pressure fire service complete.

Careful attention has been given to the use of salt water in connection with its deleterious effect upon the contents of buildings. Salt water is more injurious to the hydrants, gate valves, pumps and distributing system than is fresh water. If salt water is used the depreciation on the plant will be increased. The plans submitted provide for both fresh and salt water connections at the pumping stations. The fresh water is drawn from the Croton system. This system is capable of supplying any or all the stations. In the event, however, of any shortage of supply of fresh water the salt water may be immediately used without interference with the operation of the plant.

In making the above modification I wish to emphasize that the original salt water system is not assailed or detracted from. The use of fresh water, with salt water available when needed, as suggested, removes one of the chief objections offered to the proposed service and adds thereby to the feasibility of the proposition. In conclusion I would respectfully suggest that there are several other methods by which additional fire protection may be obtained, some of which may be more economical. Time has not permitted a study of these methods. I was asked to report on the above system and I have confined myself to this work. I would strongly recommend, however, that should appropriation be made to increase the efficiency of the fire service, the parties in whose hands the erection of the work is placed be allowed full opportunity to study other systems and be requested to make a subsequent report on the same before the city finally commits itself to any one method.

ESTIMATE OF COST.

Cost of One Pumping Station.

	Electric.	Gas.
Number of units in station....	4	6
Capacity in million gallons per hour	1	1
Estimated number of hours of operation per year..........	80	80
Cost of motors and turbines including piping, foundations, switchboard and wiring and cables	$255,000	......
Cost gas engines and pumps, including piping, foundations and auxiliaries complete.....	......	$448,000
Cost of buildings foundations and land	90,000	270,000
Total cost	$345,000	$718,000
Cost of wages per annum......	$7,650	$18,150
Cost of gas per year..........	......	17,000
Cost of electricity per year at 4½c. per K. W. hour.......	13,200	......
Cost of oil, waste and supplies per year	300	300
Cost of repairs per year	2,400	3,600
Total cost of operation......	$23,550	$39,050
Interest and depreciation......	26,710	55,000
Refunding sinking fund	11,500	27,000
Total cost per annum	$61,760	$121,050

Cost of Three Pumping Stations.

	Electric.	Gas.
Cost of three stations........	$1,035,000	$2,154,000
Operating expenses and fixed charges per annum for three stations	185,280	363,150

Summary of Total Cost.

	Electric.	Gas.
Pumping stations	$1,035,000	$2,154,000
Mains for distribution system complete with gate valves and hydrants	2,107,000	2,107,000
Telephone system	150,000	150,000
Total cost	$3,292,000	$4,411,000
Add 10% contingencies......	329,200	441,100
Add 10% superintendence...	329,200	441,100
Total	$3,950,400	$5,293,200

Letters to the Editor.

Rods for Aiding Tape Measurements.

Sir:—Mr. C. W. Swearingen's letter in your issue of February 13, describing a method of chaining used by him in city work, reminds me of pleasant times on the Adirondack State Survey in 1895, on which essentially the same apparatus was used, with some differences which were better for the work then in hand. The work was the remeasurement of old township lines, originally run in the year 1772 with compass and chain. The line was usually up or down a steep hill and we made no pretensions to the accuracy required in city work.

Two rods, 2½ inches by 1 inch, 7 feet long, were used, divided to feet and tenths and shod with sharp steel points that were to be thrust in the ground. A groove ¼ inch square was cut in each rod from end to end in the middle of each flat side, and a small disk 1 inch in diameter with a tongue ¼ inch square on one side, was riveted to the zero end of the tape, the tongue being designed to engage the notch in the rod. The spring balance was provided with a clamp that could be quickly attached to the tape at any point, and carried a small level bubble adjusted parallel to the direction of pull of the spring balance.

In going up hill the rear chainman reached up as far as possible, put the tongue of the disk in the groove and held the rod plumb. The front chainman went ahead and thrust his rod into the ground and leveled it, adjusted the tape clamp at a convenient distance, put a strain on the tape at the same time swinging it up or down the rod until the level on the spring balance showed that the tape was level. Then he took the horizontal and vertical readings. The front rod was left in place and became the back rod in the next operation. The recorder took all notes and at the same time sketched topography with the aid of the elevations deduced from the vertical readings. The use of the spring balance level does not, of course, imply that the tape is quite level, the line of direction of the pull of the spring balance being tangent to the curve of the tape at the point of attachment. I should assume from Mr. Swearingen's description of his method that an additional man is needed to hold the front rod plumb, or I should say that the up-hill rod, as the rod level is ordinarily above the chainman's eyes.

Respectfully, R. H. Keays.

New York, February 24.

Estimating Weights of Rails.

Sir:—The letters in The Engineering Record of February 20 and March 6, giving formulae for estimating the weights of rails are interesting, but, as regards ease of memorizing, they are not in it with the simplicity attained by using the metric units in the same case. With a 28-kilo rail, for instance, that is one weighing 28 kilograms per running meter, there are 28 metric tons per kilometer. Nothing could be simpler then, than the rule that there are the same number of metric tons per kilometer as there are kilograms per meter. Furthermore, the translation from our present standard sections is remarkably easy, for it is only necessary to divide the weight in pounds per yard by two to get the number of kilograms per meter. This follows from the fact that 1 meter = 1.1 yards and 1 kilogram = 2.2 pounds. A kilometer equals ⅝ mile, and a metric ton is 2,205 pounds Avoirdupois. For distances other than even kilometers it is unnecessary to memorize a lot of formulae for different weight sections, all that is required being to multiply the tons per kilometer by the desired distance in kilometers or decimals thereof.

Respectfully, Albert S. Merrill.

Washington, D. C., March 8.

Book Notes.

The Office of Experiment Stations of the U. S. Department of Agriculture has just issued a bulletin on the "Acquirement of Water Rights in the Arkansas Valley in Colorado," by Hon. J. S. Greene, of Pueblo, formerly State engineer of Colorado, prepared under the direction of Elwood Mead, Chief of Irrigation Investigations. The bulletin is written especially for those who are contemplating settling in the Arkansas Valley, and is intended to give them such an understanding of water rights and the conditions which affect their value that they can act intelligently in acquiring a water supply. Water rights are acquired from the State, in the first instance, but the individual settler must usually secure a right from some individual or company which has built a canal for the purpose of supplying water to farmers. The value of both classes of rights depends very largely upon physical conditions and upon other rights to the streams. Mr. Greene shows this connection and points out the sources of information as to these conditions. Rights purchased from canal owners are subject also to the conditions of the contracts under which the water is supplied. A large number of these contracts are given and discussed in such a way that an intending settler can tell what points he should look into before purchasing a right. The laws and contracts are discussed also from the standpoints of the canal owner and of the public welfare. The report is therefore of great value to students of irrigation law and economics since it gives much valuable information and its interpretation by one who has studied it from every point of view. The conditions in the Arkansas Valley in Colorado do not differ essentially from those in other parts of the arid West, and the report is therefore of interest to any one wishing to understand the subject of water rights in the United States.

Lead poisoning and its relation to drinking water has always attracted more attention in England than in this country and several elaborate treatises have been written on the subject. The most recent report, and at the same time one of the most exhaustive, is that of Dr. Houston on "Moorland Waters in Regard to Their Action on Lead," Vol. II., published as a supplement to the thirty-first annual report of the Medical Officer of the Local Government Board of Great Britain for 1901-2. This is in continuation of a previous report published one year ago and devoted chiefly to descriptions of certain moorland water supplies which had been the cause of lead poisoning. The present volume describes the laboratory experiments made in connection with the investigation. It is a volume of 478 pages, contains 160 tables of analyses and 18 plates. The experiments are of considerable interest to the specialist, but they do not add materially to what is already known by American water-works engineers concerning the subject of lead poisoning in its practical aspects. The author distinguishes three classes of waters in their action on lead. Those of the first class have a "plumbo-erosive ability," and possess the power of acting on the bright metal, forming relatively insoluble compounds which fall away, leaving fresh bright surfaces exposed. Those of the second class have a "plumbo-protective ability," erosion being followed by the adherence of the insoluble coating to the surface of the lead, thus preventing further action. Those of the third class have a "plumbo-solvent ability," that is, they have the power of dissolving lead and holding it in solution. Speaking generally, the erosive power is due to the presence of dissolved oxygen, and the solvent power to the presence of "acidity," by which the author evidently refers to dissolved free carbonic acid, although he does not use the expression. This solvent power due to the presence of carbonic acid is considered as more dangerous than the erosive power due to dissolved oxygen. Considerable attention is given to the cause of the "acidity" of moorland waters, and the effect of bacterial action on peat with the consequent production of carbonic acid is emphasized and illustrated by experiment. Two species of bacteria were isolated which appeared to be of special importance in this connection. From the analyses given in the tables it would appear that some of the moorland waters investigated contain larger amounts of free carbonic acid than are ordinarily found in surface water supplies in this country, and it is possible that this may explain in part the more frequent occurrence of lead poisoning in England.

The necessity of ventilation, though long regarded as beyond the need of proof, has been discussed by Mr. Konrad Meier, in a pamphlet published by him, along lines that are rarely emphasized in print, however concurrent his opinions doubtless are with those of many leading heating and ventilating engineers. Ventilation must many times be furnished to minimize vitiation emanating from sources for which the proportion of carbonic acid is no index, such as nauseating odors, smoke and vapor in kitchens, dusty carpets and draperies, and is most conveniently calculated on the basis of a given number of renewals of the air in the space involved. He believes, however, that whatever improvements are to be noted in respect to the ventilation of buildings are largely due to better measures for purification of the air supply, to a proper degree of saturation with humidity and not the least to better regulation of temperature. The author's views on the subject of humidity are interesting, as he holds that the prevailing idea that the relative humidity should be maintained at 50 per cent. indoors represents a difference that is keenly felt, especially by those exposed frequently to the change. Reasons of expediency and economy, he avers, will naturally keep the inside humidity below 40 per cent. when the outside air is dry and cold and not less than 60 per cent. when the outside air is moist and warm. The pamphlet, which is entitled, "Reflections on Heating and Ventilating Engineering," is a comprehensive review in general terms of conditions obtaining in both heating and ventilation, without reference to specific examples.

Testing of Electro-Magnetic Machinery and Other Apparatus. By B. V. Swenson and Budd Frankenfield. New York, Macmillan Co., Vol. I., Direct Currents. Cloth, 9x6 ins., 443 pages, $3.

This is essentially a testing manual and laboratory guide. Its greatest field of usefulness will doubtless be in the laboratories of technical schools and colleges. The scope of the first volume is confined to direct current work, and nearly all of it has direct and practical bearing on the design, construction and operation of dynamo-electric machinery. Under the headings, "Preliminary," and "Instruments," a few pages are devoted to general features of testing and working up results, and to the use and care of instruments. An appendix is inserted wherein are grouped the principal tests and methods of measurement used in manufacturing concerns. A second appendix contains the standardization report of the American Institute of Electrical Engineers. Of the ninety-six listed experiments in the book, each one is complete in itself. This is a feature to be noted, as it will enable instructors to easily map out a good laboratory course suitable to the equipment of the laboratory or to the needs of the individual student. Experiments which have come to be valuable only from a philosophical or historical point of view have been excluded to make way for those entirely within the province of the engineer and which have direct bearing on his work. The object or reason for doing each experiment is clearly and briefly stated at the outset. This should be of value to the student who must work blindly if he is not able to discover the exact bearing of the experiment on the general purpose of the course. Theory and method are briefly stated in each case and mathematical treatment is usually avoided. Special hints and cautions are supplied where it is deemed necessary. A list of the observations to be recorded is given in nearly all cases under the heading, "Data." Although the book is first of all a laboratory manual, the large list of direct references given with nearly all experiments will make it useful to the engineer as a reference book, while a review of the experiments themselves, bearing as they do on operation and design, may often be useful to the engineer.

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The Building Collapse in New York.

The coroner's jury appointed to investigate the causes of the death of a man in the hotel building collapse in New York, described in this journal two weeks ago, has returned a verdict finding the owner and the steel-work contractors "grossly, criminally negligent in the methods adopted and followed by them in the erection of the building." The case is now in the hands of the District Attorney and it will doubtless receive more searching investigation in the criminal courts. Enough testimony has been brought forward to show, however, that building operations are carried forward in New York that are equally dangerous to those engaged on the work and the occupants of the structures subsequently. It is further shown that lack of legal powers and of men renders the supervision of the building department over structural work of very little influence.

Speculative building is notoriously bad in large cities, but it was hoped by the framers of the present building laws that the latter would at least prevent dangerous work. Mr. George A. Just, who was a member of the commission that drew up these laws, was also a member of the coroner's jury on this disaster, his associates on the jury being men of exceptional fitness for such a duty. It is not surprising, in view of the testimony at the inquest, that the jury made the following suggestions: "We recommend that the practice of the erection of buildings without the superintendence of the original architect or a competent builder of at least five years' experience be prohibited by law. We further recommend that the Building Department of the City of New York have a corps of competent engineers to inspect the erection of all buildings requiring engineering skill, and that a copy of the approved plans of each building be kept on the premises during construction." These recommendations deserve the hearty support of everybody, for it is pretty well established that the disaster was due to lack of power to enforce the building laws rather than any defect in them.

The testimony showed, in substance, that no competent superintendent was in charge of the erection of the building, and that it was being constructed according to plans never approved by the Building Department. It is true that a set of plans for the structure had received that department's approval, but they were not used by the contractors. The nominal architects disclaimed all responsibility for the plans actually followed. It was also stated that no attention was paid to the orders of the Building Department, because it was recognized that its representatives had no power to enforce their directors. In short, it was demonstrated that under existing conditions builders could do as they liked in New York, a condition which is too manifestly dangerous to public welfare to need further comment than an endorsement of the recommendations of the jury.

Timber Tests.

So much prominence has been given during the past few years to iron and steel and the present various grades of masonry including concrete steel that the importance of timber as a structural material is apt to be overlooked. Obviously it no longer plays the important part in such a prominent class of engineering structures as bridges that it once did; nor will it ever again be of so much importance as it once was in that particular field of construction. Great quantities of timber, however, are still used in engineering work to say nothing of its employment in architectural building construction, and it will probably remain for all time a most useful structural material. It is even highly probable that the wretchedly wasteful methods of cutting and using it at the present time will be largely reformed in the near future in the effort to encourage the growing of structural timber. In short, there is every reason to believe that all knowledge of its physical and resisting properties will possess increasing value to engineer and architect. It is of the utmost importance, therefore, that tests of timber conducted for the purpose of securing that class of information required in structural design and maintenance should be so conducted as to be of the highest possible value.

While this journal has no disposition or intention to undervalue the results of the former series of timber tests conducted by the Forestry Division of the U. S. Department of Agriculture, which have been interrupted for several years, it cannot be denied that those results fail to possess the value they should. As is well known, it has been proposed by the Bureau of Forestry to organize a new series of timber tests which will be practically a continuation of the former series. An informal discussion of this proposition, containing many valuable suggestions, took place at the annual convention of the American Society of Civil Engineers in June, 1903. In the main, the views expressed in that discussion as to the purposes and methods of the investigation appear to be well adapted to elicit results of real value to engineers, at the same time there also appeared to be at least a rather strong impression that the former series of tests need perhaps only be continued without much change in character. While it cannot be stated that this impression really exists to any great extent, it certainly would be a grave mistake in undertaking the new series of tests not to avoid the conditions which so seriously limited the value of the results of the former series. These limiting conditions were almost entirely due to limited appropriations, leading to a restricted selection of test specimens both small and large.

The procedure consisted in the selection of certain representative standing trees from which the specimens to be tested were taken. Although this plan is well adapted to the study of timber physics, at least in many of its applications, it fails completely to meet the requirements of engineers engaged in the building of timber structures. What is needed is not such a narrow selection of sticks of timber for testing as to make it practically certain that their quality will be materially different from and better than that of merchantable timber which the engineer or architect must use in his work. If there is one class of engineering material in which the full-size pieces are more imperative for testing than in any other, timber is that class. Whether beams or columns are the subject of investigation, not only full-size sticks should be used, but they should be secured from dealers precisely as the owner of a building or a contractor must purchase them. It is well enough, indeed advisable, that sticks seasoned by various methods and to various degrees should be tested, but above all the green and imperfectly seasoned conditions of actual use should not be avoided. Furthermore such dimensions of full-size members should be employed as will develop the various phenomena of resistance and failure as they are found in the actual use of timber in structures. This observation applies to such features as the failure of relatively short beams by longitudinal shearing, the independence of the ultimate resistance of comparatively short columns of their lengths, and other similar phenomena developed by testing to failure.

While engineers already possess a large amount of experimental data in regard to the resistance and durability of timber a far larger amount of information than yet secured is most urgently needed, not only as to the ultimate resistance under different kinds of stress but also a much more complete knowledge of the conditions under which greater durability may be secured. The resisting value of the details of framing, the effect of preservative processes on both elastic and ultimate resistance and a great variety of other similar data are also still lacking. The proposed renewal of timber investigation under the auspices of the Department of Agriculture, if properly conducted, will yield results of the highest value to engineers and architects, but in order that such ends may be attained it is imperative that the actual conditions of structural use must be recognized much more clearly and fully than in the former series of tests.

Pensions for Teachers.

No one who is behind the scenes of technical instruction at the present date fails to recognize the deplorable tendency of certain harsh circumstances on the character of the instruction given to engineering students. The many men who are doing splendid work at a financial loss to themselves, who are literally giving up a part of the good things of life their abilities would enable them to earn in regular engineering work, will not take amiss the statement that no small part of the instruction of to-day is poor because the men who give it are discouraged and careless. The fact that men who occupy responsible positions on the faculties of engineering schools are rarely paid for such work more than a half or two-thirds of the sums they can earn in practice seems to have no meaning in the eyes of trustees. Engineering is probably the worst paid profession in the country to-day, when the time spent in securing proficiency in it is considered, but it is by no means so badly off as it was a comparatively few years ago. This advance should encourage those who are engaged in teaching it, for no trustees will pay teachers salaries of several thousand dollars to fit pupils for positions which rarely pay two thousand dollars. The time has certainly come, however, when the engineering professors should receive a rate of compensation much higher than in the past, so that really good men can be secured to take direction of the engineering courses.

This journal has no intention of taking up at this time all the various conditions which influence the fixing of teachers' salaries. It is commonly asserted that the professor has a very easy time because he has to work but nine or ten months a year and comparatively few hours a day, but it is not recognized that his work, if properly done, is really high-pressure work in which not only a knowledge of engineering, but an acquaintance with every type of young manhood is strained to produce the best results. Only those who have conscientiously endeavored to interest and instruct a class of engineering students have any right to talk about the labor involved. It is also asserted that the degree of professional knowledge requisite to instruct engineering students is not so great as that called for in the management of actual works; in other words, it is actually claimed that an engineering professor should be able to teach what he does not know. In the same way all the arguments concerning the low salaries that such men receive can be answered. But, as before stated, it is not intended to take up at this time these subjects in detail, the present purpose being to quote from President Pritchett's annual report to the Corporation of the Massachusetts Institute of Technology for the last year, the following excellent recommendation, which, if carried out, will do much to attract to teaching, and then hold in its ranks, the men who are needed to prevent engineering from becoming overloaded with pedantry and underloaded with business sense:

"Any man who knows American colleges and universities is familiar with the common experience of many of the abler young men who come up through our institutions, spend a year or two abroad, equip themselves well for the work of research, and settle down into the position of an instructor or assistant-professor in some institution, full of enthusiasm and ready to consecrate their lives to research work. Scientific men are human like other men. After a few years the investigator marries, the problem of family support becomes urgent, college pay is small, and, while it may pay current expenses, it offers no opportunity to lay up for the future. The candidate for research looks about for means of turning the grindstone; and a man who has started with flying colors and a buoyant heart for a fine career in research ends by becoming a fair teacher and a patient drudge. This is the history of most men who start in American institutions to become investigators. Tenure of office in all our American institutions, except in our greatest and strongest ones, is more or less uncertain. College presidents and college trustees, like business firms, are becoming more and more averse to accepting a new man who has passed his fiftieth year. I have known, in the past five years, men of excellent standing in science, who found it almost impossible, when turned out of one place, to secure work elsewhere. The in-breeding in our colleges, by which graduates are coming more and more to look for the places of instructors and professors, increases this tendency. Any plan which will enable the institution to offer to a professor or to an instructor a certainty of retired pay with the coming of age or of ill-health would go far to remove from his path as an investigator an obstacle which turns aside most Americans who enter upon research."

A Plague of Investigations.

It would be interesting to learn just what the Merchants' Association is endeavoring to accomplish in its attacks on the officials in charge of the water-works of New York. For some years a little group of members and employees of this organization have been thrusting themselves forward, with a pertinacity worthy of some good purpose, on the pretense that they have great scandals to reveal in the manner in which the water-works of the city are managed. These men have hitherto scored a complete failure in their attempts to prove the charges they keep bringing in their self-assumed position of reformers. The Association is losing respect for fathering such proceedings. Worst of all the city is misrepresented by newspapers throughout the country, which print under scare lines reports that "another scandal has been unearthed" by the Association's investigators, but never have room to print in an equally conspicuous manner the inevitable result of a careful investigation into the facts, viz., complete failure to make good the accusations. Of course it is not at all surprising that the editors of newspapers elsewhere are loath to believe an organization of eminent merchants should stand sponsor for any proceedings attacking without justification the administration of important city departments. The good name of a city means so much to its merchants that few people can believe these continuous attacks are without justification.

For several years past, this Association has permitted a few men without much business or professional standing to play a continuous stream of accusations of incompetence, dishonesty and sloth against various officials in the city's service. These charges were made while Tammany was in power, again during the administration of Mr. Low, and some of them are now brought forward for another assault. Nothing whatever has yet resulted from all these charges which indicates dishonesty or incompetence on the part of the officials indicted, although every opportunity has been afforded the accusers to prove their assertions. The only thing that has been brought to light is the fact that there is an honest difference of opinion among engineers concerning which is the better of two good methods of construction. Up to the present time nothing more has been shown concerning the character of the work on the reservoir undertakings now in progress, although, as before stated, every opportunity has been afforded for the investigators to prove that there has been incompetence, fraud or even extravagance.

The Association's representatives have now requested the Mayor to remove the Aqueduct Commission for incompetence, lack of diligence and failure to safeguard the interests of the taxpayers. The charges are based on much the same old stories that have been proved false in the past, and the same lack of respect for truth and careful argument is again shown. They would not be worth while noticing at all except for the fact that in the papers laid before Mayor McClellan last week various assertions are made concerning engineers which this journal proposes to contradict at once. It would hardly be necessary to do this if it were better known what unjust proceedings are carried on in the name of a once reputable Association. For example, the following attack is made upon Messrs. William H. Burr, John R. Freeman and Rudolph Hering: "A so-called investigation of some of these allegations was made by a commission delegated thereto by former Mayor Low. These facts about the disregard of the specifications in building embankments were made known to the Commission, but were not embodied in the reports made by it to your predecessor." The three engineers thus accused of concealing facts injurious to the Aqueduct Commission are respectively a member of the Panama Canal Commission, the president of six of the largest fire insurance companies in the country, and a consulting specialist in water-works design and construction of the highest character. It is preposterous that these men should conceal facts which could be brought to light by anyone, and if they were guilty of such concealment, why did that fact not come out in the dreary months of investigation of these charges before the Aqueduct Commission itself, when every opportunity was given to prove them? Again, it is stated that one of the division engineers has changed and falsified official records for five or six years, although such charges during the last hearing were found to be ridiculous. This same engineer is also asserted to have gained his previous hydraulic engineering experience by building retaining walls, while the facts of the matter are that he has been connected in a responsible manner with some very large hydraulic works. Similarly an ex-chief engineer has been accused of incompetence, presumably on account of the fact that he made a number of important changes in his predecessor's plans for the Jerome Park reservoir. These changes were made, to be sure, but most of them have been approved by eminent consulting engineers, and it is difficult to see why the Merchants' Association continues to bring forward this matter of change as though it were something to deplore instead of something that has been approved by experts in such subjects.

It is not an agreeable duty to mention such a subject as this, but as it is becoming a nuisance by the persistence with which the Association brings it forward, it might be well for that body to do a little investigating itself. In making charges against public officials, it is important to be absolutely sure of the facts on which the charges are based and then to present them in a lucid dispassionate manner. In order to arrive at facts like those on which these charges are based, the investigators must be men of great tact, business shrewdness and strong common sense. It would be well for the Merchants' Association to investigate the degree to which its agents in this matter possess such qualifications. Are the business men on the committee, particularly the chairman, men whose careers have been so successful as to warrant their being in charge of such serious work? Are the Association's employes engaged on the work men of discretion, careful, methodical and accurate? Finally, is the legal end of the investigation looked after by counsel of proved fairness and ability? In the last investigation, this surely was not the case, as the counsel was a former water commissioner of the city whose excitability, lack of administrative ability and even of ordinary business sense in some matters, made him a laughing stock to all who follow public affairs with any degree of closeness. In short, does the Association realize that it may be placing its prestige in the hands of men who are using its influence solely or largely to gratify their love of newspaper notoriety?

Fire Protection Clauses in Building Ordinances.

The National Board of Fire Underwriters has just issued a series of suggestions for clauses to be inserted in building laws and ordinances which merit the careful consideration of every architect, structural engineer and property owner. At the present time, when the fire-hazard of buildings is receiving universal attention, the publication of these notes is timely, although it is to be regretted that they were not accompanied by some statement to indicate what effect on rates would result from the compliance of a city with the various suggestions. Some of the proposed clauses relate to minor details of construction which can influence the fire risk very little, but what can be said of such a proposed clause as the following: "The height of no building or structure either fireproof or non-fireproof hereafter erected, except a church spire, shall by more than two and a half times exceed the width of the widest street upon which it stands, nor shall it exceed 125 feet in any case, nor if to be used above the ground floor as warehouses or stores for the storage or sale of merchandise shall it exceed 100 feet in height." The adoption and enforcement of such a regulation as this in any large city is improbable, but assuming that it should be done what recompense will the insurance companies make to the property owners for the additional incumbrance on the most valuable land in the city by such a severe requirement? It is, indeed, hardly probable that the Board of Underwriters puts forward such a clause except as an ideal toward which cities should strive, for it is manifest that the business sections of New York, Philadelphia, Boston and Chicago are already so studded with structures violating such a provision that it would not be worth the while to pass it. On the other hand the smaller cities, particularly those in the West having wide streets, might find it advisable to pass such a law if the insurance rates were lowered enough to compensate the people for such a restriction of their natural rights.

While some of the clauses of these proposed regulations are far more important than others, the suggestions as a whole are most interesting as an indication of the best building systems from the point of view of the insurance companies. The structural engineering considerations of building operations are pretty well settled, and the aesthetic conditions have also approached a fairly well understood state, although, of course, in matters artistic there will always be great differences of taste. But in the subject of fire-protection there is very little uniformity of opinion between owners, architects and fire underwriters. At the present time, the insurance man is undoubtedly having the best of the argument because he can enforce his views by means of changes in insurance rates, and it is undoubtedly true that money talks loudly in such arguments. It is not improbable that the importance of many of his suggestions has not been recognized in the past, and the fires at Baltimore and Rochester have been needed to arouse people to the necessity of heeding his warnings. He has been the only party to the building situation who has apparently had any consideration of the fact that fireproof construction should mean not only resistance to flames by the building itself, but also the protection of the property within the building from both outside and inside fires. If the tenant is to lose his property whether he is in a "fireproof" building or not, it is difficult to see just what advantage he is to derive from the high rents charged for the use of space in such structures. It is because the fire underwriter is just as desirous of protecting the property of the tenant as that of the building owner that the suggestions he makes concerning building laws are particularly instructive. Hence The Engineering Record gives considerable space this week to an abstract of the clauses proposed by the National Board of Fire Underwriters. These suggestions were prepared for use in Baltimore, but their manifest value as an explanation of the views of the insurance interests on sound building construction are patent.

There is of course no probability that they will be all equally desirable in every city. They represent, however, methods of construction which are perfectly sound from an engineering point of view and it is only as respects the expense of the construction they call for that they are open to serious criticism. It will be impracticable for some people to build if they are forced to comply with all the conditions imposed in these suggested laws, but on the other hand buildings erected in a city where they are in general force will be much more safe from fire than elsewhere and will have to pay lower rates for fire insurance. In order to determine just how many of the clauses any city can adopt in its building ordinances and still offer no unwarranted obstacle to healthy building within its limits, it will be necessary to consider a number of factors which only local knowledge can furnish. As a whole it is safe to expect a great deal of good will result from these suggestions of the Board.

Notes and Comments.

An Unusual Type of Filters is proposed by Mr. I. M. De Varona for two small supplies of the Brooklyn Water-works. As planned they are without impervious bottoms and sides, the collecting pipes being laid in sand below the normal water level. By laying them in this way the filters will discharge not only the water passing through the beds above, but also a portion of the ground water rising through the saturated sand below the beds.

The Famous Morris Canal in New Jersey is practically condemned in a report just rendered to Governor Murphy by ex-Governors Werts, Griggs and Voorhees. The canal company was incorporated in 1824 and built this waterway soon afterward, from Phillipsburg on the Delaware River to Jersey City, a distance of 106 miles. A number of reservoirs were constructed, some of which are now summer resorts and surrounded by valuable estates. The State has a right to take the canal in 1974. It was leased in 1871 to the Lehigh Valley Railroad Company, which has since operated it. The eminent commissioners report that even were the property in perfect condition, it could not be operated at a profit. The decline in its value has been due to the construction of railways which became powerful competitors, carrying freight at cheaper rates than is possible with the canal boats except at a loss. Eventually all traffic was diverted from it except the trifling amount from the lessee. At the present time it stands in the way of needed public improvements, but its abandonment involves the untangling of a complication of interests, including the stockholders of the canal company, the lessee railroad company, the State, the municipalities along the route, the landholders about the reservoirs, and the people having contracts for important water rights, not to mention a lot of trifling claimants for consideration. While the abandonment is assured, it now appears that it will involve more trouble and delay than the original construction of this canal, once the pride of Northern New Jersey.

Railway Engineering in this country is represented by one of the most energetic organizations which exists in the field of technical societies. The American Railway Engineering & Maintenance of Way Association not only holds an annual convention whose high character is evident from the report in the Current News Supplement of the meeting at Chicago last week, but it carries on by means of committees careful and conscientious studies of different branches of railway engineering and issues a monthly publication which should be in the hands of every railway engineer. The character of the committee work is indicated by the abstract of the report on ballast presented last week at Chicago, which is printed elsewhere in this issue. These reports form the bulk of the reading matter in the Association's bulletin, although special papers are occasionally printed. This month, for example, a paper was published on the reduction of gradient and elimination of distance, curvature and rise and fall on the Union Pacific Railroad, by Mr. J. B. Berry, chief engineer of that line. In some respects this is the most important railway paper for several years, for it explains in detail the engineering reasons for the very costly improvements made of late years on the author's road. Attention is called in this manner to the American Railway Engineering & Maintenance of Way Association because its very successful career will doubtless be of interest to men engaged in other important fields of professional work or industry. While individuality is somewhat lost by working for common aims by means of such societies, nevertheless so much more is accomplished in this manner than by individual action, that the society has come to stay as one of the most potent agencies of progress. In railway affairs, this association has already accomplished a wonderful amount of good by its standardization work, and no small measure of this good is also due to the fact that the engineers on its committees are able to deal with committees of associations representing manufacturers whose materials they use. The time saved by the joint conferences which are thus possible is too important to pass without comment. Of course the engineer who accepts a society standard as his own will have to abandon some details, possibly details on which he sets considerable reliance. But in doing this he will eventually better the condition of his company by helping to introduce uniformity of the highest character. And it is important to remember that the greater the responsibilities a man has the less he is able to have details as he desires them, for in gaining a command of many things he must give up detailed control of all of them.

The Masonry Bridge at Plauen, Saxony.

By Carl L. Palen, Dipl. Ing.

Until quite recently, engineers believed it better to use iron bridges for long clear spans, but now those of stone begin to compete successfully with them. There are serious difficulties in inspecting and maintaining iron bridges, while there is scarcely anything of that kind necessary to be done with stone structures. Many of the latter kind in the old world, built more than five hundred years ago, are still in use and good condition. Besides the price of steel being so high now, a stone bridge will often be much more economical than an iron one, especially if a good material for it is found not far away the building place. Until last year the Cabin John aqueduct bridge in Washington, D. C., excelled every other span with its arch of 220 feet, but a bridge in Luxemburg over the Petrusse surpassed it by 55½ feet. Now even this one is no longer the largest.

This summer the firm of Liebold & Company, of Langebrueck, Saxony, will complete a bridge at the city of Plauen, Saxony, having the remarkable span of 90 meters, 295.2 feet. It was designed by Mr. C. H. Liebold, C. E., of that company. The accompanying illustrations show the shape and dimensions of this bold piece of engineering. It passes in one immense span over the Syra valley, and connects two principal parts of the town. The valley being used for a city street, it was not advisable to erect piers in it, and thus render possible two or more shorter spans. The bridge carries a roadway of 11 meters, 36.1 feet width with two 1-meter, 3.28-foot trolley tracks, the gas and water mains, and two sidewalks, each of which is 3 meters, 9.8 feet wide.

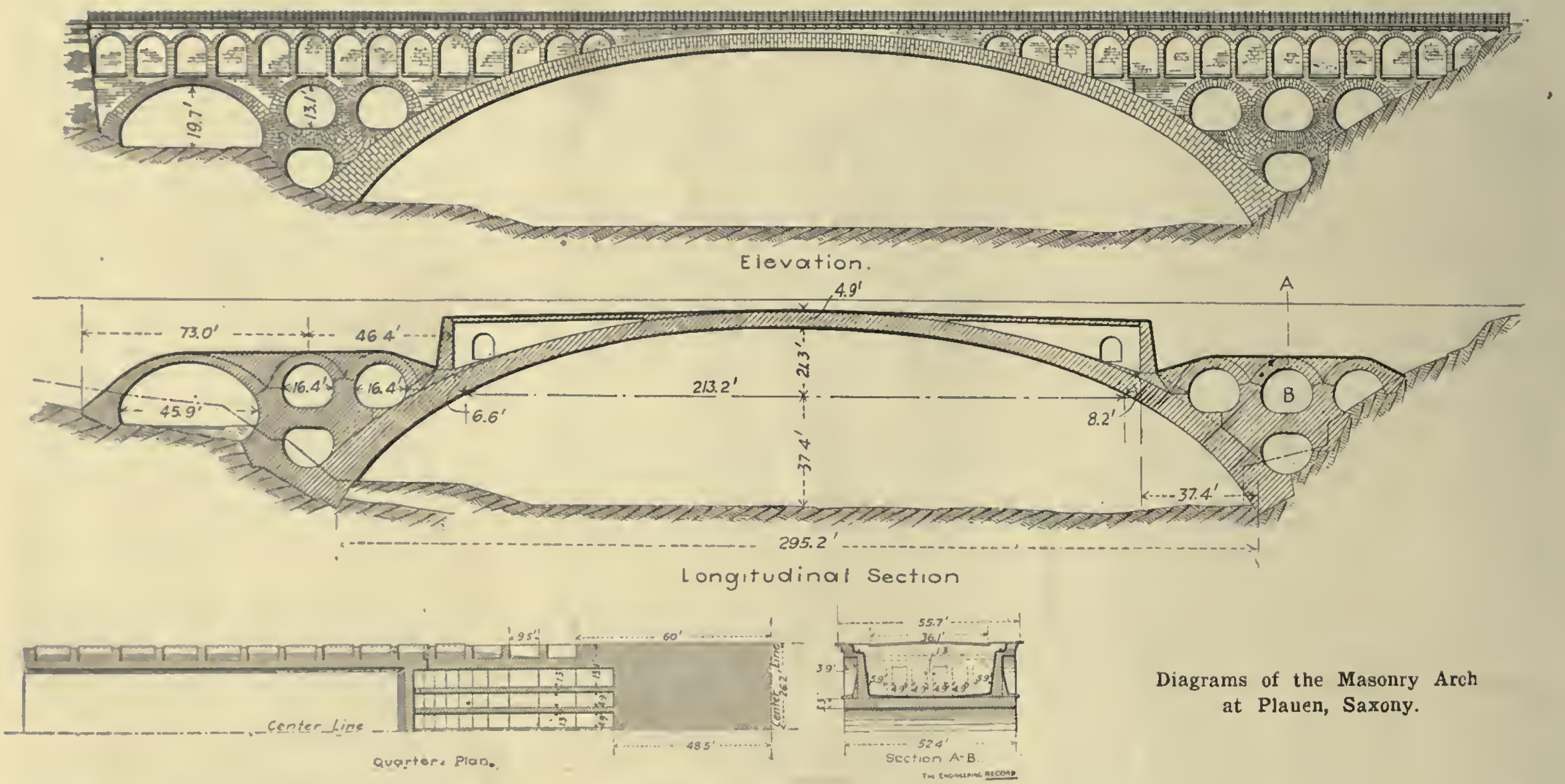
The arch itself is a five-centered curve, its radii being 105 meters = 344.5 feet, 58.5 meters = 191.9 feet, 30.1 meters = 98.7 feet. Its inner surface rising 18 meters, 59.1 feet, above the bottom of the foundations and the clear span being 90 meters, the ratio of the two is 1:5. The arch ring consists of two parts, the lower part belonging in reality to the foundations up to a height of 11.50 meters, 37.7 feet, and the upper one of 65 meters, 213.2 feet width and 6.50 meters, 21.3 feet height. At the crown it measures 1.50 meters, 4.92 feet in thickness, and at its deepest joint 2 meters, 6.56 feet. At this joint the masonry of the foundation begins and including that, the arch ring has here in reality a thickness of 2.50 meters, 8.2 feet. On the outer side of one abutment there is a smaller opening 13.2 meters, 43.3 feet, wide and 6.08 meters, 19.9 feet, high. The arch itself has a height of 4.90 meters, 16 feet. It is three centered with radii of 8.20 meters = 26.9 feet, and 4.4 meters = 14.4 feet. The main arch has been lightened by six vaults parallel to the axis of the bridge. The two side ones are 1.80 meters, 5.9 feet, and the others 1.50 meters, 4.9 feet wide. The pillars between them are 0.4 meter, 1.3 feet thick. The height of the arch is 0.30 meter, 1 foot. For the same reason the sidewalks have been corbelled out and are supported by arches 1.2 meter, 3.9 feet, deep, which also add materially to the attractive aspect of the bridge; their width amounts to 3 meters = 9.84 feet. The vaults parallel the axis of the bridge are at each end connected by openings which are 2 meters, 6.6 feet, wide and 2.50 meters, 8.2 feet, high. They are intended both to save masonry and to give an opportunity for inspection, manholes providing a means of descent from the street. At the ends these vaults are closed by walls, their dimensions being 5 meters, 16.4 feet, height and from 0.8 meter, 2.6 feet, wide at the top to 1.50 meters, 4.9 feet, at the bottom. The abutments are lightened by openings perpendicular to the axis of the bridge; they are 4 high and 5 meters wide, 13.1 and 16.4 feet, going through the whole bridge, reducing both the fill and the masonry and besides making the bridge look lighter. [The dimensions given by the author for some of the minor details do not agree entirely with those on the drawing from which the accompanying plans and elevations were prepared.]

The material of the arch is a hard slate, which is found in the neighborhood. Bavarian granite is used for the quarry-stones of the wings, the corbelled parts of the sidewalks, the moulding, the balustrade and the staircase which connects the bottom of the valley with the top of the bridge. The latter is 3 meters, 9.84 feet, wide, and has 66 steps. Granite is also used for the pavement of the roadway as well as for the plates covering the sidewalks. Only the best German Portland cement is used. The road ascends from both ends towards the center with 1:240 grade in order to conduct the water away. To protect the masonry from dampness, it will be covered with asphalt-felt, and all the water will be conducted to the abutments and from these to the town sewer. The backs of the walls will be covered with goudron.

To complete a work like this demands the most exact calculation considering not only besides the weight of the bridge itself, the change of the live-load, and also the change of temperature, and the pressure of the wind. After the bridge was designed by use of the line of resistance for the weight of the arch ring only, for the dead-load of the completed bridge, for both a half and the whole span covered by a live-load consisting of steam rollers, it was considered necessary to examine this calculation exactly according to the rules of the theory of elasticity. By use of the lines of influence, the most unfavorable positions of the live-load were determined for the three most dangerous joints, the crown, the skew-back and the breaking point, the position of which was also found by calculation. It was found that the pressure in the masonry rises to 70 kilos per square centimeter, 953 pounds per square inch, and on the foundation to 24 kilos, 341 pounds. The line of resistance runs so that nowhere will a dangerous stress be caused nor an important increase in the stress be produced by temperature. The temperature was supposed to cause no stress at 10 degrees Cent., 50 degrees Fahr., and a change both ways of 40 degrees Cent., 72 degrees Fahr., was considered. The addition to the stress by temperature being about 15 kilos per square centimeter, 213 pounds per square inch, it seems quite necessary to consider it, though this calculation can only be rough as one has to assume the temperature to change evenly throughout the whole structure, while in reality the temperature inside will be quite constant, the difference in its distribution causing a considerable stress.

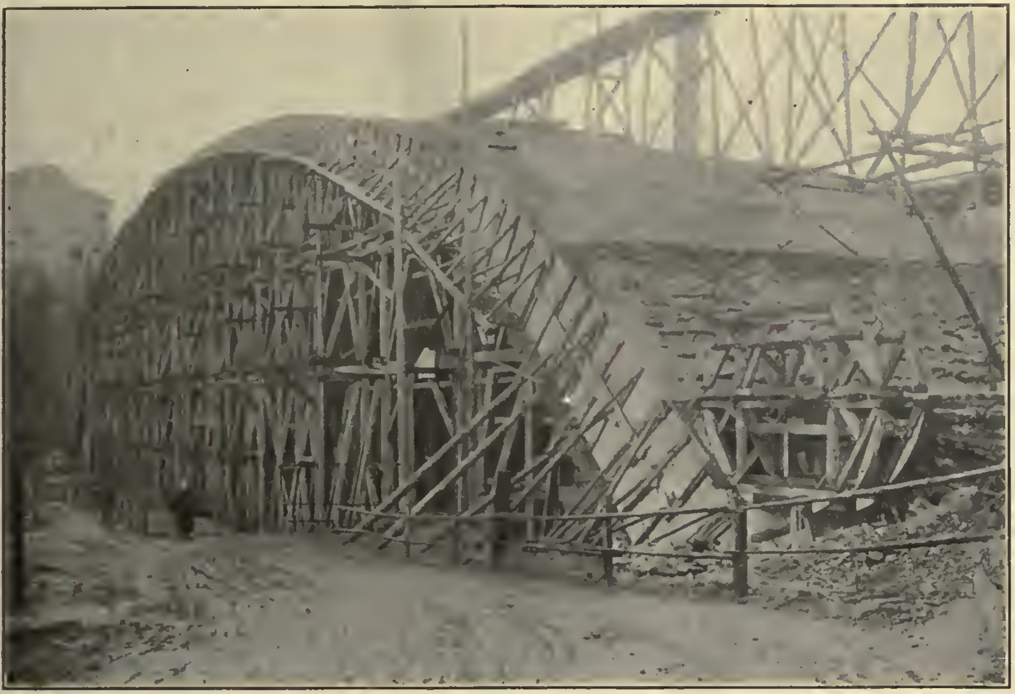
All these difficult calculations would not have been of any use if the execution of the work had not been according to the assumptions on which the analytical studies were based. This could only be done by using very skilled laborers, of whom Liebold & Company have a large number, thoroughly acquainted with their method first adopted thirty years ago.

Most of the modern European masonry bridges of large clear spans are provided with



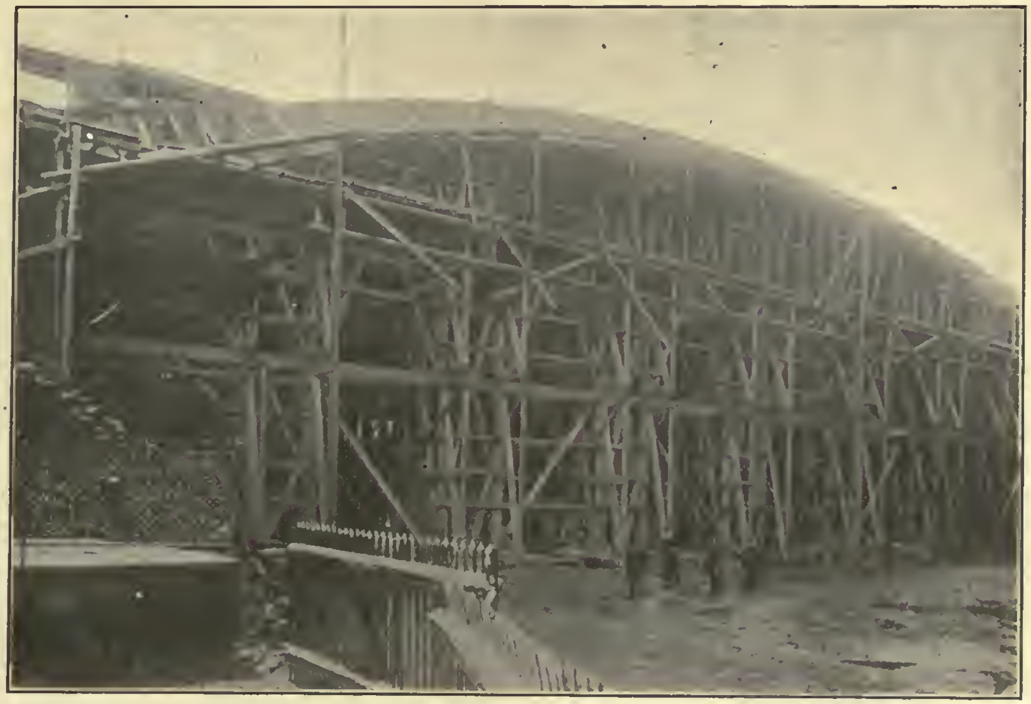
Diagrams of the Masonry Arch at Plauen, Saxony.

stone hinges, meant to make the line of resistance go exactly through the middle of the crown and skew-back joints, as is assumed in designing, and to give to the masonry the ability to follow the movements of the center. The Plauen viaduct has no hinges. On account of the immense weight of a large stone bridge, the friction in the hinges is so large that they cannot work according to the theory. Besides it is not necessary to make the line of resistance go through a certain point. Its position can be exactly stated according to the theory of elasticity and it does not leave the center of the ring at any place sufficiently to cause a dangerous tension. Secondly, it was considered much better to give the center beforehand by loading it, the shape which it will obtain when carrying the finished arch ring. We proceeded, therefore, in the following way: The arch was built in sections, conforming with the construction of the center, all the materials wanted being piled on the center. The latter settled at the crown 2.5 centimeters, a trifle less than an inch, which is very little, considering a span of 295 feet and the arch ring weighing about 12,000 tons. Now it could not change considerably any more, and the joints were closed. The success of this way of building had been previously proved at many German bridges.



View of Falsework of Plauen Arch, Showing Method of Laying Masonry.

The foundations rest on a hard volcanic rock, which was reached at a depth of 4 to 6 feet below the surface. Rough steps were cut into it to prevent the foundation from slipping. A difficulty arose when several levels, the remains of an old mine, were found. As it could not be known if there were more of these below, it was considered necessary not only to fill them with concrete, but to cover them besides with a grillage of 18-inch I-beams to enable the concrete to resist a possible tension.



The Falsework of the Masonry Arch at Plauen, Saxony.

A very difficult problem was the construction and foundation of the center itself. As there are no hinges in the arch ring, it had to possess a great stiffness. It was solved by Mr. R. G. Holzapfel, C. E., one of the chief members of the company. About 1,600 cubic meters, 678,000 feet B. M., of sawed timber, 2,000 square meters, 28,000 square feet of planks and 15,000 steel pins were used for it. Notwithstanding the high price of wood and the fact that the material had to be brought from Bohemia and Styria, we did not economize in our plans to give to the center the wanted stiffness. An opening of 5 meters, 16.4 feet, was left for a thoroughfare. To give it a good foundation, a number of trenches were dug to the firm rock. These trenches are 20 meters, 65.6 feet, long; 4.50 meters, 14.8 feet, wide, and about 2 meters, 6.6 feet, deep. They were filled with concrete in which spruce planks were sunk. These carried the wooden columns. The timber of the center had been framed so as to give to the sheeting the shape of a cylinder. But in order to lift the arch ring more towards the axis of the bridge and towards the middle in comparison to the sides, beech planks of different thicknesses were put under the columns. The oak wedges, to strike the center, were also dimensioned according to this idea. The reason for that was to prevent the arch in settling from becoming out of shape. The wedges were placed between the second and third stage. The first and second story consists of eleven full girders. Between those there are on the ends of the arch half girders, while the third story has twenty-one full girders. On these the purlins rest, carrying the twenty-one rafters on which the sheeting is fastened. The center has not only to give to the inside part of the arch its shape, but also vertical faces or forms were placed on the sides, the use of which will be explained later on. These faces are kept in their position by inclined struts which rest on planks carried by the extended purlins.

The arch was built in the manner adopted by Lieboid & Company. First the top of the sheeting and the inside of the side forms were covered with Portland cement mortar, which was thrown on them with the spade. Then the quarry stones were placed in it, care being taken to give the joints the direction of the radii of the arch ring, to prevent the joints from opening towards the bottom and to use only a very dry mortar. In order to give the faces the appearance of cut stone, strips were nailed on the forms. This mortar covering the whole exterior of the masonry makes it possible to give it the appearance of cut stone and it also is a protection against the influence of the weather, which was proved even with very soft stone.

The planks of the sheeting are 5 centimeters, 2 inches, thick, the purlins, rafters, beams and pillars, 20x20 centimeters, 8x8 inches, and the binding pieces 14x16 centimeters, 5½x6½ inches.

The bridge was begun in May, 1903. The arch ring was finished in November, and in a few days the center will be struck. The bridge is expected to be ready for traffic this summer. It will be richly decorated.

The price of the structure will be about 500,000 marks, or $125,000, a very low price, considering that the Luxemburg bridge over the Petrusse cost 1,200,000 marks of $300,000.

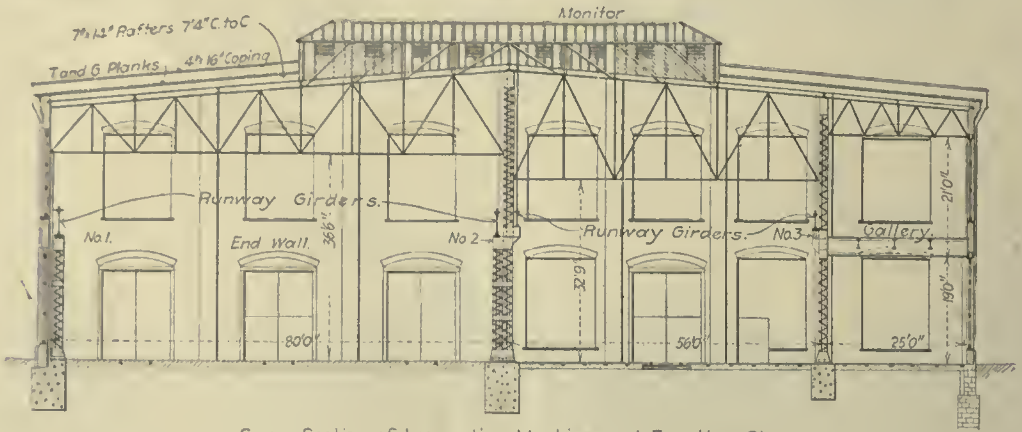
The firm of Lieboid & Company will also finish this summer a bridge of 60 meters, 169.9 feet, clear span over the river Mulde, at Goehren, Saxony. This bridge is provided with stone links. The center of it was struck in November and after this had been successfully done, the royal Saxony government sent its congratulations.

A 5½-Foot Head Water-Power development has been made at Newry, England. A central-flow turbine developing 49 horse-power at an efficiency of 76 per cent. and therefore requiring 6,200 cubic feet of water per minute is installed. It is placed vertically in the bottom of a short flume and runs at 55 revolutions per minute. It drives a 30-kilowatt dynamo.

The Canadian Pacific Railway Shops at Montreal.

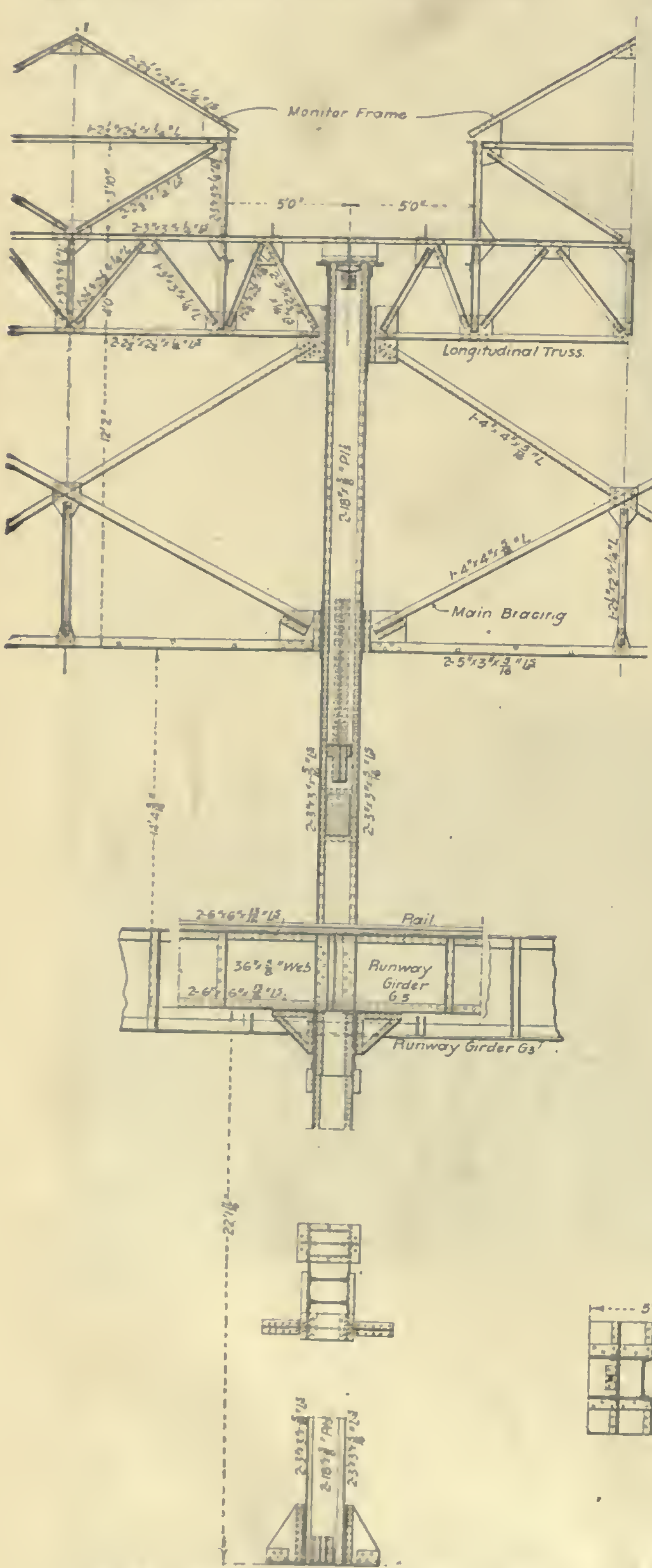
PART II.—STRUCTURAL DETAILS OF THE LOCOMOTIVE SHOP AND THE FOUNDRIES.

Locomotive Machine and Erecting Shop.—The 162x1,166-foot locomotive shop is on the east side of the plant, south of the Midway and adjacent to the gray-iron foundry. There are surface tracks on both sides parallel with its longitudinal axis, and the yard crane crosses the east end. The shop is divided by longitudinal rows of columns into two main one-story aisles and one 26-foot two-story side aisle. Five standard-gauge surface tracks pass through one of the main aisles from end to end and one track passes through the center of the other aisle, and is connected with a parallel outside track by eight transverse tracks with turn-tables. One of the main aisles is commanded by two 60-ton girder cranes of 76½-foot span and the other by one 10-ton and one 15-ton girder crane of 52-foot span. The boiler-making plant is located at one end of the shop, where there is a special tower and riveting machinery. The remainder of the main aisles is used principally for erecting and repairing locomotives, and the side aisle is used for storage and for small machine tools. On the west side of the shop there are four 12x24-foot one-story lavatory extensions. The walls are about 48 feet high to the eaves and are divided into 22-foot panels by the buttresses in the planes of the roof trusses. Each

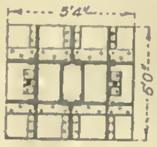


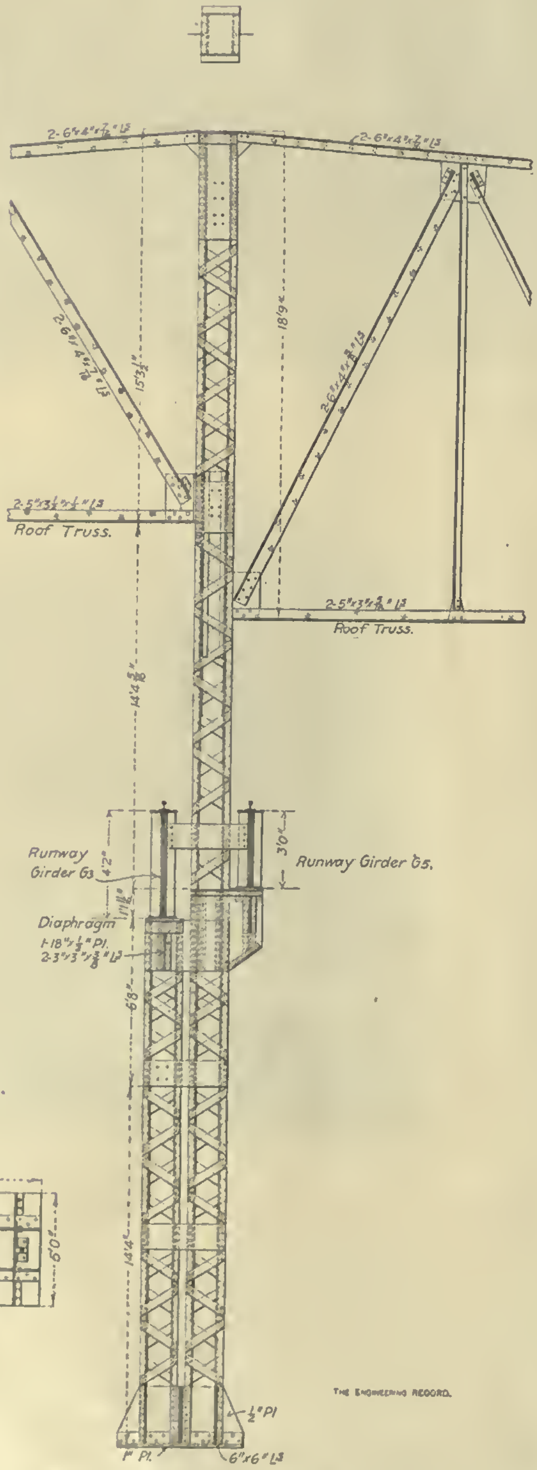
Cross-Section of Locomotive, Machine and Erecting Shop.

THE ENGINEERING RECORD.

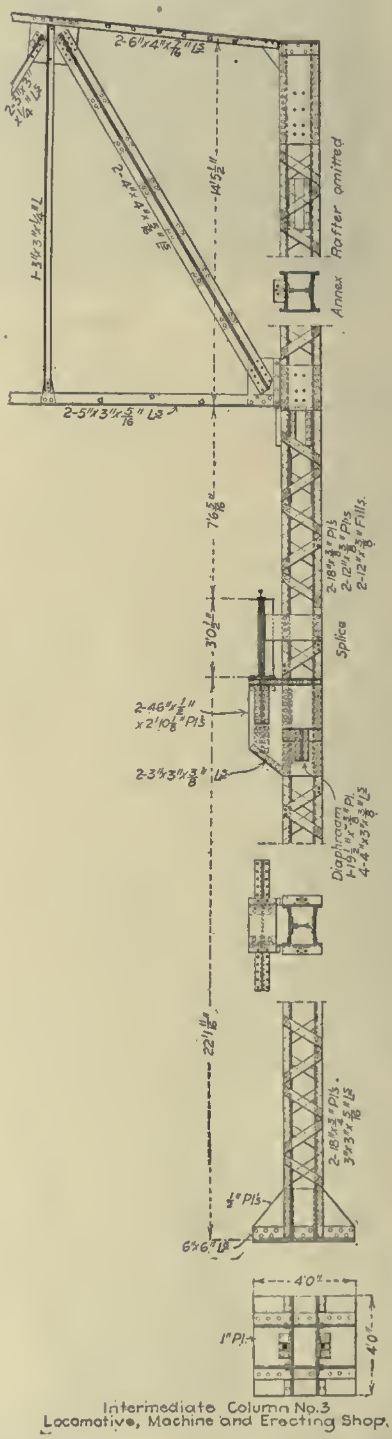


Longitudinal Elevation of Center Column No 2, Runway Girders and Trusses, in Locomotive Machine and Erecting Shop





Transverse Elevation of Center Column No. 2 and Roof Trusses of Locomotive, Machine and Erecting Shop.



Intermediate Column No. 3 Locomotive, Machine and Erecting Shop.

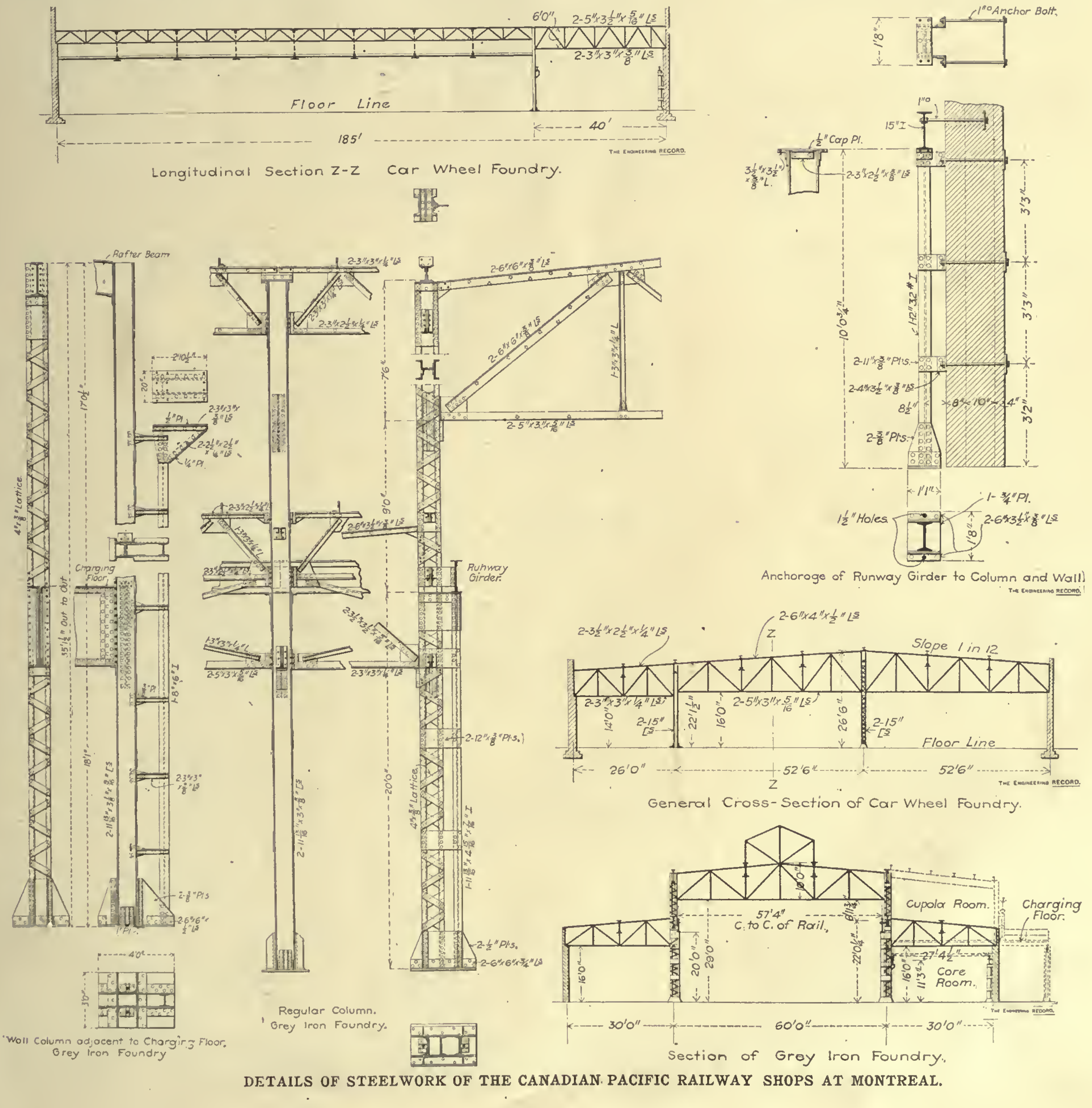
THE ENGINEERING RECORD.

DETAILS OF STEELWORK OF THE CANADIAN PACIFIC RAILWAY SHOPS AT MONTREAL.

panel has two windows 12 feet wide and 16 feet high, and each window has three sash, the middle one being fixed and the upper and lower ones sliding vertically. In some cases the lower part of the window opening is cut down to floor level and the space is filled with a double-leaf door 10 feet high. In each panel of the roof there is a 12x72-foot transverse monitor with a double-pitched skylight roof and walls pierced with eight 2x3-foot hinged ventilation doors on each long side.

In the steel framework there are fifty transverse bents 22 feet apart, each of them composed of three vertical columns and three roof trusses, as indicated in the cross-section diagram and roof plan. On the south side the columns are built into the pilasters in the wall of the building and are double so as to carry the roof truss and the runway for the 60-ton cranes independently of the brick wall, which is entirely self-supporting. The transverse bents are connected by the runway girders and a line of longitudinal lattice-girders in each row of columns, by diagonal bracing between the upper parts of the columns in the two interior rows and by five lines of longitudinal girders between the upper parts of the trusses. Three of these lines are kneebraced to the lower chords of the trusses. These longitudinal girders and braces are built of small angles with riveted connections and form a light and rigid system of sway-bracing. The center line of longitudinal struts and the two lines at the middle of the roof trusses support transverse monitor trusses parallel to the roof trusses and midway between them and the centers of the panels. All longitudinal members have expansion joints about 200 feet apart, where their connections are made with bolts through slotted holes. At the second panel from the west end the riveting tower rises to a clear height of 65 feet above the floor. It occupies one panel of the 80-foot aisle and has in the upper part an 80-foot runway for two 25-ton hydraulic cranes. At the ends of the building the roof is supported on the gable walls and there are no roof trusses, but lattice-girder trusses are carried across the wide aisle to connect the tops of the end columns and provide lateral stiffness for the runway girders.

The roof trusses are of simple construction, being made with pairs of angles back to back with riveted connection plates between their flanges. The columns of the center row are made with their lower parts double, so as to carry the runway for the 60-ton crane at the top of one side 21 feet above the floor. The base plates are nearly 5 feet square and the two parts of each column are practically separate members riveted together through their tie-plates. Solid double web brackets are riveted to the long side of the column just above the seats for the heavy runway and carry on the opposite side the parallel runway girders for the cranes in the north aisle of the building. These crane girders are respectively 50 inches and 36 inches deep and have their lower flanges riveted to the extended seats. They are braced transversely by web connections to horizontal tie-plates projecting from the column and their upper flanges are braced together by zigzag lateral angles. There is ¾ inch clear-



Longitudinal Section Z-Z Car Wheel Foundry.

Anchorage of Runway Girder to Column and Wall

General Cross-Section of Car Wheel Foundry.

Wall Column adjacent to Charging Floor, Grey Iron Foundry

Regular Column. Grey Iron Foundry.

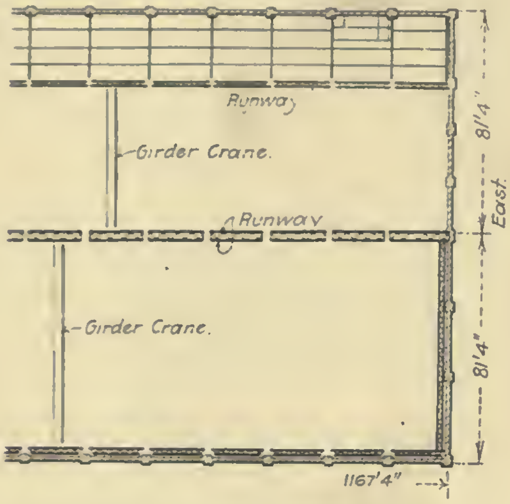
Section of Grey Iron Foundry.

DETAILS OF STEELWORK OF THE CANADIAN PACIFIC RAILWAY SHOPS AT MONTREAL.

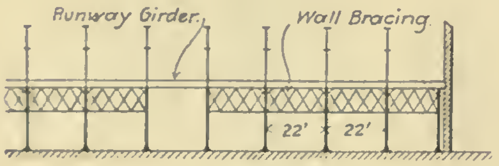
ance between the abutting ends of the girders, and the track rails are hook-bolted to the top flanges on the center line. The trusses are connected to the column webs by vertical flange angles riveted to the connection plates at the ends of the lower chords. The top chords of the trusses are braced to the tops of the columns by pairs of angles riveted to diaphragms projecting from the sides of the column. The longitudinal trusses between the tops of the columns on the center line of the building have drop ends seated on their caps, and the diagonal angles in the same planes have column connections similar to those of the bottom chords of the roof trusses. The columns between the main aisle and the side aisle are made of two built channels latticed, and carry crane runways on eccentric brackets. These brackets are made by extensions of cover-plates riveted to both flanges of the column and have longitudinal solid web knee-brace extensions on both sides to give a longer bearing for the lower flanges of the runway girders and to brace the latter more securely. The runway girders are also braced to the columns by horizontal tie-plates riveted across the flanges of the latter and to the vertical web stiffeners of the girders. The top flanges of the runway girder on this line of columns and along the wall columns of the other aisle of the building are transversely braced by zigzag angles riveted to a horizontal angle just clear of the wall and 20 inches distant from the center of the girder. This angle is supported by kneebrace angles to the vertical web-stiffener angles in the girder and the arrangement serves to give great rigidity to the runway girders and to prevent tremor and deflection under impact and traction of heavy crane loads. The connections of the roof trusses and longitudinal girders to the wall columns are similar to those already described.

The columns in the south wall of the building are similar to those between the main aisles, but are lighter. The short parts of the columns carry the runway girder and are secured to the long parts by diaphragms riveted to them on the center lines. The long part of each column is built solid into the brickwork and serves only to carry the roof truss. The monitor trusses are about 36 feet long. They are 8 feet deep at the ends and 5 feet deep in the center, and are made of single angles. The connection plates are riveted between the opposite flanges of chord and web angles. The truss is divided into 9-foot panels by vertical angles and each panel is braced by a single diagonal angle. This shop is the largest in the plant and covers an area of 191,552 square feet. The structural steel in it weighs about 2,700 tons and was built by the Dominion Bridge Company.

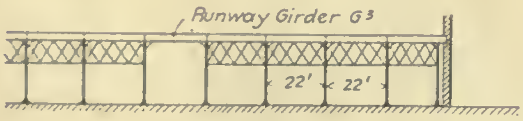
Gray-Iron Foundry.—The 122x342-foot gray-iron foundry is adjacent to the locomotive shop with surface tracks alongside and the yard cranes on one side and one end of the building. It is divided into a 60-foot center aisle and two 30-foot side aisles by two main longitudinal rows of steel columns. There are no wall columns excepting those to carry the crane runway and some to support the charging floor. The side walls are about 22 feet high and



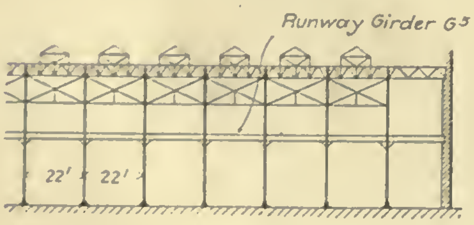
Part Plan at Gallery Level.



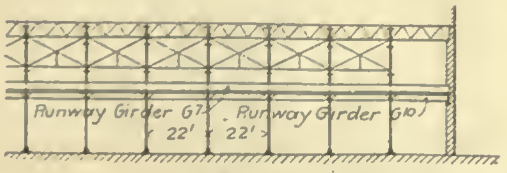
Part Section Z-Z.



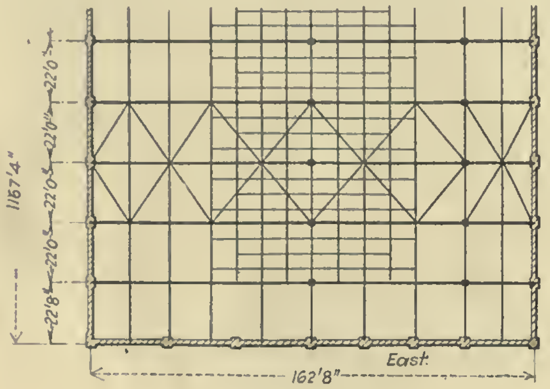
Part Section X-X



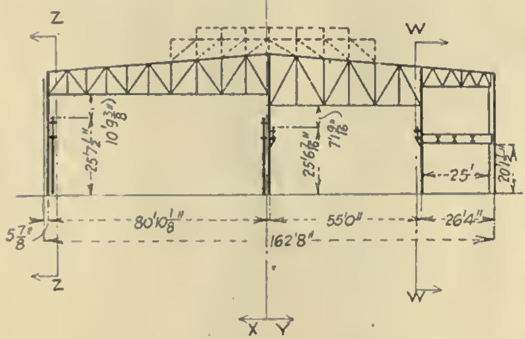
Part Section Y-Y.



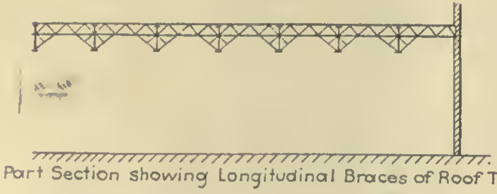
Part Section W-W.

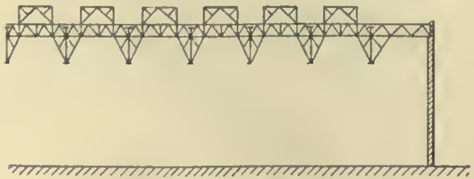


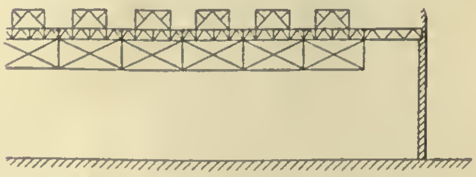
Part Roof Plan.

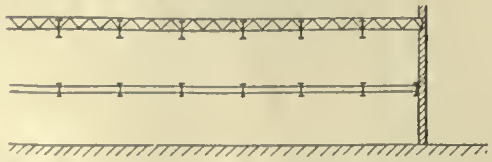


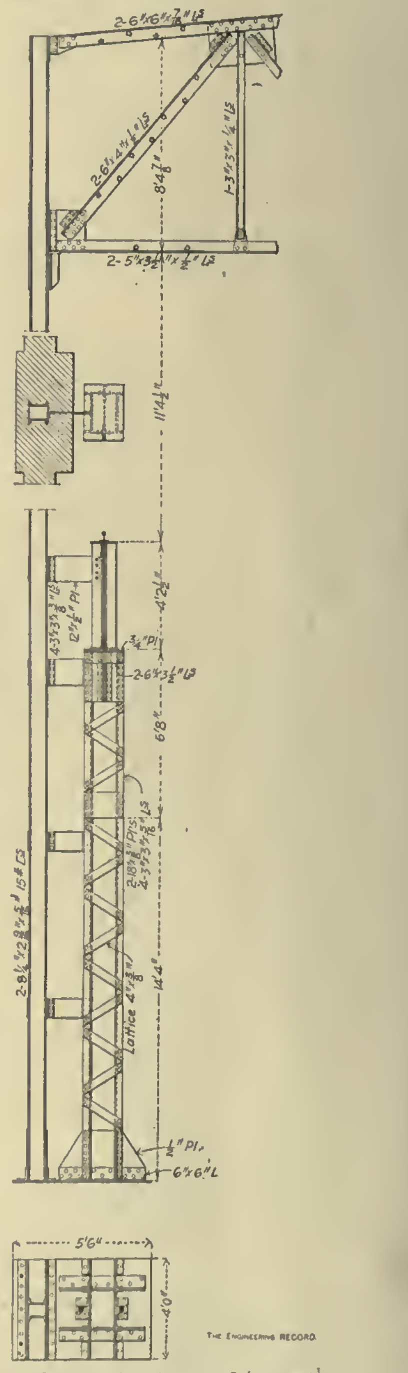
General Cross-Section.


Part Section showing Longitudinal Braces of Roof Trusses.


Part Section showing Monitor Frames.


Part Section showing Longitudinal Sway Bracing


Part Section through Gallery.



Wall Column No. 1. Runway Column No. 1. and End of Roof Truss.

DETAILS OF LOCOMOTIVE SHOP OF CANADIAN PACIFIC RAILWAY AT MONTREAL.

the roof of the main aisle is 40 feet high at the eaves, giving, above the side roofs, clerestories 12 feet high, which have their entire surfaces glazed. About half of the area of the side walls is occupied by large double windows and wide doors. A 22-foot monitor extends nearly from end to end of the center aisle and has a double-pitched skylight roof and solid walls with hinged ventilating doors.

The main floor of the building is used for a moulding floor, and the north aisle is reserved for flask and core makers, and for the cupola room, sand room, blower room, tumbler room and offices. Over the cupola room there is a second story with a coke storage bin and a very heavy platform which serves as a charging floor, with an outside extension to which the yard crane delivers pig-iron and coke. The charging floor has 24-inch and 15-inch beams and girders supported on special one-story columns and covered with ¾-inch flat plates 52 inches wide. It is proportioned for a maximum load of 400 pounds per square foot. In one corner of the building a lavatory and toilet room is provided and has a special set of shower-baths.

The framework of the building is simple; it has sixteen main transverse bents 20 feet apart, besides the extension for the charging platform. The regular bents are symmetrical about the center line and correspond with the left-hand side of the cross-section diagram. Through the core room the construction is modified, by the side aisle crane and its wall columns, and through the cupola room the side aisle roof trusses are replaced by the roof girders, shown by dotted lines at the right of an accompanying drawing, and the second floor and outside platform are added. The bents are braced by the crane runways, by X-bracing and horizontal struts between the columns underneath them and by seven lines of lattice-girder purlins. The second panel from each end of the roof is X-braced by single 4x4-inch angles riveted to the top chords of the roof trusses. The roof trusses are made with pairs of angles back to back with connection plates riveted between them. They are supported from their lower chords, which at one end are riveted to the faces of the posts through vertical connection angles, and at the other end are seated on stone templates in the side walls. The top chord angles of the center aisle trusses are continued to the column tops to serve as struts. The main columns are made with two parts, the long part carries the roof and is built with two channels latticed. The tie-plates on both flanges extend about 12 inches beyond one channel and are riveted to the flanges on an I-beam which is connected to the same base-plate and independently supports the runway girder for the traveling crane.

The columns adjacent to the charging floor are similar to the main columns illustrated, but are made heavier and have special connections to receive the floorbeams. The columns in the outer wall of the cupola room are made double, as shown in the detail, so as to provide for the independent support of the yard crane runway girders. The side aisle runway girders are carried along the wall on special I-beam columns, which have horizontal brackets engaging the face of the wall and bolted to it. These girders are 15-inch I-beams without lateral bracing and are anchored to the masonry by horizontal bolts through their webs as shown in the detail. The main runway girders are transversely stiffened by horizontal bracing to parallel girders, as described for the locomotive shop and as practiced for the principal crane girders throughout the plant. This shop covers an area of 42,475 square feet. The structural steel work weighs about 385 tons and was built and erected by the Dominion Bridge Company.

Wheel Foundry.—The 107x187-foot wheel foundry is a rectangular building with two 52½-foot main aisles and a 27x148-foot extension for the cupola room, core room, blower room, office and storeroom. The walls have one tier of wide double windows which, with the doors, occupy more than half of their total surface. The roof is lighted by eight transverse monitors 9 feet wide and 53 feet long with solid walls and double pitched skylight roofs of the standard type adopted throughout this plant. The cupola room extension is two stories high for a length of 90 feet and the second floor is built, like that in the gray-iron foundry, for a charging floor. On the opposite side of the building there is a one-story 12x27-foot extension for toilet room, lavatory and shower-baths. Across one end of the building an unobstructed space 40 feet wide is reserved for a stacking floor and soaking pits, and is served by a 3,000-pound crane running transversely to the longitudinal axis of the building. The roof here is supported by longitudinal lattice-girder trusses 17½ feet apart, which are carried at one end by the gable wall and at the other end by a special row of transverse columns. The remainder of the roof is supported by two sets of 52½-foot steel trusses carried by the side walls and by a center longitudinal row of columns 18 feet apart. The roof trusses are braced by five lines of lattice-girder purlins in the main part of the building and have sway-braces between them in the plane of the columns, but have no diagonal bracing in the planes of the chords. There are fifteen longitudinal lines of horizontal 7-inch I-beams seated on the lower chords of the roof trusses 9 feet apart and 18 feet clear of the floor which serve as supports for hoists used for lifting the wheels from the moulds and for handling the flasks.

The roof trusses are similar to those in the gray-iron foundry and have corresponding connections to the columns. The latter are made with a pair of channels latticed and have vertical transverse plates riveted across the caps to receive the connections with the lattice-girder purlins. Where they support runway girders, the latter are carried on double gusset plate brackets riveted to the channel webs. The columns supporting runway girders adjacent to the wall are single I-beams anchored to the masonry, as in the gray-iron foundry. The building covers an area of 24,516 square feet. The structural steel weighs 162 tons and was built by the Dominion Bridge Company.

(To be continued.)

The Power Plant of Watson Brothers, Linwood, England, the performance of which is noted in this issue on page 388, in the article on "The Cost of Generating Electric Power," includes two 250-kilowatt steam-driven dynamos employing triple-expansion engines working with a boiler pressure of 250 pounds at a temperature of 500 degrees Fahrenheit at the stop valve. By means of jet condensers a vacuum of 25 to 25¼ inches is obtained. Each unit runs about 128 hours per week, the output at night being only slightly less than that during the daytime. There are two Babcock & Wilcox boilers, each of 3,580 square feet of heating surface. Chain-grate stokers are employed and the boilers are fitted with their own superheaters, each made up of sixty-four 4-inch tubes having a heating surface of 460 square feet. There is a feed-water heater containing 316 square feet of heating surface, designed to handle 22,000 pounds of water per hour, utilizing the exhaust from the pumps. The feed water is heated in it to 160 degrees, and is then passed through an economizer, which it leaves at about 300 degrees. The total cost per kilowatt-hour, including interest and depreciation, is 0.67 cent.

Recent Investigations With Treated Ties.

An article by Dr. Hermann von Schrenck appended to the report of the Committee on Ties of the American Railway Engineering & Maintenance of Way Association.

In February, 1902, an experimental section of track was laid on the Beaumont Division of the Gulf, Colorado & Santa Fe Railway. In this track both treated and untreated timbers of various kinds were laid to test the comparative lasting powers of timbers treated with various kinds of treatment. These ties have now been in position about two years, and while it is as yet rather early to derive any definite conclusions from this test, an inspection made during the month of December showed the following general results:

(1) All of the untreated timbers show more or less signs of decay. Tamarack, loblolly pine and beech have so far shown themselves as the least resistant of all the timbers. In the case of the untreated tamarack, out of 49 ties, 37 had fungi growing on the ends of the ties, indicating that they were beginning to decay. The various species of oak showed the highest resistance in the untreated state.

(2) Referring to the treated timbers, the most striking results so far evident refer to the bad results with oak timbers which were overheated in the treatment with creosote. These timbers were for a brief period of time exposed to an extreme heat. A large percentage of the ties so treated have during the last year or so broken in the middle or underneath the rail bearing, so as to endanger the safety of the track, and they had to be removed. Great stress should be laid upon the results in this particular instance, which should serve as a warning to avoid excessive heating, whether the same be dry or moist heat.

(3) The ties treated with the zinc-chloride process have so far shown no signs of decay, and there is little evidence of any wear under the rail. The same is true of the ties treated by the zinc-creosote, two-injection process.

(4) Ties treated with spirittine are in every case sound.

(5) Summing up the results which are so far evident, one can say that every treatment has so far protected the timbers against decay, and, in view of the fact that all of the untreated timbers are decaying, this stretch of track is already forming an object lesson of great interest as to the value of treated timbers.

(6) Some of the ties treated with the Barschall process have fungi growing on the ends. These are, however, a lot of ties which were poorly treated, and it is not thought that the appearance of these fungi on the ends warrants the conclusion that this treatment will not protect the timber against decay. Another year ought to be allowed to elapse before any definite conclusion is drawn.

During the past year a number of modifications in the treatment of various timbers have been made, of which the following may be noted:

Treatment of Seasoned Pine Timbers with Zinc-chloride Without Steaming.—The value of seasoning pine timbers before treatment has been urged for a number of years. In hardly any case is timber steamed in Europe before being treated. During the last summer tests were made at the Las Vegas treating plant of the Santa Fe, with seasoned mountain pine, with the following results:

Absolutely dry, air-seasoned timber was put into the cylinder, and the following is a record of a run: Vacuum begun 5.50 P. M.; 21 inches vacuum reached 6.50 P. M.; zinc-chloride pumped in 6.50 P. M.; 80 pounds pressure reached at 7.15 P. M.; started forcing back, 1015 P. M.; completed 10.35 P. M.; total time of treatment, 3 hours 45 minutes.

The ties were carefully weighed before and after treatment, and when the treatment was finished they showed an average gain in weight, because of the solution absorbed, of 84.22 per cent. The solution had thoroughly penetrated the wood. This test was repeated a number of times with the same results, and since those tests were made the steaming operation, which is not only a lengthy one, but costly likewise, has been eliminated from the treatment.

Similar tests are now under way at the treating plants of the Burlington & Missouri River Railroad in Nebraska and at Somerville, Tex. Attention should be called to the fact that this treatment will only succeed with absolutely dry timber. In view of the fact that the penetration is so much greater and takes place with so much greater rapidity, and, furthermore, in view of the fact that the heating is left out, it is believed to be a great improvement over the present method of treatment. Tests are now in progress.

Creosoting.—An increasing amount of creosoting is being done at the present time, and the necessity for a careful inspection of the oil is being realized more and more. It is generally being realized that only a good oil will serve the purpose. What constitutes a good oil is a matter which has been much discussed. In spite of many researches conducted in this country and in Europe, it has not yet been decided whether (referring now only to ties or bridge materials) any one of four or five compounds is the essential constituent of good tar oil.

What is known, however, is that tar oil, in order to be of a high grade, should have such products in it as will not disappear from the wood when the same is exposed to atmospheric influences, but that will remain in the wood for indefinite periods. Every inspection ought to determine whether the tar oil has this quality of remaining in the wood. This method of inspection should be simple, easy and one which can be rapidly executed by almost anyone.

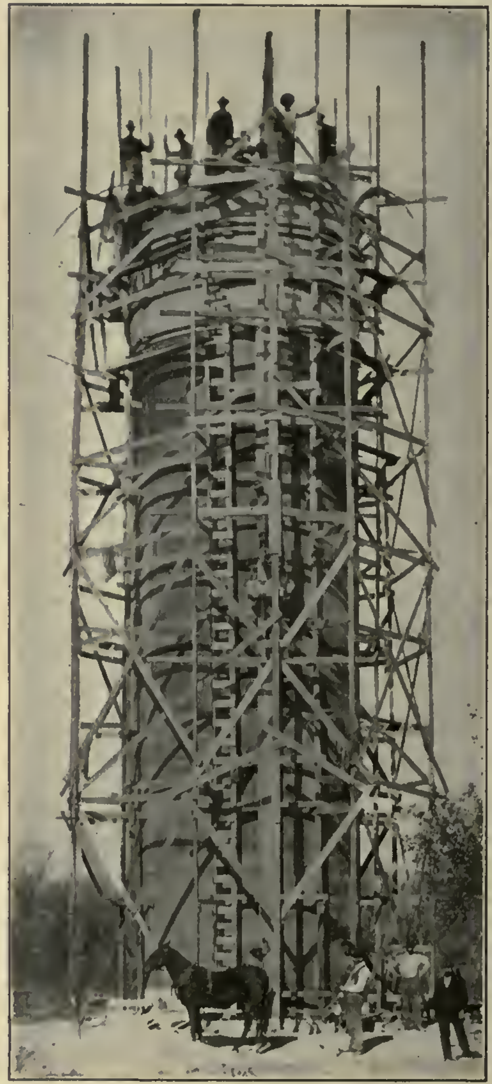
The following set of specifications are being urged by the Department of Agriculture as to what constitutes high-grade oil: (1) The tar oil must be clear; that is, there must be no substances in suspension. This is best tested by putting a drop of the oil on a piece of filter paper. The resulting spot must be clear and translucent. (2) The specific gravity must be about 1.04 to 1.05 at a temperature of 20 deg. C., 68 F. (3) Boiling points. Up to 150 deg. C. nothing must come off. Up to 200 deg. C. not more than 10 per cent. may come off. Up to 235 deg. C. not more than 25 per cent. may come off. Up to 355 deg. C. at least 90 per cent. must come off. (4) The oil must be absolutely soluble in benzine or absolute alcohol.

An Earth Dam 110 Feet High at its maximum and 1,830 feet long is under construction for the extension of the water works of Leeds, England. As described in a recent issue of "The Surveyor," this embankment will be 32 feet wide on top with a maximum width at toe of 600 feet, and will have inside slopes of 1 on 3 and outside slopes of 1 on 2½. The outside slope will have three almost horizontal benchings 20, 30 and 45 feet respectively, thus approximating the best form of resistance. The puddle wall will be about 80 feet at its greatest depth. The trench for retaining the underground waters is to be filled with concrete in its lower portion and clay puddle above. When the reservoir is full the pressure at the bottom of this concrete will be about 250 feet. The capacity of the reservoir will be over 2,000,000,000 gallons.

Steel-Concrete Standpipe at Milford, Ohio.

A steel-concrete standpipe was recently constructed for Milford, Ohio, from the designs and under the superintendence of Mr. J. L. H. Barr, of Batavia, Ohio. The system of reinforcing the concrete is known as the Weber system, and makes use of small steel tees for the reinforcement. The general appearance of the finished standpipe is shown in one of the accompanying illustrations, and the other indicates the method of construction, having been taken when the walls had reached the height of 57 feet. The standpipe is 81 feet high from the base to the roof, and the dome-shaped roof has a rise of 3 feet, making the total height above the foundation 84 feet. The minimum inside diameter is 14 feet. For the lower 30 feet the wall is 9 inches thick; for the next 25 feet the thickness is 7 inches, and the upper section of the wall is 5 inches thick, the reductions in thickness being made on the inside. The outside surface of the wall is perpendicular. The foundation is octagonal, with an inscribed diameter of 20 feet, and it is 6 feet deep. The concrete for the foundation was mixed in the proportion of 1 part cement to 7 parts gravel, while the concrete for the wall was made of 1 part cement and 3 parts clean, sharp sand. The standpipe proper was washed with neat cement grout and the top was troweled smooth.

Steel-Concrete Standpipe, Milford, Ohio.


Erection of Steel Concrete Standpipe.

The wall is reinforced with 1x1x⅛-inch steel tees bent into rings with the ends lapped about 6 inches. These rings are set about 3 inches from the outer surface of the wall and are held in place by perpendicular tees spaced about 18 inches apart, to which the rings are fastened by wire bands. The perpendicular tees are also intended to reinforce the concrete for wind pressure. The intake pipe extends about 18 inches above the bottom of the standpipe and the overflow pipe reaches to within 18 inches of the top, thus giving 78 feet of available water space. There is also a washout pipe. All these pipes are embedded in the concrete foundation. A steel ladder extends from the bottom of the standpipe on the inside to the top of the wall and down on the outside to within 10 feet of the base.

The forms were made of 1⅛-inch flooring boards 3 inches wide cut to 3 feet in length, for the staves, and 4x4-inch ribs. The staves were nailed to the ribs and the upper rib projected 1 inch above the ends of the staves so as to form a rabbet to receive the section of the forms next above. Three sets of forms were used, each consisting of an outer and an inner form, and each form was divided into eight sections for convenience in handling. The sections in each ring of the outside forms were held together with latches, and those of the inside forms were bolted together. When taking off the lower set of forms the different sections were temporarily hooked to the form above. The average rate of progress in building the wall was 5 feet per day. The work was carried on every day, and so the cement in one ring did not set hard before the next was placed. The cost of this style of construction is said to be about the same as that of steel, while greater durability is claimed for the concrete.

The Charge for Electric Power from the water power at Schaffhausen, Switzerland, is 3.86 cents per kilowatt-hour, with a minimum of $9.65 per year per kilowatt capacity.

The Plate-Girder Approaches of the Clairton Bridge.

The double-track railroad bridge across the Monongahela River at Clairton, near Pittsburg, is designed largely for steel mill traffic and is of unusually massive construction proportioned according to the specifications of the Pittsburg & Lake Erie Railroad. It has a 498-foot channel span, illustrated in The Engineering Record of March 12, at each end of which there is a viaduct approach with center lines curved to a radius of about 475 feet. These viaducts have masonry piers 8 feet wide under the coping which support three plate-girder spans on each side of the river. At the east end of the bridge the girders are from 103 to 117 feet long, and at the west end from 86 to 117 feet long. The abutment spans are through girders and the others are deck girders.

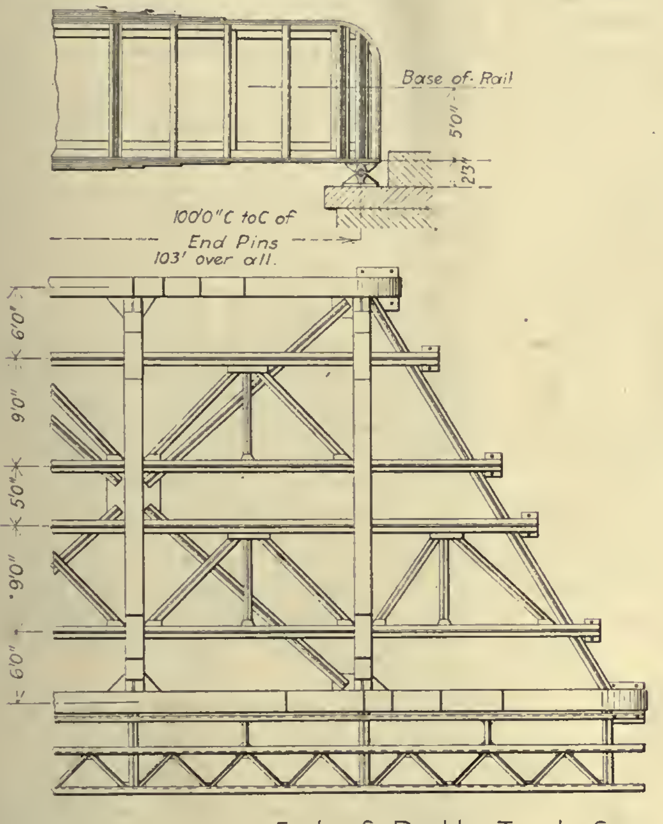
On the west side of the river the tracks from the mills and from the Pittsburg & Southwestern Railway arrive at the river crossing from opposite directions, and converge to the channel span, forming a Y. The superstructure, as now constructed, comprises only the approach from the mills and the viaduct at this end of the bridge has only single track spans. The pier between spans Nos. 2 and 3, however, is built to accommodate the future span for the north leg of the Y.

On the east side of the river both tracks leave the bridge in the same line, and the approach has two single track deck spans, Nos. 5 and 6, and one double track span, No. 7. Although the piers have been built for double track, the superstructure has not yet been provided for the second track for spans 5 and 6, this being deferred until the second track is required.

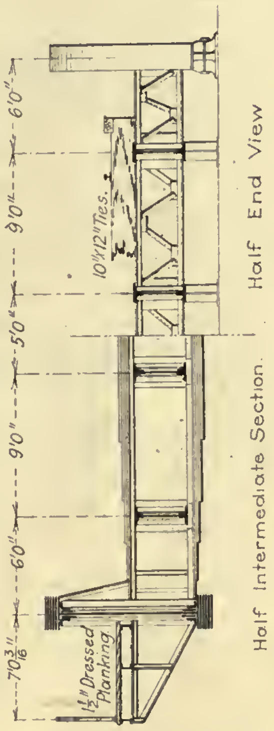
Span 7 is of through girder type in order to give clearance underneath for the tracks of the Pittsburg & Lake Erie Railroad, and was built double-track for the purpose of securing a better alignment of the second track whenever it may be added, than if two complete single track spans were used.

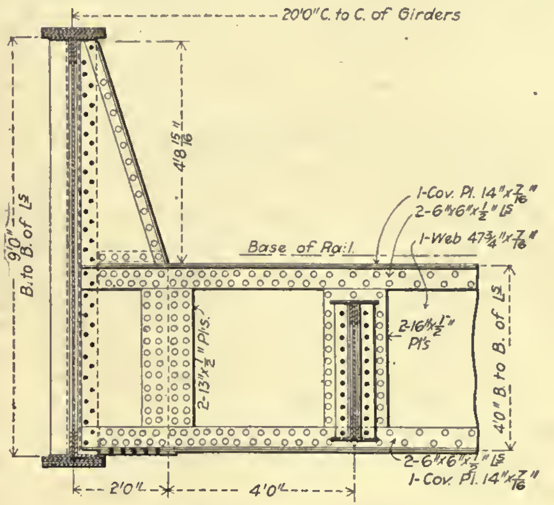
All the spans have been built for the same loading as the channel span, namely: one 152½-ton engine followed by a train load weighing 5,000 pounds per linear foot. The dead load was assumed to be 2,200 pounds per linear foot. The track is on a 12-degree curve with the center line 2.1 feet from the center of the inside girder at the end. Allowance has been made, consequently, for the centrifugal force due to a train speed of 30 miles an hour, which was considered as equally divided between the top and bottom flanges. Spans 3 and 5 are nearly duplicate and each is 113 feet 8 inches long on centers of piers and 116 feet long from out to out of girders. The girders are of soft steel which, above ¾ inch thickness, was reamed after punching.

The outside girder has maximum momenta of flexure as follows: Dead load, 888,200 foot-pounds; live load, 5,227,800 foot-pounds; centrifugal, 576,500 foot-pounds; total, 6,692,500 foot-pounds. This gives a maximum flange stress of 691,400 pounds, which, at 8,500 pounds per square inch, requires a net section of 81.34 square inches. This section was made up of 8x8x¾-inch angles and five 24x⅝-inch cover-plates having a combined area of 82.38 square inches. The maximum flange stress and the net area of the inside girder are respectively 559,700 pounds and 69.88 square inches. The dead-load shear is 62,500 pounds, live shear 178,700 pounds, giving a maximum of 241,200 pounds, which, at 4,000 pounds per square inch, requires a total web area of 60.3 square inches. The ⅝-inch web exceeds this amount and has an area of 73.1 inches. The web is stiffened by the splice plates from 9 to 12 feet apart and by

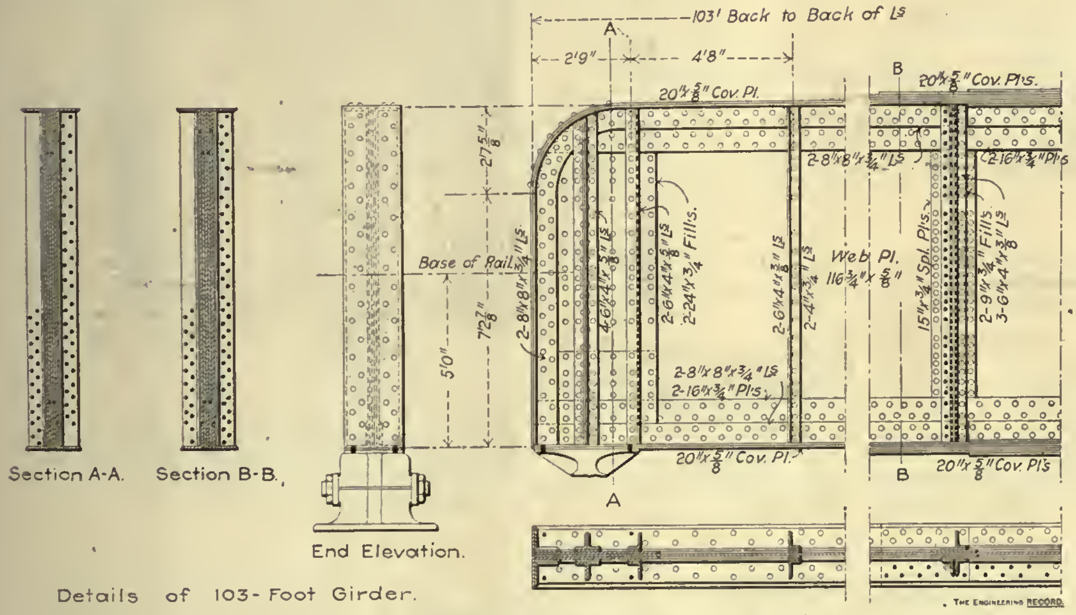


End - of Double Track Span

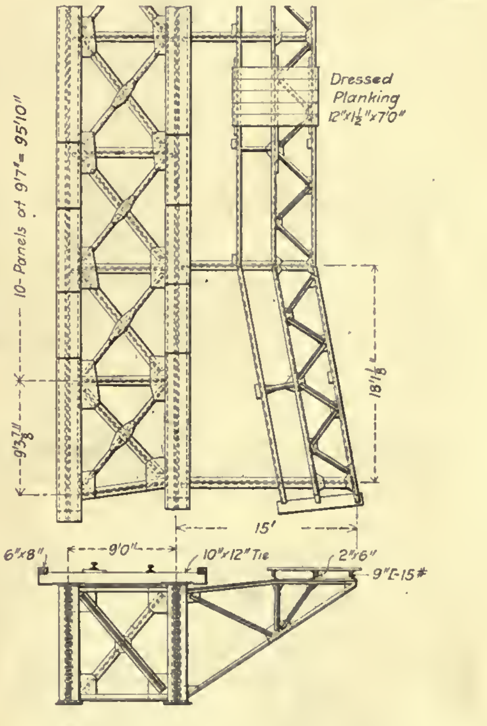




Half Cross-Section of 88-Foot Span.



Details of 103-Foot Girder.



Lateral Bracing and Cantilever Sidewalk at End of 116-Foot Single Track Deck Span No. 3.

Steelwork Details of the Plate-Girder Approaches of the Clairton Bridge.

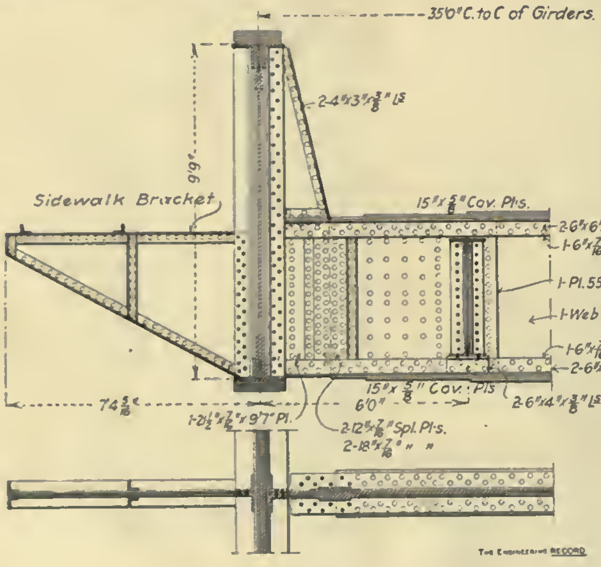
intermediate pairs of vertical 6x3½-inch angles and fillers, both of which are finished to bear on the flange angles. At every web splice, that is at every alternate panel point, the girders are braced together by sway frames and the panels between the sway frames are X-braced by top and bottom laterals. These are single or double angles 3½ or 4 inches wide, riveted to horizontal connection plates engaging the inner edges of the cover plates. The vertical flanges are turned down in the top laterals and up in the bottom laterals. One diagonal is made continuous and the other diagonal is cut to clear it and spliced across it by a horizontal flange plate, shop-riveted to it and field-riveted to the continuous angles. The connection plates are shop-riveted to one of the diagonals and field-riveted to the sway-brace frames, the other diagonals and the main girders. From the south girder of each span long cantilever open brackets project at alternate main panel points to carry a foot walk a considerable distance clear of the girders. This walk is parallel with the girders, except in the end panel where it is divergent, as indicated in the diagram.

The main girders are 7 feet apart in the clear and support the track ties on their upper flanges. The web splices are made with a pair of 13x½-inch plates, two angles and two fillers, and all of them are riveted up complete in the shops, the girders being shipped whole to the site. At the ends of the span the web is reinforced by two 28x¾-inch and two 24x½-inch plates, besides the six vertical 6x3½-inch angles, and is seated on cast-steel pedestals with pin-bearings. At one end of the span the upper flange extends 12 inches beyond the end of the girder and is supported by solid-web kneebraces to carry the ties over to meet the track on the adjacent span.

The end pedestals are bolted to the lower flange and consist of steel castings having thick transverse and longitudinal webs with half-hole bearings on the 5-inch pins, which engage corresponding lower castings and are locked in place by shoulders and recessed discs engaging bosses in the faces of the castings. At the expansion end of the bridge the lower casting is seated on a nest of seven 3½-inch rollers, which are centered by the usual guide ribs. The rollers are set on a 28x31-inch bed-plate having pairs of angles on both sides, which form Z-shaped guides enclosing both rollers and pedestal flange so as to exclude dirt. At the fixed end of the bridge the lower pedestal is made 5 inches higher than that at the expansion end so as to allow for the thickness of rollers and bed-plate, and is seated directly on the masonry, which is built to the same height in both cases. At both bearings there is a clearance of ½ inch between the upper and lower pedestals to allow for possible deflection in the girder. The track ties are dapped a variable amount equal to the thickness of the cover-plates so that their lower edge is always flush with the top of the flange angles. The outer rail is raised by oak wedges.

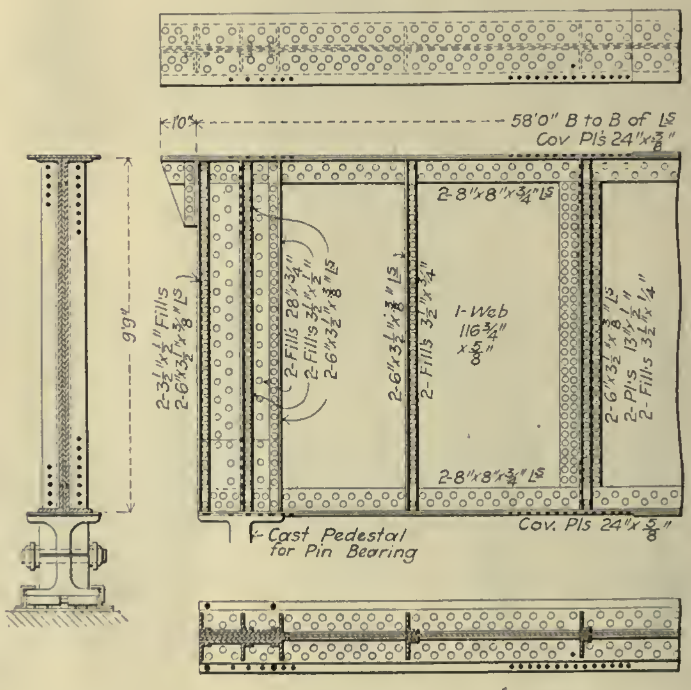
The through spans at the shore ends of both approaches are similar, except that one of them is for single and the other for double track service. In both of them the general character of the main girders corresponds with those of the deck spans already described, except that the upper corners are rounded to a radius of 2½ feet; that there are no upper lateral struts or sway-bracing, and that there are floorbeams about 19 feet apart in the double track spans and 17 feet apart in the single track spans, web-connected to the main girders with gusset plates, which form the end sections of the floorbeam webs and have a height equal to the full depth of the main girders. Both spans are considerably skewed and carry a parallel sidewalk cantilevered out from the main girders on solid web brackets about 7 feet long. The general system of bracing in the double-track span is shown by the plan, elevation and cross-section diagrams of the end panel. In the 103-foot double-track through span the girders have a ⅝-inch web 9 feet 9 inches deep and a maximum flange section composed of two 8x8x¾-inch angles, two 16x¾-inch web plates and six 20x⅝-inch cover plates. There are four lines of rivets in the web connection to the flange and four lines through the cover-plates and horizontal legs of the flange angles.

The ends of the girders are connected by oblique lattice-girder struts riveted to the stringer webs. The ends of the end stringers are supported on riveted pedestals seated on the abutment masonry. The top-chord angles terminate at the rounded corners and the vertical end flange angles are made continuous from the lower flange around the curved corners to a tangent with the top flange angles, thus avoiding the bending of the long angles. The girders are supported on pedestals and pin bearings corresponding with those of the deck

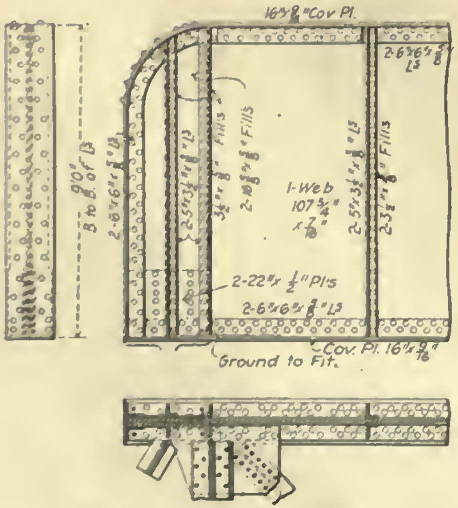


Part Cross-Section of 103-Foot Span

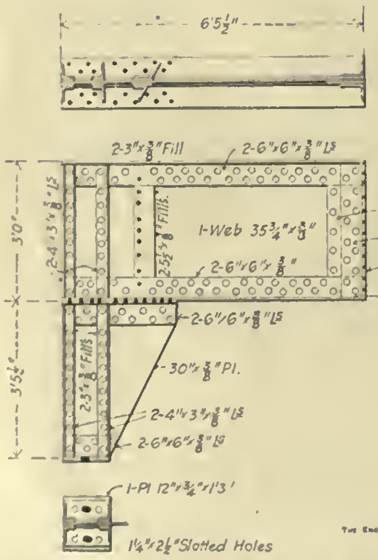
Sidewalk Bracket on one side of Bridge only.



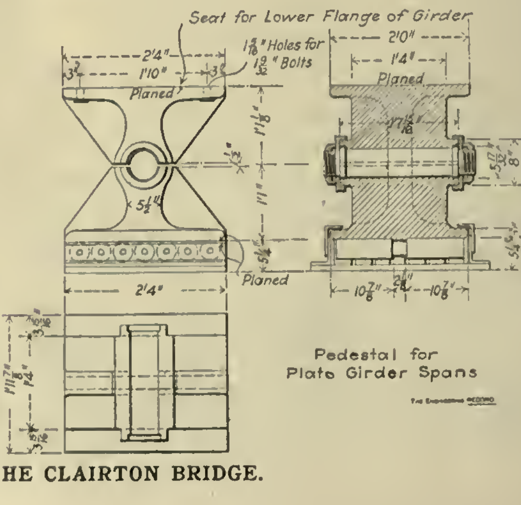
End of Deck Plate Girder Spans 3 and 5.



Details of 87½ Foot-Girder.



End Pedestals and Stringers, 88-Foot Span



Pedestal for Plate Girder Spans

STEELWORK DETAILS OF THE PLATE GIRDER APPROACHES OF THE CLAIRTON BRIDGE.

spans. The connection at each end of each floorbeam has forty-four ⅞-inch field-driven rivets in double shear and each stringer has twenty-six ⅞-inch rivets at each connection. The intermediate stringers have a 41x9/16-inch web and pairs of 6x6x9/16-inch flange angles without cover-plates or web stiffeners. The single-track through span corresponds closely to the double-track span as above described, except in the height of the girders which are only 9 feet, in the cross-sections of their flanges and in the length and depth of their floorbeams.

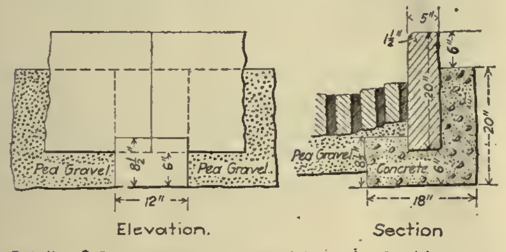
The weight of the 116-foot single-track deck span is 268,000 pounds. The weight of one 103-foot double-track through girder is 118,000 pounds and the weight of the complete span is 415,000 pounds. All girders were shipped whole and separately to the site, where they were run to position on tracks carried by trestle falsework. They were unloaded and set in position on the falsework by an ordinary tower traveler and the lateral bracing and floor systems were assembled and field-riveted by pneumatic hammers.

Mr. J. B. McIntyre was the chief engineer, and the bridge was built and erected by the American Bridge Company.

Details of Street Pavements in Salt Lake City, Utah.

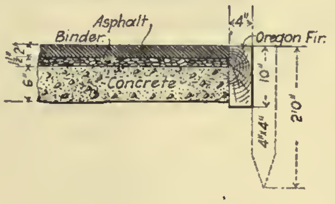
On December 11 of last year the engineering department of the Board of Public Works, of Salt Lake City, Utah, opened bids for grading, curbing and paving First South Street from State Street to Second East Street. From the excellent drawings prepared for this work a number of details have been selected and are reproduced herewith, and a few extracts from the specifications are printed below. First South Street is 132 feet wide between property lines and has two street car tracks in the middle. On each side of the street a space 20 feet wide is reserved for a sidewalk, but the monolithic sidewalk pavement is only 8 feet wide. The roadway, including the gutters, is 92 feet wide.

The curbs at the outer edges of the sidewalk reservation are of Utah sandstone 5 inches thick, not less than 4 feet long; their exposed surfaces are dressed smooth and the upper outer edges are rounded to a radius of 1½ inches. Ends of curbstone are dressed for ¼-inch joints to a depth of 1 foot. As the stones are set the ends are supported by a concrete base at every joint, as shown in the detail. Except at the joints, the curbs rest on screened pea gravel not less than 6 inches deep and are backed with the same kind of gravel for a thickness of 6 inches

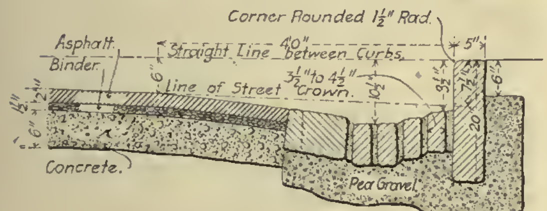


Detail of Concrete Base under Joints in Curbing.

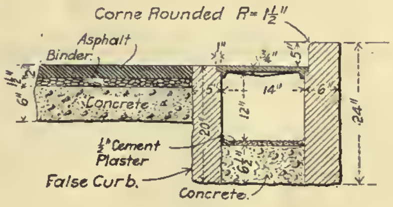
THE ENGINEERING RECORD.



Section on Line C-D.

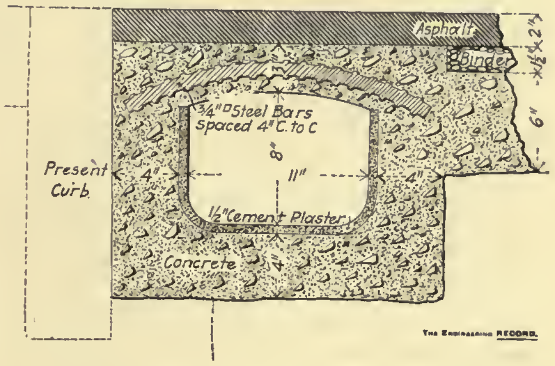


Asphalt.



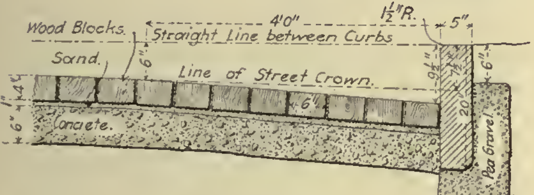
Section on Line E-F.

THE ENGINEERING RECORD.

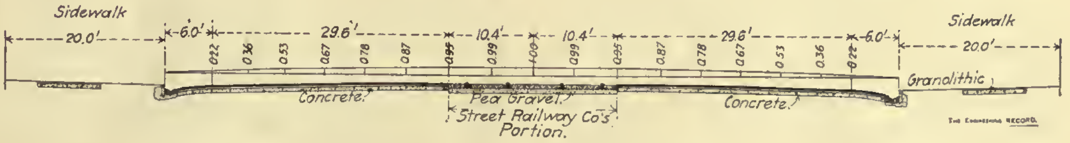


Section of Concrete-Steel Gutter.

THE ENGINEERING RECORD.

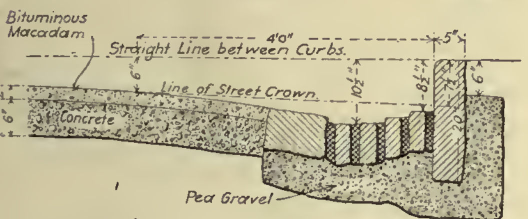


Wood Blocks.



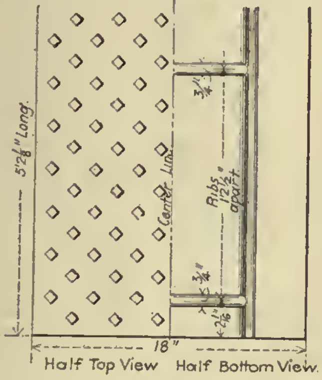
Cross-Section on Line A-B.

THE ENGINEERING RECORD.

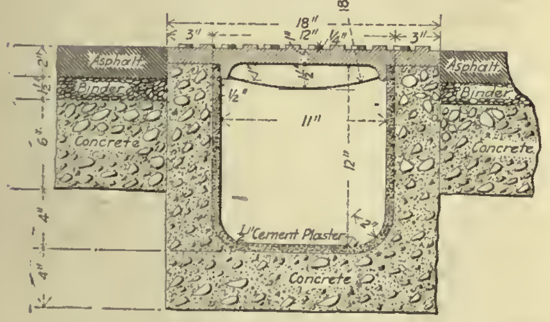


Bituminous Macadam.

THE ENGINEERING RECORD.

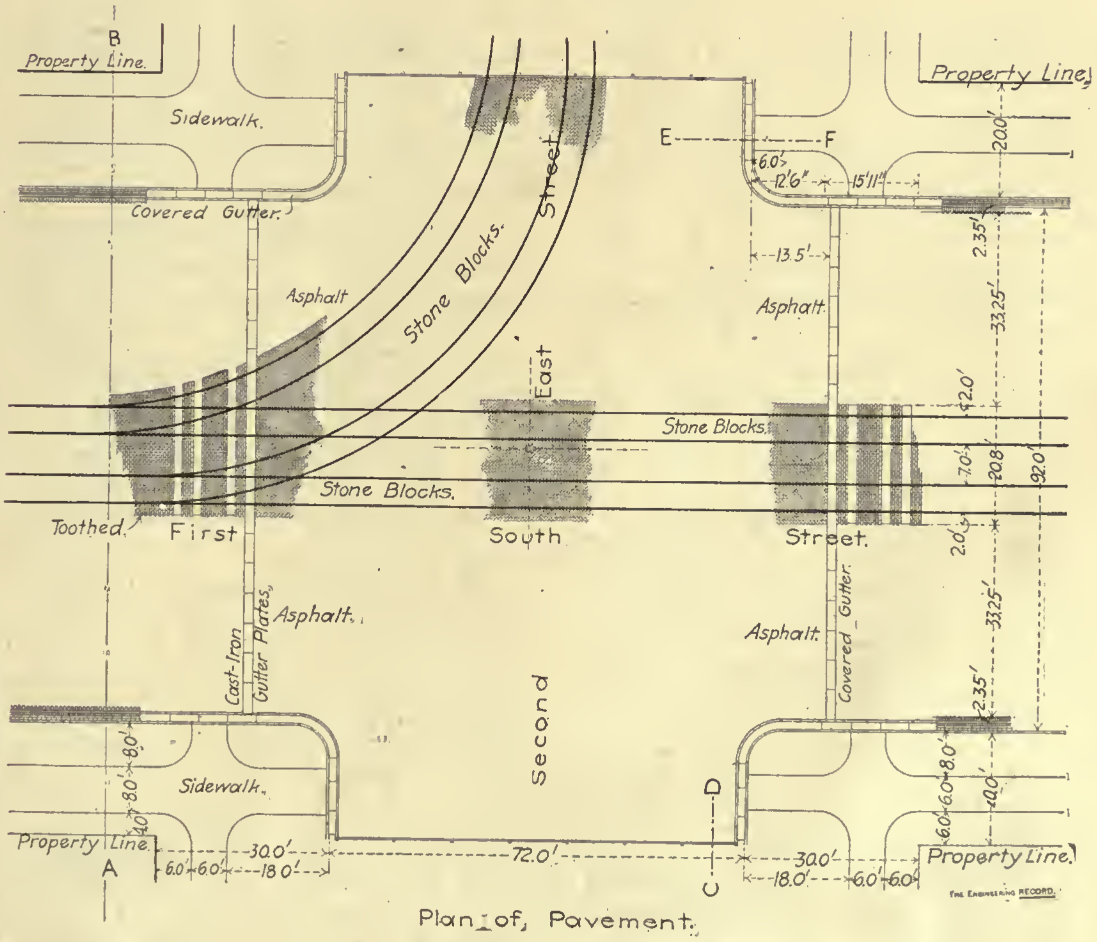


Plan of Cast-Iron Cover.



Section at End of Gutter

THE ENGINEERING RECORD.



Plan of Pavement.

THE ENGINEERING RECORD.

PLAN OF STREET INTERSECTION IN SALT LAKE CITY, WITH STANDARD DETAILS OF PAVEMENTS AND GUTTERS.

to within 6 inches of the top, the gravel being thoroughly tamped.

The spaces between the street-car tracks and a strip 2 feet wide on each side of the tracks are to be paved with stone blocks, the outer edges of the 2-foot strips being toothed in order to bond with the sheet asphalt which is to be laid on the remainder of the roadway surface between curbs, excepting the gutters. The gutters are to be paved with stone blocks arranged as shown in the detail sections, on pea gravel foundations. The drawings also show typical details for gutters to be used with wood-block or bituminous macadam pavements. Around the outer edge of the sidewalk at each of the four corners of a street intersection, as shown in general on the plan and in detail by the section on line E-F, the gutter is formed by setting a false curb 14 inches from the curb and filling the bottom of the space between them with concrete so as to leave a clear waterway about 1 foot deep, which is covered by cast-iron plates 16 inches wide, supported in rebates cut into the curbstones. The bottoms of these covered gutters are finished with ½ inch of 1 to 1 Portland cement plaster. At these corners the sidewalk curb is made 24 inches deep. This construction does away with open gutters at the crosswalks.

The covered gutters at street corners are connected by gutters extending across First South Street at each side of the cross street, as shown on the plan. These gutters are formed in concrete and have a waterway 11 inches wide finished all around with ½ inch of cement plaster, in accordance with one of the detail drawings herewith. They are covered with cast-iron plates 18 inches wide and 1 inch thick having square bosses projecting ¼ inch from the upper surface and reinforcing ribs on the bottom ¾ inch thick, 1½ inches deep at the middle. These covers are set in cement mortar under their edges so as to have a full and even bearing. Beneath railroad and street car tracks it is required that gutters of this class shall have a clear depth of at least 12 inches. The covers for the gutters at the crosswalks are similar, but only ¾ inch thick and have a diamond pattern on the upper surface. In front of the fire department station the gutter is to be of concrete-steel construction, as shown by one of the detail drawings, the top being reinforced with ¾-inch square corrugated steel bars 20 inches long bent to a radius of 18 inches and spaced 4 inches apart on centers.

It is specified that when making the preliminary excavations for grading the street, the plow point shall not penetrate below a line 3 inches above the sub-grade surface; the remaining 3 inches are to be dressed off carefully with picks. Filling, wherever needed, is to be placed and rolled in layers not more than 6 inches thick. It is required that the sub-grade surface is to be brought to an exact parallel with the finished surface by trimming and rolling.

The specifications for stone paving blocks state that all blocks shall be free from lamination, stratifications or other defects; that stones from different quarries or of different colors shall be laid together in different portions of the work. All stone blocks are to be neatly cut with the following dimensions: In length, not more than 10 nor less than 7 inches; in width, not more than 4½ nor less than 3½ inches, and to a uniform depth of 7 inches. The sides and ends shall be dressed so as to make ¾-inch joints the full depth of the blocks. The blocks are to be laid on a foundation of well compacted clean screened pea gravel 6 inches thick, and all longitudinal joints shall be broken by a lap of at least 2 inches. Screened pea gravel is to be swept into the joints after the blocks are laid and rammed, but the upper 3 inches of all joints are subsequently to be cleaned out and filled with 1:2 Portland cement grout. No grouting is allowed, however, when the day or night temperature falls below 35 degrees Fahrenheit. After the joints have been grouted, a ½-inch layer of dry coarse sand is to be spread over the whole surface of the pavement and left for a period to be determined by the engineer.

A 6-inch concrete foundation is required for asphalt and wood-block pavements, and the specifications stipulate that as soon as laid and before the top becomes dry, the entire surface of the concrete foundation shall be covered by 1 inch in depth of clean sand to protect it from the sun and wind. The sand so spread shall be kept moist for a period of 10 days, and the concrete shall be protected against use during that time. No concrete is to be laid when the temperature at any time during the day or night falls below 35 degrees Fahrenheit. The concrete gutters are likewise to be kept moist for 10 days and protected by covers of 2-inch planks. The specifications for the asphalt pavement contain the usual requirements.

The prices bid for paving the portion of First South Street above mentioned were printed in detail in the contracting news columns of The Engineering Record, January 9. Mr. P. J. Moran, of Salt Lake City, was the lowest bidder and was awarded the contract. Mr. Louis C. Kelsey, as city engineer, has charge of the work.

A Concrete-Steel Reservoir for East Orange, New Jersey.

East Orange, situated in the northeastern part of the State of New Jersey, is practically a suburb of New York, being about twelve miles from the metropolis. The community has a population of about 25,000, and uses on the average between 2,500,000 and 3,000,000 gallons of water per day, of which nearly one-half is purchased from the water-works of the city of Newark, the remainder being pumped from the leased works of the Orange Water Company. Desiring to be independent in this respect, the city is constructing water-works of its own. The source of supply which is being developed is a water-bearing deposit of sand and gravel in the valley of the Passaic River, at White Oak Ridge, about two and a half miles northeast of the village of Milburn. Here the city has purchased a tract of about 600 acres and is sinking two groups of wells about 110 feet deep. The water-bearing sand is overlaid by clay and hard pan in such a manner as to exclude any possible sources of pollution. The water, as determined by a large number of test wells, is of excellent quality and abundant in quantity, reaching the wells only after filtering through deep beds of sand. Near one of these groups of wells a pumping station is to be built, which will pump the water from all the wells to a covered reservoir.

The reservoir is to be of concrete-steel construction and is somewhat novel in design. This part of the works was recently put under contract; the details of the bids were printed in the contract news columns of this journal in the issue of March 12. The site of the reservoir is on Orange Mountain, in the town of South Orange, about 200 feet above, and nearly five miles distant from, the pumping station site. A 24-inch cast-iron pipe will connect the station with the reservoir, but only for 4,000 feet will this pipe be a force main, this portion ending at a surge standpipe on the top of the mountain. From the surge standpipe the water will flow by gravity to the reservoir. As the reservoir site is approximately 200 feet above the general level of the city, the water will flow by gravity into the distribution system and will have a pressure at the hydrants of about 80 pounds. All parts of the bottom of the reservoir will be in excavation in a stiff hardpan, the depth of the cut varying from 2 to over 20 feet, owing to the slope of the hillside. The materials excavated will be used for covering the roof of the reservoir, embanking around its walls and terracing the side of the hill down to the adjoining street.

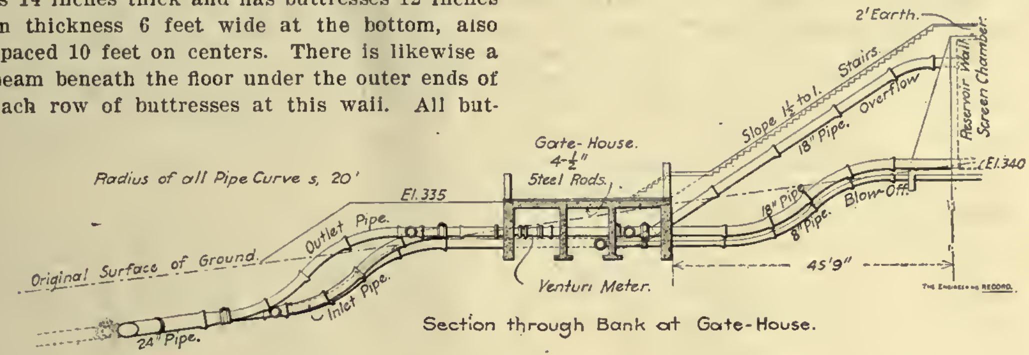
The reservoir will be 139 by 240 feet inside, and with the proposed maximum depth of water of 20 feet will have a capacity of 5,000,000 gallons. The interior height from floor to roof is to be 21 feet 4 inches. A partition wall will divide the reservoir into two equal and nearly square basins, each independent of the other, so that either one may be shut off and emptied without interfering with the other. The novel feature of the design is the use of very thin walls over twenty feet high braced by thin triangular buttresses at intervals of 10 feet. All masonry, except the superstructure of the small gatehouse just below the reservoir, is to be of rich Portland cement concrete made with trap rock broken to 1½-inch size. Sand and trap rock can be obtained near the site. Special pains are to be exercised to make the structure as nearly monolithic as possible and to secure smooth surfaces. The tops of the floor and of the roof are to be floated and troweled to a smooth hard finish.

Expansion joints are to be formed in the exterior and dividing walls of the reservoir at intervals of about 50 feet by inserting a plate of steel ¼ inch thick and 6 inches wide, 21 feet long, covered with two sheets of lead ⅛ inch thick, bent in U shape and fitting tightly to the steel plate. Interruptions in the building of the walls will be permitted only at the expansion joints. The reservoir is to be waterproofed by covering the water sides of the floor and walls with a 1-inch coating of 1:2 Portland cement mortar mixed with a solution of light soft soap in the proportion of 1¼ pounds to 15 gallons of water, and having 3 pounds of powdered alum incorporated with each bag of cement. This mortar is to be deposited in the forms for the concrete as the work progresses. For the reinforcement of the concrete St. Louis corrugated bars will be used. The specifications require a tensile strength for the steel, in test pieces not less than ½ inch square, of 100,000 to 110,000 pounds per square inch and an elastic limit of 50,000 to 60,000 pounds.

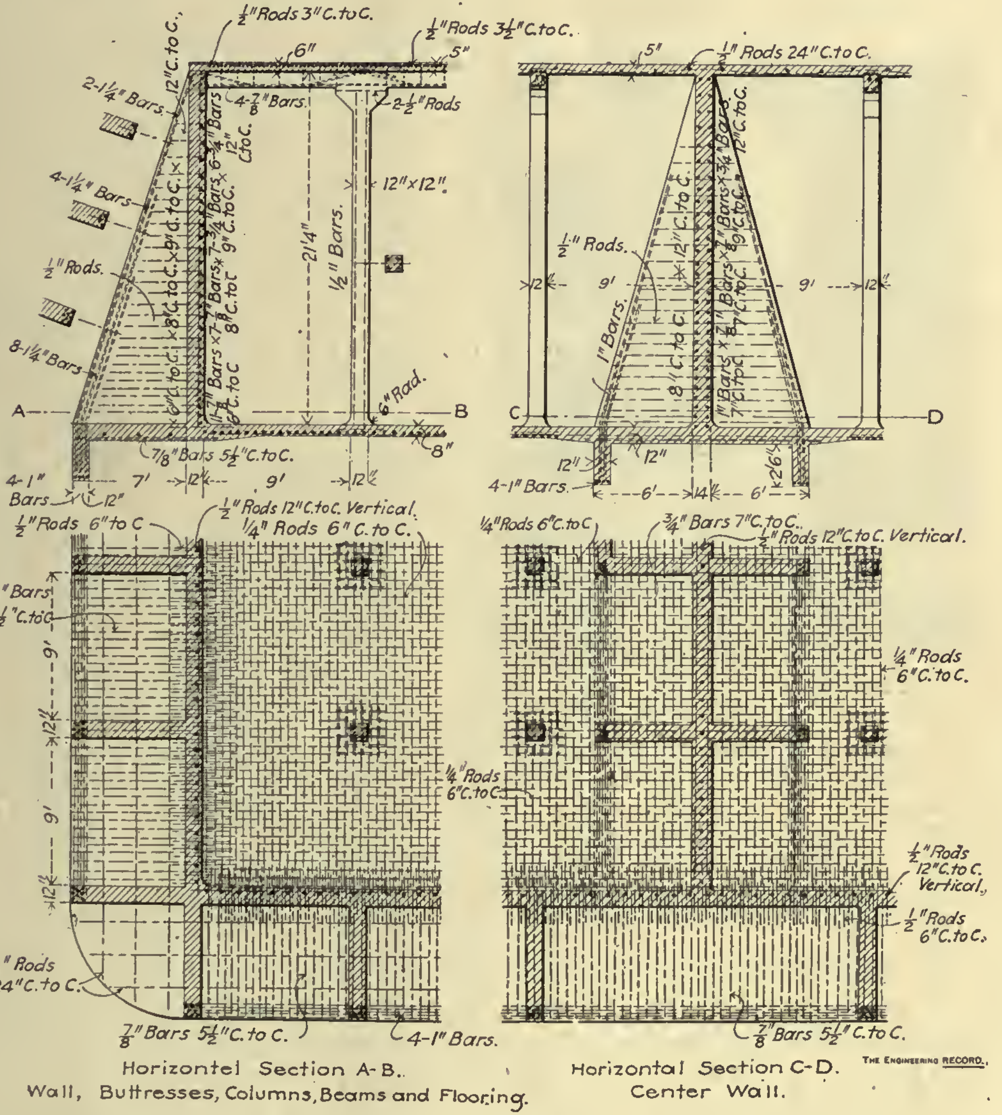
In making the excavation for the reservoir no plowing will be allowed within 6 inches of the sub-grade. The last 6 inches of material are to be removed by pick and shovel, and the bottom so trimmed as to be thoroughly compacted by means of a 10-ton steam roller. The floor concrete will be placed directly on the hardpan as thus prepared. The embankments are to be rolled and tamped, and the lighter surface soil is to be used for dressing the slopes and covering the roof to a depth of 2 feet. The slopes are to be one on one and one-half.

The floor concrete is to be 8 inches thick, excepting under the wall buttresses, where it is to be 12 inches, and will be deposited in one layer, surrounding the reinforcing rods, directly upon the earth, formed in blocks about 10 by 10 feet. The floor is to be extended beyond the walls on all four sides to a width of 7 feet with a thickness of 12 inches as a footing for the wall buttresses, and under the outer edge on each side there will be a beam 12 inches wide and 30 inches deep, formed in a trench cut in the hardpan. These beams will be reinforced by four 1-inch rods placed 1 inch above their bottoms. The floor is to be reinforced for the most part with ¼-inch rods 6 inches center to center in both directions, with additional ½-inch rods 4 feet long, 6 inches on centers under the exterior walls and the columns, as shown.

The exterior walls will have a uniform thickness of 12 inches from top to bottom, with vertical and horizontal steel bars of the sizes and spacing shown, and will be braced by triangular buttresses 12 inches thick and 7 feet wide at the bottom, formed as integral parts of the wall monolith. As shown in an accompanying drawing, the outer edges of the buttresses will be reinforced with steel rods, which will extend downwards so as to tie into the beams under the edges of the floor. The buttresses are to be spaced 10 feet apart on centers and are intended not so much to aid in resisting the pressure of the water from within as to withstand the pressure of the earth from without and to brace the structure. The dividing wall is 14 inches thick and has buttresses 12 inches in thickness 6 feet wide at the bottom, also spaced 10 feet on centers. There is likewise a beam beneath the floor under the outer ends of each row of buttresses at this wall. All buttresses and the floor slabs beneath them are to be reinforced with horizontal rods, as indicated.



Section through Bank at Gate-House.



Horizontel Section A-B.
Wall, Buttresses, Columns, Beams and Flooring.

Horizontal Section C-D.
Center Wall.

Details of Concrete-Steel Covered Reservoir for East Orange, New Jersey.

The roof is to be a flat concrete slab, 6 inches thick for 10 feet from the exterior walls and 5 inches thick over the remaining area, reinforced with ½-inch steel bars spaced 24 inches apart longitudinally and 3½ and 3 inches transversely, in the 5-inch and 6-inch slabs, respectively, embedded 1 inch below the top. It will be supported by the walls and by transverse rows of columns spaced 10 feet apart on centers, carrying girders 12 inches wide and 16 inches deep below the under side of the roof. The columns are 12 inches square and are spaced 10 feet on centers in each row. They bear directly on the floor, being flared slightly at their bottoms in order to increase the bearing area, and at their tops corbelled out to a length of 3 feet under the girders. Each column will be reinforced by four vertical ½-inch bars connected by 3/16-inch tie wires, and over each column there are to be additional reinforcing rods in the roof slab. The girders are to be reinforced with four ⅞-inch bars in each, placed as shown in the illustration, with four additional ⅞-inch rods 5 feet long over the top of each column; there will also be stirrups to resist the shear. The spacing of the girders and columns brings them in line with the buttresses on the long sides of the reservoir.

Three manholes will be placed in each alternate bay of the roof, staggered in adjacent rows, making fifteen in each basin or thirty in all. They will be 30 by 42 inches and will provide means of access, light and ventilation when the reservoir is being cleaned. Their walls will be of concrete built up from the roof slab, and each manhole will have a frame and cover of cast-iron with a secondary sheet steel cover 3 inches below.

At the end of the dividing wall toward the street a 4 by 9-foot screen chamber is to be formed in each basin with 18-inch walls extending from floor to roof. Over these chambers there is to be a 16 by 20-foot concrete platform with granolithic finish, with a 3 by 4-foot opening above the screen groove in the longer wall of each chamber. The openings in the walls for the screens are to be 30 inches wide. The screens will have oak frames and ¼-inch copper netting of No. 10 wire. One screen 9½ feet high will be kept in the lower part of the opening in each chamber and the space above the screen will be filled with a wooden diaphragm.

The gatehouse containing the valves which are to control the pipes to and from the reservoir will be built on a terrace below the reservoir, as indicated on an accompanying section through the embankment showing the vertical arrangement of the pipes. The substructure walls will be of concrete, but those of the superstructure will be of brick with cut stone trimmings. The roof will be of cinder concrete reinforced with 3-inch mesh number 10 expanded metal, supported on a steel frame. The concrete will be covered with terra cotta tiles ⅝ inch thick. The superstructure is to be 22 feet 4 inches by 27 feet 4 inches outside. From the street concrete stairs will lead up the slope to the gatehouse and thence to the platform over the screen chambers.

From the street to the reservoir the pipes are parallel, in plan and in duplicate, one set to each basin. Only one main from the pumping station and one supply main to the city will, however, be completed at present; the other main of each kind will be stopped at a gate valve near the street which passes the reservoir and will be cross-connected to the completed main. The inlet mains cross the basins diagonally to the farther corner of each, while the outlet mains start in the screen chambers. All of these are 18 inches in diameter. The overflow pipe from one basin will extend directly to a brook and the overflow from the other basin will be connected to it by turning so as to run across the gate-chamber, intercepting in the chamber the two 8-inch mud pipes or blow-offs from the basins. The overflow pipes are each 18 inches in diameter. An 18-inch Venturi meter will be installed in the gatehouse in the supply main to the city so as to measure the quantity of water consumed. This meter will be fitted with a register and a chart recorder.

The estimated quantities involved in the construction of the reservoir and its appurtenances are: Excavation, 16,800 cubic yards; puddled embankment, 11,500 cubic yards; Portland cement, 4,310 barrels; concrete, 2,900 cubic yards; steel bars and wire for reinforcing the concrete, 187 tons of 2,000 pounds. Mr. C. C. Vermeule, of New York City, is the engineer in charge of all the work connected with these water-works. Mr. Asher Atkinson has had immediate charge of the preparation of the plans for the reservoir and some other portions of the work. The contract for the reservoir was awarded to the Commonwealth Roofing Company, of Newark, N. J.

A POWER-GAS PLANT at the Embrach Pottery, Switzerland, ran 8,235 hours during 1903, developed 355,233 kilowatt-hours and consumed 1.56 pounds of coal per kilowatt-hour, or 0.99 pound per horse-power-hour, according to the "Schweizerische Bauzeitung." The plant includes three 250-horse-power gas generators and three 100-horse-power gas engines.

Data for Locating Engineers.

One of the most interesting and extensive series of improvements in location which have been undertaken in recent years by American railroads was that inaugurated on the main line of the Union Pacific Railroad in 1898. While a great deal of information has been made public concerning the actual construction, the engineering reasons for it were not fully stated until Mr. J. B. Berry, chief engineer of the company, contributed to a recent "Bulletin" of the American Railway Engineering & Maintenance of Way Association a full explanation of the principles governing the relocation. As the paper is sold by the Association, no attempt will be made to give an abstract of it, but it is nevertheless believed that the following data for the field use of locating engineers will prove of interest to many readers of The Engineering Record, who will not care to send for the full paper.

For general purposes the tractive power of a locomotive can be considered at 20 per cent. of the weight on the drivers at a velocity of 10 to 12 miles per hour, although with fair weather conditions a well-designed locomotive should develop a tractive power of 22½ per cent. of the weight on the drivers at 10 miles per hour.

Assuming 6 pounds per ton for velocity and frictional resistances as a fair average for slow and fast freights, with the grade resistance 20 times the rate per cent. of grade, the tons weight of train, including engine and tender, will be: Tractive power $\div$ (6 + 20G), where G is the per cent. of grade. In using this formula for estimating the number of trains necessary to handle the tonnage, the weight of freight may be considered as 50 per cent. of the weight of the train exclusive of the locomotive.

A reduction of gradient on an engine district 100 miles long so as to require one less daily train in each direction will result in a saving of $37,200 per annum. For other lengths of district or a greater reduction in the required number of trains, the saving in operating expenses per annum will be in direct proportion to this.

Any reduction in the length of helper grades or other change that will eliminate one helper engine of the same size as the standard road engine, will result in a saving of $14,600 per annum, provided the helper engines average 100 miles per day. For other average daily mileages of the helper, the saving can be estimated as directly proportional to this.

A saving in distance will result in the following savings per annum per daily train one way: 1, Distances so short as not to affect the wages of engine or train men, 2.6 cents per foot, or $137 per mile. 2, Distances affecting train wages but not affecting the number of side tracks required, 3.7 cents per foot or $196 per mile. 3, Distances so great as to affect the number of side tracks required, 4.8 cents per foot or $252 per mile.

The elimination of one degree of curvature will result in a saving per annum per daily train one way of 23 cents per degree for uncompensated curvature and 19 1/3 cents for compensated curvature.

The elimination of one foot rise and fall will result in a saving per annum per daily train one way as follows: Where grades are such as to require shutting off steam in descending, but not to require the application of brakes; $0.55 per foot on minor grades and $0.96 per foot on ruling grades. Where grades are so heavy as to require the application of brakes, $1.15 per foot on minor grades and $1.57 per foot on ruling grades.

In Mr. Berry's opinion these values are sufficiently close for the use of the locating engineer in comparing the various lines, although a final and more careful comparison is to be made in the office of the chief engineer.

A Test of Wire Glass at Baltimore.

The importance of wire glass as a fire-resisting material was pointed out in this journal a number of years ago, when it was first brought out commercially. A good proof of its usefulness for this purpose was furnished by many windows which passed through the fire at Baltimore with comparatively little damage. Among the buildings glazed in this manner may be mentioned the transformer house of the United Electric Light & Power Company. An important factor in its escape from the heavy injury and destruction of other structures in its vicinity in the burned district was the resistance offered to exterior flames by the wire glass windows of its front, which were in the path of the fire and parallel to it. They were thus not exposed to the impact of the flames although they received the full heat effect from a burning building on the opposite side of a narrow street. The side walls of the structure, which were across the path of the fire, were of solid brickwork without any openings.

The accompanying photograph shows the present condition of the front of the building. It will be noticed that the wire glass with its metal sash and frames occupies a very large part of the surface. Some of the windows were broken by falling walls, and there are small holes in the glass of other windows, caused by the intense heat. The building escaped practically uninjured and served as a shield for the low brick building adjacent to it on the leeward side, as shown in the engraving.

Wire Glass in Transformer House, Baltimore.

The Test of a Refrigerating Plant was reported last year in the "Zeitschrift" of the Society of German Engineers by Mr. E. Brauer. A brewery installation having 175-horse-power in compressors, 918 ice tanks of 28.6 pounds capacity each and cooling surface in the refrigerator and condenser amounting to 2,153 square feet was tested. The cooling effect was measured by passing hot water through pipes in the brine, and the gross performance, that is, the hourly amount of heat represented by the heat abstracted in this way together with the equivalent represented by the lowering of temperature of the generator contents and the heat radiated into the refrigerator, was 14,657 British thermal units per indicated horse-power-hour.

The Cost of Generating Electric Power.

At a meeting of the Cleveland, England, Institution of Engineers, held February 22, a paper was read by Mr. E. J. Fox on the cost of generating electric power. The total unit costs of power production of the British plants which serve largely as the source of his information are not in themselves of primary interest in this country, but as showing the relative difference between generating costs in the plants of public service corporations and in those of private industrial establishments they will prove quite instructive. Not the least interesting of his observations, however, deal with the effect of different classes of auxiliary apparatus in a power plant and with the effect of different degrees of refinement to secure economy in production. These are given more or less fully in the succeeding review, and, it should be added, refer only to stations employing reciprocating steam engines.

Throughout the paper reference is made to the important bearing that the power factor has on the economy. The auxiliary plant requires, in the words of the author, an amount of power that is largely constant, regardless of the load, and is liable, if the plant is frequently worked at light loads, to cost more than the savings which it introduces. In the case of the Salford station he states that the auxiliary plant absorbed between 6.5 and 8.3 per cent. of the total electrical output generated, depending on the state of the load factor. Of this lower figure the motor-driven air pump is responsible for 4.67 per cent., the motor-driven boiler feed pump for 1.18 per cent., the remainder being divided between the mechanical stokers, ash conveyors, economizer scrapers, coal elevators and workshops. It appears that the station operates with a low load factor. The electrically-driven auxiliaries in the case of Crompton's Works at Chelmsford, when taken over a period of six months' working, amounted to 3½ per cent. only of the total units generated, showing how great is the saving in running the auxiliary plant with an improvement in the load factor, as existed in this case. This figure, he says, has not been obtained without being carefully watched, and without improvements being introduced from time to time, leaving us with the moral that attention should be paid to these points.

With regard to boiler-feed pumps, the author refers to the performance of a 4,000-gallon motor-driven pump in use at the Salford plant. When 8,971 gallons were delivered, 27.6 kilowatt-hours were absorbed by the unit and when 15,822 gallons were pumped, 36 kilowatt-hours were absorbed. Assuming each electrical unit as requiring 30 pounds of steam to generate it, which, the author says, is more than 25 per cent. above the full-load consumption of the steam engines installed, it will be found that 108 and 147 pounds of water were delivered per pound of steam used in the two conditions of load cited. This performance was realized, the author points out, in spite of the fact that the pump is worm-geared with a full load efficiency of only 60.67 per cent. It absorbs 1.18 per cent. of the total station output.

As to the duty of steam pumps, he gives 77, 79, 81.5 and 84 as the number of pounds of water delivered per pound of steam corresponding to deliveries of 1,000, 2,000, 4,000 and 6,000 gallons respectively. These figures were taken from a paper read some time ago before the Institute of Electrical Engineers, and in discussion on it, some further comparisons were made and these are quoted by the author. The duties, in pounds pumped per pound of steam, are given for full, three-quarter, one-half and one-quarter loads in order. For the standard steam pump they are stated to be 86, 85, 84 and 80; for an old pump, 58, 56, 49 and 36; for an electrically-driven, 164, 123, 82 and 41; for an electric variable-stroke, 164, 163, 152 and 129. These figures indicate among other things that the efficiencies for the electrically-driven outfit depend greatly on the proportion of load and point to the desirability of a careful subdivision of plant where ordinary motor-driven pumps are used. In this connection, however, it must be remembered, the author intimates, that as the motor-driven pump costs about three times as much as the steam pump, the interest and depreciation on the extra capital expenditure must be debited to the saving in the coal bill.

With regard to the value of superheated steam, he gives the results of a trial of a 400-horse-power Willans engine which had been at work in a Lancashire cotton mill for eight years. A superheater was introduced into the downtake of the boiler. The amount of superheat obtained in the engine was not definitely known, but, as far as can be ascertained was somewhere between 50 and 100 degrees Fahrenheit. The length of steam pipe between the boiler and engine was 120 feet and it was found that before the superheat was employed 18 per cent. of moisture was present in the steam at the engine stop-valve. The comparative figures obtained from the test are as follows: The water per indicated horse-power per hour was 13.7 pounds, using the superheater; 16.08 pounds with the saturated steam; showing a gain in favor of the superheater of 2.38 pounds, or 14.8 per cent. The coal per indicated horse-power per hour was 1.76 pounds with the superheater and 1.89 pounds with the saturated steam, showing a gain in favor of the superheater of 0.13 pound, or 6.88 per cent. These figures are interesting as showing the difference between the saving on the basis of the water rate and on the basis of the coal consumption.

The high-speed steam engine in power-plant work has an advocate in the author of the paper. He says that the piston speed is less in most high-speed engines than it is in slow-speed engines, and that for fifteen years' running, comprising the period over which he was able to obtain reliable figures, the results of eight of the older stations in England show that the repairs were as small during the later years as they were during the first years.

Condensing versus non-condensing is then considered by the author. At Salford, the jet condensers absorb 4.6 per cent. of the total power generated; while at Southport, the power required for circulating water for the ejector condensers during a three hours' trial came out at 5.8 per cent. of the power of the engine, and 7.26 per cent. of the total units generated, when taken over an evening's working. At Crewe, the power absorbed for circulating water for ejector condensers has come out at 6.3 per cent. of the total units generated, when taken over a period of twelve months' working. He does not wish to imply that condensing has not paid in these three cases, but mentions the figures as representative of the cost of condensing in stations with a comparatively poor load factor. He thinks every plant that aims at obtaining low running costs should make a point of recording the amount of power expended in condensing for different periods of the day, when it may be found that while condensing pays during certain periods of the twenty-four hours, it may be cheaper to run non-condensing during other periods. In Nottingham 6,000 kilowatts of plant has been installed, all running non-condensing, and the costs, he feels, compare favorably with many stations which are running condensing, as shown in an accompanying table.

In one table herewith are given the results obtained during 1902 by twelve towns which have achieved the lowest working costs per unit sold, the capital charges being omitted. In another is set forth the working costs in a few private power stations with a large output per unit of plant installed. In discussion of the tables he points out that the actual size of the plant has little to do with the cost of production. Other things being equal, a station with a large output, he feels, has no doubt a better chance than a station with a small one, but a good deal more depends upon the conditions of working and the nature of the load than upon the actual kilowatt of plant installed. As an instance of this, he refers to Messrs. Kynoch's works in Birmingham, where the working costs in these works amount to 0.68 cent. per kilowatt-hour when they run during the day time only, generating 18,400 kilowatt-hours per week, whereas when they increase their output to 22,400 kilowatt-hours per week, and maintain a supply during the night time, their costs come up to 0.83 cent. Most public lighting and traction stations, such as are enumerated in Table D, have bad load factors, by which is meant the yearly output of the station in comparison with what this output would be if the maximum demand were maintained continually during the whole year, instead of over a few hours per day, and then often during the winter months only, a state of affairs prevailing in many stations. As this load factor is rather a difficult figure to arrive at in the case of private power plants, he has substituted in its place a figure which represents units generated per year per kilowatt of plant installed. If the figure is too low, it is obvious either that a liberal amount of spare plant is being carried, or that the number of working hours are small. In Table D the maximum yearly output per kilowatt of plant installed in public stations is 1,900, whereas the average is well under 1,000. Corresponding figures in private works are about 5,500, and the average about 4,000. This gives private power plants a considerable advantage in their capital charges per unit sold, as well as advantages in wages, repairs and maintenance, which involve practically the same cost, whether the plant is working fully loaded or not.

Table D.

Town.	Kw. installed.	Kw.-hrs. sold per an. per Kw. inst'd.	Load factor, per cent.	Costs per Kw.-hr. in cents. Coal.	Oil, water etc.	Wages.	Repairs.	Works costs.
Bradford..	6,380	1430	20.93	0.52	0.1	0.16	0.26	1.04
Leeds....	8,740	508	12.31	.56	.06	.34	.28	1.24
St. Helen's	1,340	920	17.84	.52	.06	.34	.38	1.3
Edinburgh	10,477	742	14.75	.68	.08	.18	.36	1.3
Bolton ...	3,700	1028	18.87	.70	.12	.3	.2	1.32
Bootle ...	850	1906	28.44	.82	.06	.3	.22	1.4
Liverpool.	21,190	1094	25.11	.74	.12	.3	.26	1.42
So. Shields	1,600	716	15.82	.74	.08	.4	.3	1.52
Nott'gham	5,642	727	12.97	.92	.2	.32	.18	1.62
Preston...	1,920	550	13.31	.72	.12	.36	.46	1.66
Farnworth.	610	730	14.54	.92	.2	.36	.22	1.7
Leith.....	990	925	19.79	1.10	.08	.42	.18	1.78

Table E.

	Kw.-hrs. per yr. per Kw. installed.	Pound coal per Kw.-hr.	—Costs per Kw.-hr. in cents.— Coal.	Oil, water, etc.	Wages.	Repairs.	Works costs.
Watson, Linwood	5400	3.25	0.276	0.022	0.022	0.036	0.37
Watson, Linwood	5400	3	.306	.024	.042	.042	.414
Watson, Linwood	5400	4	.342	.032	.054	.054	.484
Watson, Linwood	5400	3.1	.262	.028	.046	.046	.382
Dorman, Long & Co., 1903.	5037	2.8	...	...	...	...	...
Dorman, Long & Co., 1902.	5050	3.04	.358	.038	.17	.06	.626
Kynoch, day load	1240	5.5	.38	.09	.13	.086	.686
Kynoch, day and night...	1490	7.0	.486	.1	.15	.09	.826
City & South London Ry.	2817	4.16	.614	.074	.128	.076	.892
Crompton & Co., Chelmsford	2820	4.25	.86	.036	.218	.044	1.158
Vickers, Sheffield, South.	2000	...	.51	.064	.202	.162	.938
Vickers, Sheffield, North.	3280	...	.626	.126	.204	.202	1.158

In Table D the cost of fuel is the highest item making up the works costs in public power stations. This figure, however, is the cost of fuel per unit sold, and includes all distribution losses, consequently it is necessarily somewhat higher than the figure corresponding with the cost of fuel in private power plants. By keeping the plant at work more hours per day and loaded more fully to its economical capacity, a set of conditions impossible in public stations, this item for fuel can undoubtedly be considerably lowered. From Table E it will be noted that several plants are producing a kilowatt on the switchboard for an expenditure 3 to 4½ pounds of coal, including the steam used in the auxiliary plant.

The wages of workmen may vary between 0.05 and 2 cents per unit, depending almost entirely upon the output obtainable. Public stations are handicapped in two ways. The costs include labor outside the engine-house, such as looking after mains, and a public power station, being isolated, must have labor sufficient for dealing with an emergency, whereas a private works need only have sufficient labor for keeping the plant in good condition, and in the event of a breakdown, or one of the staff being indisposed, there is usually little difficulty in drawing from another department.

The Pumping Machinery for the new dock at Chatham, England, was described recently in "Engineering." There are two sets of main pumps, each set in a separate excavated shaft. The pumps are of the vertical centrifugal type, with 8-foot horizontal impellers, each driven by a horizontal compound condensing engine. These have 16 and 32-inch cylinders with a 24-inch stroke, but the high and low pressure parts of the engine are placed at right angles to each other in a horizontal plane, both working on the same crank which rotates about a vertical shaft. The pumps are capable of emptying the dock in 4 hours, the maximum quantity of water discharged in this time being 66,000 tons against a head of 38.5 feet, with a pump speed of 122 revolutions per minute. Two sets of drainage pumps are used for keeping the dock clear of leakage water, and these consist in each case of three single-acting lift pumps, with diameters of 22 inches and a 48-inch stroke. Each set of three pumps is driven by a compound vertical engine, with 14 and 24-inch cylinders and 16-inch stroke. These pumps are in separate shafts, and three long connecting rods extend from each set vertically upward to cranks in the pumping station, and the horizontal crank shaft is driven by its corresponding engine through heavy spur gears. The drainage pumps have a capacity of lifting 1,500 tons of water per hour at a lift of 53 feet 9 inches. All the steam machinery is operated condensing. The pumping and auxiliary machinery is located in a building above the shafts, 65x67 feet in inside dimensions, with boiler room adjoining. The condensers, of which there are two, are of the surface type, each designed to handle 30,000 pounds of steam per hour. There are 3,000 square feet of surface in each condenser and the air pumps are of the twin type, with water ends 16 inches in diameter by 8 inches stroke, directly driven by compound steam cylinders 9 and 14 inches in diameter by 8 inches stroke. The circulating pump is of the centrifugal type, 10 inches in diameter, driven by a 7x6-inch steam engine. The plant was designed and constructed by Messrs. W. H. Allen, Son & Company, Ltd., of Bedford.

Cylindrical Movable Dams at Schweinfurt, Germany.

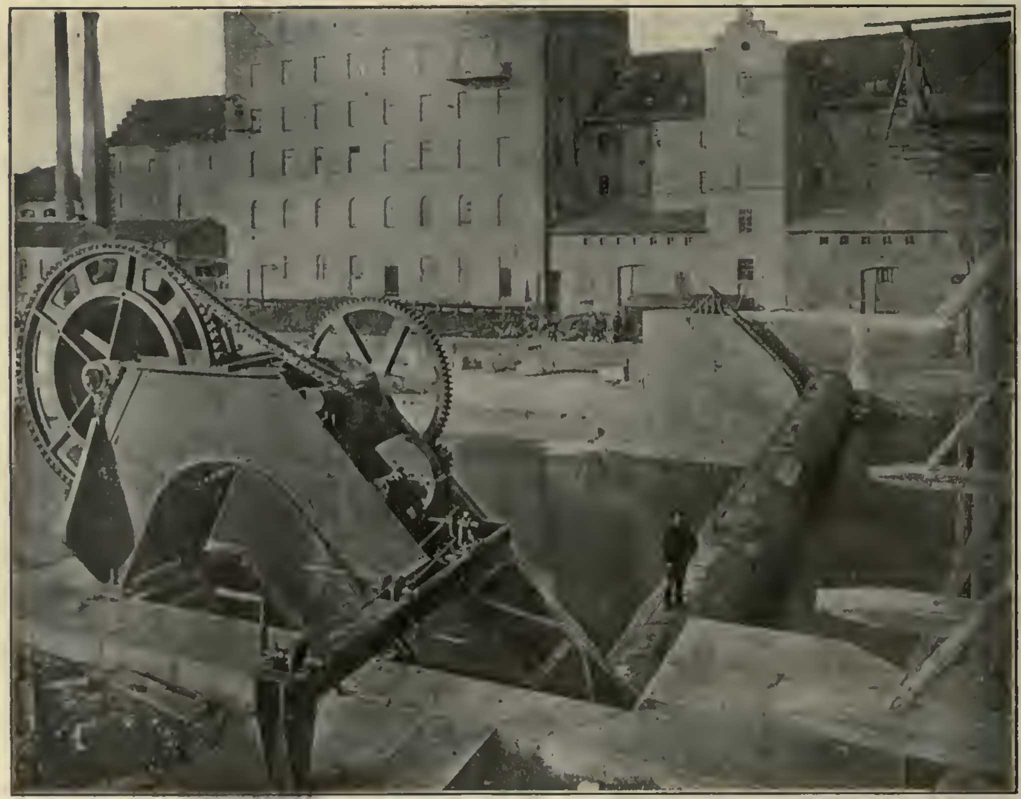
Two hollow cylinder dams, one of which is the subject of the accompanying engraving, have been constructed at Schweinfurt, Germany, across the River Main. They were built partly to render the stream above them navigable and partly to divert the water for power utilization. As the river is one subject to heavy floods, a type of dam that could provide for the rapid discharge of the freshet water had to be designed, and the cylindrical form, arranged to roll upward above the flood level, was adopted. To demonstrate fully its practicability, the first was constructed across a secondary branch of the river at Schweinfurt, with a total length of 59 feet and a diameter of 13.58 feet. The satisfactory operation of this led to the construction, across the main branch, of the dam shown in the engraving. This is 115 feet long and 6.56 feet in diameter. Briefly, it is a hollow cylinder of sheet steel, on each end of which is fixed a toothed wheel which meshes into an inclined rack built in each abutment.

The dams were erected under the authority of the Direction royale des Routes et Voies navigables by the Vereinigte Maschinenfabrik Augsburg-Nuernberg. The first dam was arranged to be hauled upward from its lowest position by cables on each end, while in the longer dam, as indicated in the view, the driving mechanism is all located at one end. When the downstream level of the water rises, the pressure would have a tendency to lift the gate. While the cylinder itself is watertight, to prevent the freezing of water which might otherwise collect in it, an interior pipe is provided in the smaller dam open at each end of the dam, but shielded by its interior location from the cold. This pipe is filled with water to secure greater stability by the weight of the water. The toothed racks in this case are placed at an angle of 45 degrees. The cylinder, in its lowest position, rests on a sill of oak and the tightness of the dam at each end is provided for by a band of leather around the periphery, the pressure of the water acting to hold the leather against the masonry. There is a stairway in each abutment giving access to the racks. The weight of the movable cylinder of the first dam was 158,400 pounds. To bring it above the level of the highest flood it is necessary to raise it a distance of 16.4 feet. It is arranged for hand working, with six men on each side. In "Genie Civil," from which this account is taken, an interesting calculation of the time necessary to lift it is made. Giving each man the capacity for work of 57.75 foot-pounds per second (8 kilogrammeters), and allowing for an efficiency of 35 per cent. in the hoisting mechanism, the time required to lift the cylinder the given distance is determined as follows, remembering that twelve men are engaged all told: $158,400 \times 16.4 \div (57.75 \times 12 \times 0.35) = 10,710$ (seconds), or 3 hours.

To lift the cylinder above ordinary freshets, only about half this time is consumed. Since January, 1902, when the work was completed, the operation of the dam has not, it is stated, given any trouble.

The larger dam was begun in May, 1903, and was put in service in December. While it has a rollway length of 114.8 feet, its actual length is 121.3 feet, 3.28 feet of each end extending into the masonry of the abutment. The steel is 1.1 inches thick, and constructed in sections 9.84 feet long with a single longitudinal joint. The transverse joints are butt joints and each section is reinforced in the middle by a brace contributing to its rigidity. This cylinder is watertight except in two chambers in the upper part at each extremity. When the downstream water level does not rise more than 3 feet or so above the bottom of the dam the weight of the cylinder is sufficient to counterbalance the pressure. When, on the contrary, the water level rises above this limit, the water enters the two chambers, giving the cylinder added stability. The racks in the case of this dam are at an angle of 45 degrees only along the upper part. Toward the bottom the pitch is increased, attaining 4 to 1. This increase in pitch is made on a radius of 10.46 feet. The steepness of the bottom part of these racks gives the dam better bearing against water pressure tending to raise it. The weight of the cylinder is 193,600 pounds.

The operating apparatus includes two steel cables of 1.8 inches diameter, each formed of six strands. Each cable has a useful section of 1.3 square inches and is designed to withstand a stress of 154 tons. One cable is calculated equal to three times the maximum effort to lift the dam, so that by the use of two cables there is a factor of safety of 6. The two cables are rolled on drums, and to raise the cylinder above high water, that is to say 13.12 feet, an electric motor of 18 horse-power is employed, and the operation takes less than a quarter of an hour. The mechanism possesses, however, four cranks which allow for lifting the dam by hand. As is shown, the cranks drive a worm gearing through chains, and this, in turn, is meshed by a train of gears and a chain to the hoisting drums. The watertightness at each end of this dam is provided for by hemp fixed to the masonry on each side.



Barrel Dam across River Main, Schweinfurt, Germany.

Pulverized Coal for combustion under steam boilers was the subject of a paper read at a recent meeting of the Western Society of Engineers, Chicago, by Mr. John M. Sweeney. According to the results of comparative trials cited by him, 9.4 pounds of water, equivalent evaporation from and at 212 degrees Fahr., were realized per pound of fuel with the pulverized coal and 7.5 pounds per pound of fuel with hand firing. On the basis of combustible the equivalent evaporation in the two cases was 10.47 and 8.4 pounds, respectively.

Reminiscences of Early Railway Location in the West.

The experiences of the men who located the railways across the Western plains are difficult to appreciate at the present time. Their pioneer work was followed so rapidly by the growth of villages and the reduction of this vast territory to a law-abiding condition that it is hardly conceivable the change has been so speedy. It is interesting to read of the work of these pioneers, and for this reason attention is called to the following considerably condensed report of an address recently made before the Montana Society of Engineers by Mr. George T. Wickes, the retiring president, who took an active part in running the line from Kansas City to Denver during the Civil War.

My earliest far Western experience commenced at Wyandott, now Kansas City, Kansas, in the year 1862-63. Kansas City, it now seems to me, could not then have had a total population over 3,500—Wyandott, not half that. Leavenworth was then the metropolis of the "border," from which the freight teams in large trains, loaded for the West and New Mexico, were sent. Leavenworth could not have had a population of over 5,000. Kansas City had evidently seen better days, judging from the then vacant warehouses on the bank of the Missouri River.

Beyond Wyandott, west 40 miles, was a small settlement called Lawrence; then a few miles farther was a still smaller congregation of stone houses at Topeka; then came Fort Riley; adjoining this was the true "border," 125 miles west from the Missouri River. Beyond Fort Riley, then the farthest western United States Government military post, was a vast rolling plain, 500 miles wide, before reaching the Rocky Mountains, in my recollection, with not a tree in the whole district.

This country, though, was covered with a thick matting of buffalo grass, a surprising thing, for it grew from a hard baked surface soil, something like a concrete pavement of today; from this hard surface would be emitted a rumbling noise like the roll of distant thunder when herds of buffalo were stampeded over it.

At the time of my arrival in Wyandott there were two projected lines for Pacific railroads, both subsidized by the Government; one was planned to go west upon the Platt River Valley, starting at Omaha; the franchise for this was then held by Mr. Durant, of New York. The other was to leave the Missouri River at Kansas City, or Wyandott, going west through Kansas. This franchise was originally held by John C. Fremont, afterwards transferred by him to Mr. Samuel Hallett, a New York Wall street broker. Mr. Hallett at that time had rails laid on about ten miles of road west from Wyandott.

This was during the Civil War. Men were very difficult to secure to prosecute the work, so that progress, at the start, was very slow; and, I am quite sure, that money for building a road across what was then considered a desert, was also very hard to obtain. It was a scheme that seemed to most people at the East, of the wildest nature, and most likely never to be accomplished.

Mr. Hallett built perhaps 15 or 20 miles when some trouble arose between him and one of the engineers in regard to a report he wished the engineer to make. This report was thought by the engineer to be a misstatement of facts; this led to the abuse of the engineer by Mr. Hallett, and finally to Mr. Hallett's being shot by the engineer, and almost instantly killed. To give an idea of the times, this created but little excitement, and in a few days was apparently forgotten. The engineer afterward gave himself up, stood his trial, and was acquitted.

Before his death, Hallett had interested John D. Perry, and with him Adolphus Meyer, Carlus S. Greeley, Thomas L. Price and Mr. Archer, with some others of St. Louis, in his enterprise. After his death, Mr. Perry sent Mr. Bartholow to Wyandott, who for a time had charge of the railroad construction.

Under the latter, having been a rodman for Mr. Hallett, I was continued as such on the line between Wyandott and Lawrence; of the exact time a more responsible position was given me I do not remember, but do recall locating the line from Leavenworth to Lawrence, then, beginning near Topeka, and carrying the preliminary surveys through to the mountains, and after, the final location of a portion.

Until the road was completed to the neighborhood of Topeka, work progressed very slowly; then the St. Louis men interested parties in Cincinnati, under the leadership of R. M. Schoemaker, of that place, and a unique company was formed, something on this fashion: They divided themselves into two parties; one was the president and directors, the other were the builders, under R. M. Schoemaker as chief engineer and manager. This arrangement worked out very satisfactorily to all concerned. Contracting with themselves was an admirable scheme, and the work was rushed vigorously. I will not trifle with you by saying our orders were to avoid going through any ant hills; but we were to avoid any others if we could get around them. This, though, before 20 or even 9 degree curves were considered practicable. Long tangents, though, were not in it; miles of road was what was wanted. The country was such that we could get a good alignment, on easy grades, and very light work.

The Government subsidy of $16,000 per mile, the land grant, and then the privileges of issuing other securities in the way of bonds and stock, made probably a rich harvest for those interested.

The grading, tie-making and other kindred work was done by men brought from Canada. The men suited for such service in our own country were in the army. These importations were sent out on the line with guns as well as shovels and picks. If a party of a half dozen or more Indians made a dash toward them, I have known 75 or 100 graders to fling down their guns with their shovels and picks and rush pell-mell for their adobe houses. Drawing guns to stop them was no use. The Indians in the start, I think, before they realized what they were up to, would make these dashes for the fun of seeing these fellows run, and a possible scalp; they would turn very quickly if a very few subcontractors or engineers started after them on horseback. Such chases were apt to be exciting, particularly if one of the pursuers got separated from his friends unaware. The Indians would quickly see this, and would then circle around in a gulch to corral this lone individual; then he would have to lay down on his horse and stick the spurs in—good horses were important at such a time.

The general course of the survey was that of the Smoky Hill River. Divides had to be followed to avoid the deep canyons washed out through the great depth of easily washed surface. The immediate surface crust was hard and would shed water like a roof, but when this water began to gather together into channels, with ever increasing numbers of streams added, they would become mighty floods that would tear down these gulches as if they would cut through to the under side of everything. There were great areas for these floods to gather in; now, with the land cultivated, so that rain may be absorbed, such floods are probably rare.

Following the high lands with the road, for a long time, getting water was a serious problem; at first the low places were selected in which to dig wells, but they were without success. Afterward, wells were tried at or near the divide, and water was found at reasonable depth. We followed these uplands until some of the headwaters of the Arkansas and Platt rivers were reached, and then, following down the Platt branches, to Denver.

Our outfits for these surveys had to be very complete, having to provide for necessaries that would cover our wants for six months' absence from sources of supply. Our teams, wagons and tents were obtained from the Government, paid for by the railroad company. I had an order from Government Headquarters at Washington that any requisition I might make upon any post for supplies, in case of necessity, should be honored.

We absolutely lived upon buffalo meat; it was almost bread and meat. To be sure, we had quick-made bread, but that did not count. My recollection goes back to the perfect satisfaction of sitting down on the ground with a stack, a tin plate heaped with nicely fried hump or tenderloin before me, which was none too much to satisfy the appetite, with a quart or two of coffee sweetened with brown sugar.

This was before the tin can age. We once tried what the men called "desecrated vegetables." This was a desecated, dried-up, apparently hydraulic pressed mass of old cabbage, mostly, and, it seemed like, any other old thing mixed. But it had one quality that surpasses belief, in the way it would swell when put to soak. I think one cake would expand to the bulk of a fair horse feed. It was, when cooked, about as good as eating toothpicks, so we gave it up. Our regular meals were at daylight in the morning, and just before dark at night. We carried jerked buffalo meat in our pockets which we ate, when inclined, during the day, while walking or riding.

This "jerked" buffalo meat is worthy of especial note. All of ours was made from the "hump" and "tenderloin" of the bull; it was cut into strips about 1¼ inches thick, about three inches wide, and say about a foot long; then it was threaded upon small rope, which was wound around our wagons, bodies and bows; sometimes a wagon would be literally covered with such a fringe. At first a thin but very strong cuticle would form, which would strengthen and thicken in time to say about the thickness of blotting paper. Cutting a piece of this meat to eat, cross the grain, the inside, unless it was very old, would be found soft, with none of its flavor gone. Even if very old, when properly prepared, it was the delicious meat it was before it had gone through this process of curing.

Instructions for Operating Hot-Blast Heating Systems.

It is unusual to find formal lists of instructions covering the operation and care of the hot-blast heating systems now common in modern school buildings. In East St. Louis, however, directions of this character, have been prepared for the plants of the Webster and Franklin schools. To indicate the scope of the directions, which were written by the consulting engineer, Mr. William H. Bryan, of St. Louis, it may be stated that the points treated are as follows: Raising steam; starting system; shutting down; air (inlets, circulation, etc.); hours of operation; heating coils; boiler; firing; engine; heat regulating system; maintenance and repairs. The following extracts will give an idea of their detail:

Hours of Operation.—In mild weather the entire plant may be shut down after the session closes, and the fires banked. Close track of the weather must be kept at all times, and attention paid to the weather predictions, so as to operate the plant to the best advantage. Fires must be started at a sufficiently early hour in the morning to insure the building being thoroughly warm before sessions begin, using the indoor air before 9 a. m. if necessary. In severe winter weather steam should be kept up at night, and pressure carried on the coils, circulating indoor air. The fan may also be run if found necessary, although natural circulation of air will be sufficient except in extremely cold weather. The same precautions should be observed on Sundays and holidays.

Heating Coils.—Use only the outer section of tempering coil in ordinary winter weather. In mild weather (above 40 degrees) cut out both sections. Use both sections in very cold weather. The temperature in the engine room should not be over 65 degrees. When the weather is mild one or more of the heater sections should be shut off, those nearest the fan being shut off first. In very mild weather shut off all coils, but run the fan to give ventilation. Close main steam valve at boiler whenever all coils are off. A steam pressure of from 2 to 3 pounds on heating coils will usually be sufficient, but this should be raised to 5 pounds in extremely cold weather, the pressure reducing and relief valves being adjusted to correspond.

Boiler.—Carry an average of 20 pounds steam pressure on boiler (range 15 to 25) and about 1½ gauges of water. Carry pressure and water as nearly uniform as possible. Blow out gauge-glass and water columns frequently to be sure they are working properly, and are not choked with scale. Clean boiler flues from soot, at least every second day in mild weather, and every day in severe weather. Set safety valve at 25 pounds and try it at least once a week to insure that it is not stuck. Blow down the boiler about two gauges, about twice a week. Clean boiler internally twice a season.

Firing.—Fire frequently and in small quantities. Break up the lumps to fist size. Carry a level fire over the entire grate surface, not too thick. Avoid thin or bare spots. Keep the fires clean. Fire one door at a time, and wait until that fire is in good shape before charging the other door. Keep the time intervals between firings as nearly uniform as possible.

Ventilating and Heating the Franklin Square Theatre, Worcester, Mass.

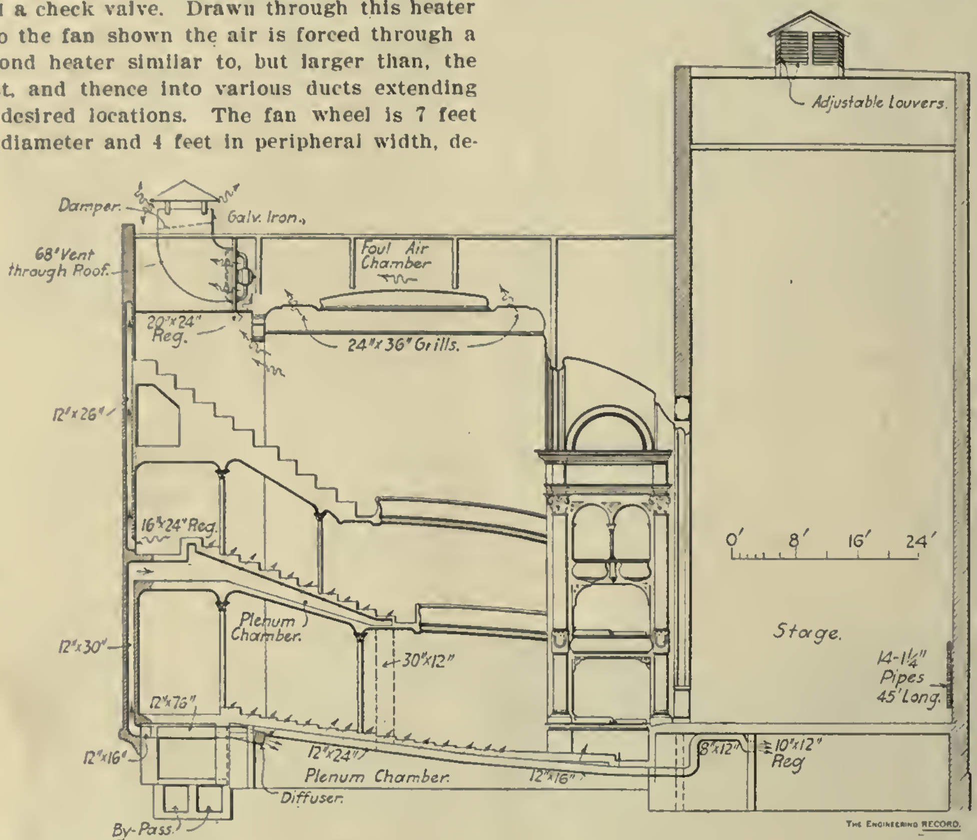
In the Franklin Square Theatre, Worcester, Mass., an interesting plant for ventilating and heating has been installed. While much of the scheme is familiar to heating engineers, there are several noteworthy features in construction, such as an elliptical-shaped diffuser for dispersing the supply of air entering a plenum chamber and the use of screened openings in the chair legs for the admission of air into both orchestra and balcony.

The theatre, built along the lines of usual playhouse construction, comprises an orchestra seating 658 persons, a balcony and boxes accommodating 459, and a gallery which provides room for 519 more; total, 1,636. The stage is 38x56 feet in size and the ground floor plan covers about 10,520 square feet. Besides the orchestra and stage on the ground floor are the actors' dressing rooms, an entrance vestibule and foyer, and check and various rooms. In the basement the greater part of the space directly beneath the orchestra floor is utilized as a plenum chamber. Under the stage there are two dressing rooms, a property room, coal bunkers and a boiler room at one side. On the balcony floor there are several small compartments, such as the manager's office, counting room and dressing rooms. The gallery floor above contains dressing rooms also; all these small rooms on each level are heated by direct radiation. An attic above the gallery utilized as a foul air chamber gives a total height to the building of 64 feet.

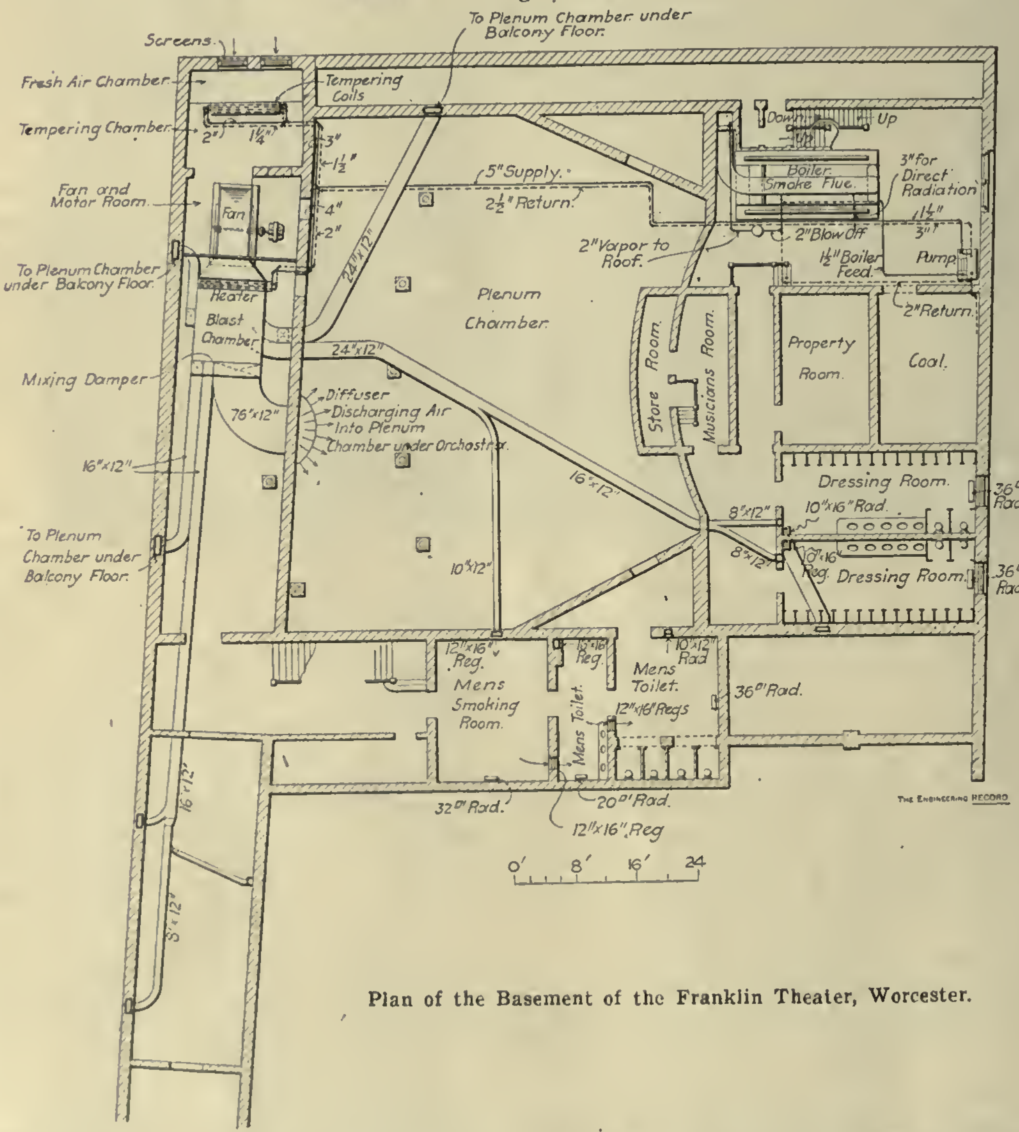
The boiler and pump room conveniently located contains a horizontal tubular boiler, 60 inches in diameter, enclosing eighty 3-inch tubes, 16 feet long. Out of the top of the boiler are taken two steam connections; one, a 6-inch to supply the indirect radiation and incidentally a Warren boiler feed pump; and the other a 3-inch, supplying the direct radiation. The boiler has a 24x24-inch smoke breeching attached, which is carried off at right angles to a brick chimney of the same dimensions. In regard to the piping for the heating apparatus, which is two-pipe, a number of the sizes are given on the accompanying plan and those on other floors are proportioned similarly. Both steam and return pipes in the basement are covered with asbestos and carried overhead on ceiling hangers. A 2-inch vapor line, taken out of the return from the direct radiation is carried over to the 24x24-inch smoke flue and extends upward to the roof. Radiation on this floor is supported on brackets at sufficient height above floor level so as to have a positive gravity return to the pump or boiler.

Because of the importance of the ventilation over the heating, which is helped out approximately 5 to 10 degrees Fahrenheit by the warmth given off from the audience, a positive circulation of tempered air has been planned through the agency of a large centrifugal fan delivering into plenum chambers supplying both orchestra and balcony, assisted by the withdrawal of foul air by an electrically driven fan in the attic discharging into the atmosphere.

Fresh air is taken into the building through two rectangular openings in the basement masonry aggregating approximately 36 square feet. Cheese cloth filters, constructed in the usual way on light pine frames, which are spread across the intakes cleanse the air of dust before it passes on to the tempering coils. The latter is composed of several lengths of black-iron pipe arranged in tiers, receiving steam at 3 to 5 pounds pressure through a 2-inch connection and releasing the water of condensation through a 1¼-inch pipe provided with a gate and a check valve. Drawn through this heater into the fan shown the air is forced through a second heater similar to, but larger than, the first, and thence into various ducts extending to desired locations. The fan wheel is 7 feet in diameter and 4 feet in peripheral width, designed to deliver 32,200 cubic feet of air per minute, so that on the basis of the total seating capacity fresh air is supplied at the rate of 20 cubic feet per minute per capita. The fan is enclosed in a three-quarter steel plate housing and connected by sheet steel to the heating stacks. The fan wheel is driven by a direct-connected 6-100 M. P. S Sturtevant electric motor. Tempering coils, a tempered air by-pass, volume and mixing dampers are installed as shown. It will be noted that the individual ducts start from a so-called blast chamber, in which an



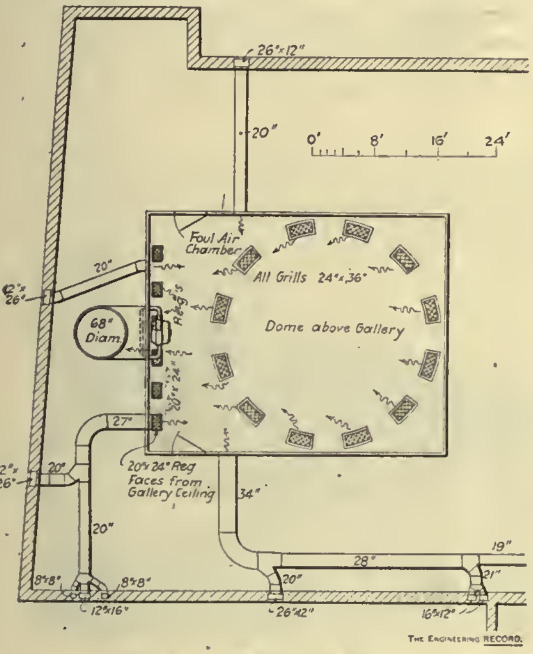
Cross-Section through the Auditorium.



Plan of the Basement of the Franklin Theater, Worcester.

equalization of air pressure can be realized, so that each duct can obtain a volume of air proportionate to its cross-section area, other things being equal. The elliptical diffuser is made of heavy galvanized iron and supplied with guide blades which distribute or diffuse the inflow of air into the chamber, as indicated in the cross-section engraving. The deflecting blades are spaced 4 inches apart.

The orchestra is warmed indirectly by the heated air issuing from the plenum chamber upward through the chair legs having grated openings. The temperature is regulated by a thermostat operating automatically the mixing damper for the 12x76-inch duct shown. The stage is heated directly by coils placed in the rear and sides, aggregating 413 square feet of radiating surface. Two and three-column National pattern radiators, of the American Radiator Company, are provided for the small rooms. The balcony is warmed in a similar manner, there being three flues emptying into its plenum chamber. The temperature is governed thermostatically and vent registers and flues are provided for the exit of foul air. In the gallery more attention is paid to the ventilation than the warming as the heat rising from below is all that is sufficient. Twelve grills each 24x36 inches in size encircle the dome overhead and foul air passing through them is received in an attic space where a 66-inch electric propeller fan is installed to accelerate the circulation. It will thus be noted that the air issuing into the auditorium at the floor line of both orchestra and balcony is arranged to rise gradually and escape through the ceiling, but in addition the rear space of the balcony is served by vent registers which admit the air into flues leading to the exhaust chamber in the attic. There are four of these, nearly one-eighth the combined area of the auditorium ceiling registers. The exhaust fan is driven by a 1-100 M. P. 8 motor and discharges into a galvanized iron riser, controlled by a damper, leading to the atmosphere. Ventilation of the stage portion is accomplished by natural means through a ventilator on the roof having adjustable louvres and a damper operating from below.



Foul-Air Chamber in Attic.

The architects for the theatre were Cutting, Carleton & Cutting, of Worcester, Mass., and the complete heating and ventilating plant was designed and installed by the B. F. Sturtevant Company, of Boston, Mass.

The Yukon River has a length of about 2,400 miles, and it is stated that it is navigable by steamer for over 2,000 miles.

The Morris High School, New York City.

Schoolhouse construction in New York City, as exemplified in the Morris high school at One Hundred Sixty-sixth Street and Boston Road, was the objective of an excursion on Saturday, March 19, by the Municipal Engineers of the City of New York. Through the courtesy of Mr. C. B. J. Snyder, superintendent of school buildings of the city, this building, which is now practically completed, was thrown open for inspection. It has accommodations for 2,735 pupils and was erected at a cost, including both building and equipment, but excluding real estate, of $240 per pupil. Its exterior is of gray brick with gray stone and terra cotta trimmings. The most striking feature is a central tower nearly 50 feet square and about 189 feet in height, which contains a large ventilating shaft for conducting away from the building the vitiated air. The shaft is embellished with turrets in each corner, and in one of these is placed the boiler chimney, which, in this way, is entirely hidden. In the sub-basement at one end of the building, where minimum rock excavation was necessary, is located the heating plant; and in the basement are lunch rooms at opposite ends, one for boys and the other for girls. On the top floor at each end are gymnasiums, one for girls and the other for boys, each provided with a running track, shower baths and locker rooms. Besides this, on the ground level, extending backward from the center of the building, is an auditorium seating 1,300 persons. This has a gallery, a large stage and is accessible by separate entrances opening directly out of doors, so that, if the occasion demands, the room may be used for other purposes outside of regular school work.

The building is ventilated by the plenum system, designed to deliver 67,500 cubic feet of air per minute, when all class-rooms are occupied. There are four tubular boilers, each 5½ feet in diameter, 18 feet long, containing 104 tubes 3 inches in diameter and representing a boiler capacity of 110 horse-power each. For heating, direct radiation surface in the rooms is employed, so that the air supply is for ventilation only. There are, all told, for the eight floors, 24,580 square feet in radiators and coils and the entire length of steam and return pipes is 31,257 linear feet. There are three heating chambers having a total of 5,250 square feet of indirect heating surface. Three of the blowers serve the building proper and are all belted to a long shaft supported by specially constructed stands. These are of iron of a sort of braced A-frame, bringing the shaft some 7 feet above the floor line. By connecting the blowers in this way to one shaft, one engine is able to drive them all. The total cubical contents of the building is over 2,700,000 cubic feet, and the cost per cubic foot, less rock excavation, was about $20.50. The sub-division of the total cost is as follows: Building, $469,383; elevators, $9,000; heating and ventilation, $49,447; sanitary, $35,545; electric, $43,836; furniture, $47,670; total, $654,881. The blower and engine equipment was furnished by the Buffalo Forge Company, and the heating work was installed by the United Heating Company, of New York, from designs of the Building Bureau.

Some of the special features of schoolhouse construction in New York were described in The Engineering Record of June 16, 1900. Among these is the arrangement of two stairways in each stairway well. Through each story each stairway has two runs; the first run of the second flight starts beneath the second run of the first flight. Generally the wardrobes resemble large lockers placed along one side of the corridor and are provided with doors which are locked at one point for each group. This makes it impossible for anyone to get clothing from any part of the locker until the one having the key in charge can release the doors. At the lower part the doors are provided with ventilating screens and the tops are entirely of wire mesh to allow for a circulation of air. The corridors are notably wide and the partitions between them and the classrooms are glazed above the wardrobes. The building is built with steel frame and interior cast-iron columns, but no brick walls, so that, if the city should at any time wish to dispose of any building, it could readily be made into a manufacturing structure, cutting out the partitions if desired.

The building is tastefully decorated, the general style of wainscoting consisting of a baseboard and a chair rail with green painted plaster between and the upper walls white. All radiation is painted a terra cotta enamel and stands behind a screen of the same color, the screens serving to protect the nearest pupils from the heat of radiation and also as a means for accelerating the flow of air upward through the radiator. The corridors on the main floor have a wainscoting of large white tile and tinted walls above. The auditorium has stained glass windows.

Maintenance of Roads in Spring.

The worst condition of highways occurs in the spring as the frost comes out of the ground. As a rule very little is done at such times in the way of maintenance, and on this account it is interesting to notice that Mr. James H. Macdonald, State Highway Commissioner of Connecticut, has just issued some suggestions on the subject. He has found it a very good practice in the early spring immediately on the roads becoming bare to rake off whatever stones have become loosened through whatever cause and immediately roll the surface. This treatment, however, is not to be done until after the frost has completely left the ground so as to have a reasonable degree of surety that after the rolling has become an accomplished fact the roads will remain in the compact condition left by the roller.

All shoulders should be pared down sufficiently to allow an uninterrupted flow of the water from the crown of the road directly to the gutters. All culverts should be opened up as quickly as possible so that whatever the spring may offer in the way of constant rains will in no way injure the road. Gutters should be cleaned out and a general overhauling take place. It may be possible, however, that the road scraper cannot be used to advantage or with profit immediately, but it would be certainly a wise plan to rake off all stones that have worked up through the action of the frost or by the assistance of travel in any way and immediately roll the road.

In addition to this treatment it would be well to add whatever screenings are necessary to protect the surface of the road. One of the most certain indications of the necessity of repair is when the stones show bare on the surface. Immediately a cushion of some kind should be provided to interrupt the impact of the hoof and the destructive influence of the wheel coming in contact with the bare stone surface. These may appear little matters and to those who are not students in the art of road building it might suggest that such things could be put off until the general road repairing time; but delays are always dangerous; the expenditure of a few dollars immediately on the frost leaving the ground will remove the necessity for the expenditure of perhaps hundreds of dollars later on in the summer months.

The absence of rolling a macadam road in the early spring assists to its destruction by leaving the road very porous and open in its construction, which is always fatal in dry weather. On newly built roads, those which were finished last year, a sufficient number of screenings were doubtless left by the several contractors to accomplish any necessary repair without any expense to the town except that of placing the screenings upon the road. It will not be necessary after the application of the screenings to do any extensive rolling; the principal part of the rolling should be done prior to the application of the screenings. If any rolling should be done afterwards it should be done at the time the shoulders have been pared down and make a general rolling of the roadbed proper and the shoulders at the same time.

Substructure Work and Erection of the Shubenacadie Bridge.

The Midland Railway crosses the Shubenacadie River, Nova Scotia, where it is about 1,220 feet wide at high water, at a point about five miles above its mouth. At low water the channel is about 200 feet wide and 10 feet deep; the river bed is composed of shifting sand varying from nothing to 10 feet in depth, overlying a stratum from about 5 to 20 feet thick of gravel, clay and loose stones on the irregular surface of the solid rock. Here the tides have a maximum range of more than 32 feet, and the water rushes between the bridge piers with a velocity of fifteen miles an hour. At high water there is never more than about 40 minutes when boats can be handled in the river, but at low tide there is about five hours when the current is moderate and the sand flats above low water mark are bare. The tide comes in with a bore not exceeding 2 feet in height, and when it turns from flood to ebb the water flows swiftly up stream in the center of the river for half an hour after it commences to flow down stream on the sides of the river. At certain seasons the current carries large masses of ice, and as the bottom in some places is very irregular and in others is very soft, the building of the substructure and the erection of the superstructure was dangerous and costly work, requiring special and interesting methods and plant. There are six concrete piers carried down to a maximum depth of 57½ feet below high water, two concrete abutments and five 215-foot pin-connected, through Pratt truss channel spans which weigh about 330,000 pounds each.

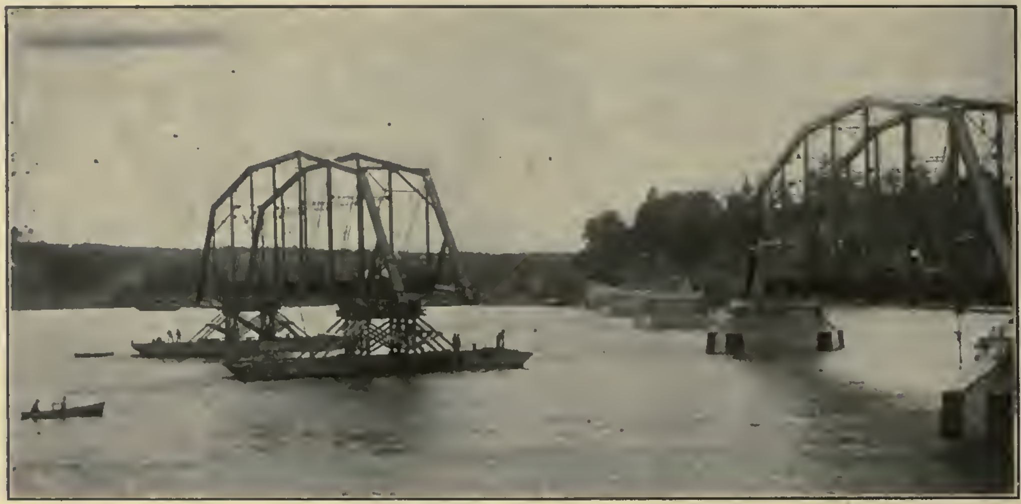
Preliminary test borings were made with a 1¼-inch drill and a 150-pound sliding hammer, with which it took two hours to drill 20 feet through the gravel, with four men on the lifting ropes. The Engineering Contract Company, New York, the contractor for the substructure, commenced operations by the installation of a 1,350-foot span Lidgerwood cableway across the river parallel with, and 24 feet from, the bridge axis. It had a 2½-inch cable supported on heavy timber towers 66 feet above high water, and anchored at each end to three heavy logs laid in trenches and loaded with stone. During its erection the cable was caught by the tidal bore while it was stretched across the river bottom and a length of 800 feet was buried 5 feet deep by the shifting sand. The cableway was considered invaluable for transporting both men and materials at all times and was used to handle all of the 8,000 cubic yards of concrete. With it a one-yard bucket of concrete could be sent 790 feet from the mixing platform to pier 5 and returned empty in 3¼ minutes.

The substructure contains about 8,000 cubic yards of concrete averaging 1½ barrels of English Portland cement to each cubic yard. It was all hand-mixed and was made of three different grades, grade No. 1 containing one part cement, one and one-half parts sand, one part gravel up to ½ inch diameter and three parts crushed stone, was used from the foundations to a point 2 feet above low water. Above this level the facing, 1 foot thick, was made with one part cement, two parts sand and one part gravel up to 1 inch diameter. The corresponding hearting was made one part cement, one and one-half parts sand, one part gravel up to ½ inch diameter and four parts crushed stone up to 2 inches diameter. The stone was quarried near the bridge site and crushed at the mixer platform.

Pier No. 1 was 13 feet wide, 23 feet long at the foot and about 43½ feet high. It was battered on all sides, and was built in a permanent open coffer dam made of 12x12-inch spruce timber above water and white hemlock below water level. The other five piers were founded with wooden pneumatic caissons built on shore, launched and floated to position. The extreme dimensions were 62 feet long, 38 feet wide at the cutting edge and 10¼ feet high. They were built chiefly of 12x12-inch white hemlock and were braced by four transverse horizontal timbers just above the cutting edge. These timbers were from 12x12 inches to 12x24 inches and were cut 4 inches short and wedged against the vertical walls to insure solid bearing. Adjacent and parallel to each was a 1½-inch tension rod passing through the walls with outside nuts and washers and inside turnbuckle adjustment. To the solid timber deck was screw-bolted a mooring crib, which consisted of four 12-inch courses of timber designed especially to receive the connections of the anchoring cables. For each caisson six 12x12x12-foot anchor cribs were sunk around the site, each of which had a ⅞-inch vertical rod passing through each corner from top to bottom. The lower ends of the rods engaged two heavy cross-logs around which was secured a ⅞-inch steel cable which passed up through the stone filling and had a loop in the upper end to receive the mooring cables. There was one 1¼-inch upstream and one 1¼-inch downstream cable and four ⅞-inch breast cables for each caisson.

Each caisson was towed from the yard on one daylight tide and beached near the bridge site. The next day it was towed to approximate position and at high tide was secured there by the six mooring cables. The deck was loaded with as much concrete as the caisson could carry and still float, and on the third daylight tide additional concrete was placed to sink it to bearing, the position being accurately regulated by twenty or thirty men operating the anchor cables. This work was difficult and hazardous. In one case only part of the anchor cables could be secured in time and the caisson was carried two miles down stream before it could be reached. It was brought back on the next flood-tide and successfully anchored, but on the succeeding night broke away again, overturning one of the anchor cribs and pulling out the drift-bolted deck fastenings, which were afterwards screw-bolted.

While the last caisson was being grounded, after having been accurately located, the changing current of the ebb-tide was concentrated on it and broke two of the lines, allowing it to move several feet out of position. The next day an unsuccessful attempt was made to pull it back to place and the men had just left the caisson when another line broke and the caisson turned bottom up. The following day while an attempt was being made to right it, it made a complete revolution, broke all mooring lines and floated bottom up for four miles up stream. It was towed to the shipyard and repaired, the concrete removed and finally it was brought back to position and successfully sunk. After the caissons had been grounded just enough concrete was placed on them to insure their stability, and 80x22x7½-foot twin barges were moored to them to carry the derricks and machinery. The water supply was kept in a large number of oil casks in the hulls of the barges. The caissons were provided with combination shafts having Moran air-locks for men and materials.


Floating Finished Span from Erection Piers to Site.

The work was done in two 5 or 6-hour shifts daily. Fifteen or twenty-five men went down in each shift when the tide was three-quarters ebb and came up when the bore of the incoming tide reached the bridge site, no men being allowed in the caissons during the strongest run of the tides. One shift trenched evenly around the cutting edge throwing the material into the center of the working chamber near the material shaft. The following shift loaded this material into the hoisting buckets and made the center excavation. The material was all too hard to be discharged through the blow-out pipes. When the caisson reached bed rock, holes 2 feet deep were drilled in it 5 feet apart, and 2-inch steel bars 4 feet long were grouted in them to dowel into the concrete filling. The surface of the rock was benched level and cleaned before the concrete was deposited. The rock at pier No. 2 dipped at a considerable angle and so the highest corner was blasted down and the low corner built up with hard clay and stone to make a landing place for the caisson. During the sinking of caisson No. 5 the attendant allowed both air-lock doors to be open at once and the caisson immediately filled with water, drowning four men.

The concrete used in the working chambers was dumped from the cableway on elevated platforms at the air-locks. A cylindrical bucket 2½ feet in diameter and 8 feet long was wedged into the air-lock between the upper and lower doors. It had a hopper bottom closed by a hinged-flap operated by a wire rope passing up through the bucket and through a stuffing box in the upper lock door. When the lower lock door and the hopper bottom were closed the upper lock door was opened and concrete was shoveled from the elevated platform into the bucket. Then the upper lock door was shut, the lower door opened and the bottom of the bucket was tripped, the concrete being discharged through the air shaft to a platform in the bottom of the caisson, whence it was shoveled to position. After the working chamber was filled with concrete, the air lock was removed and from three to five sections of shaft were filled with concrete and left permanently in each pier.

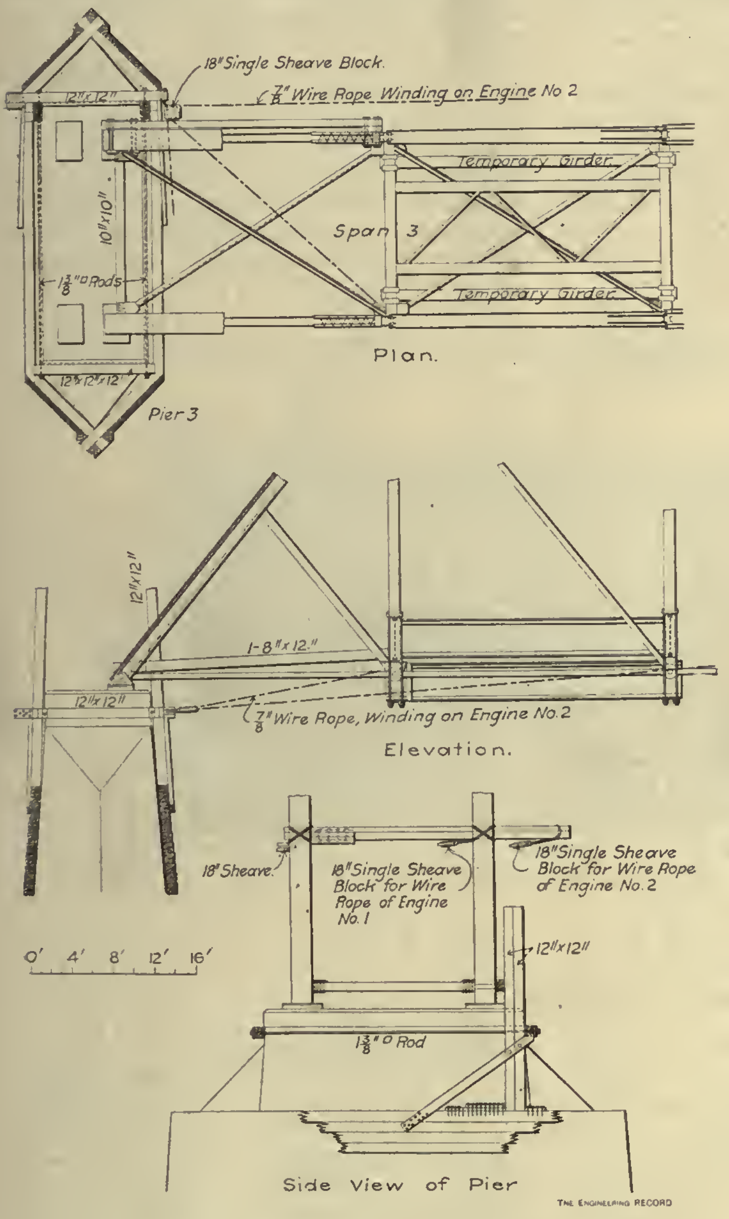
As each caisson was sunk, its sides were continued up above the deck by bolting on horizontal courses of timber to form the tapered walls of the upper crib, which, for a long time, were submerged by every tide. The concrete was deposited in these cribs by the large derricks which received the buckets from the cableway.

Great trouble was experienced in preventing the fresh concrete from being scoured by the violent tides. Work was always stopped some time before high tide arrived, and the concrete was protected by planks and covered with old sails, weighted down with large stones so that very little of it was lost. Large quantities of mud were, however, deposited under the covering, making it necessary to sweep the surface of the concrete daily with brooms. The concrete was reinforced by ¾-inch round horizontal longitudinal bars with hooked ends lapping 1 foot and placed 3 feet apart vertically and 1 foot in from the faces of the cut-water. Similar vertical bars 4 feet apart on the sides and 2 feet apart in the cut-water faces extended from the top to the bottom of the concrete. Four 1¼-inch transverse tie-rods were bedded in the concrete in planes 4 feet apart vertically and passed through the crib timbers of every fourth course. They had nut and washer bearings at both ends and turn-buckles in the middle. The concrete above high water mark was built in plank moulds which were afterwards removed. The bridge seats were made of Halifax granite 2 feet thick. The cut-waters from 3 feet below low tide to high water mark were sheathed with vertical 6-inch birch planks drift-bolted to the crib timbers. The nose and shoulders of the cut-waters between high water and a point 4 feet below low tide were protected from ice by steel angle plates ⅜ inch thick secured by drift-bolts with countersunk heads.

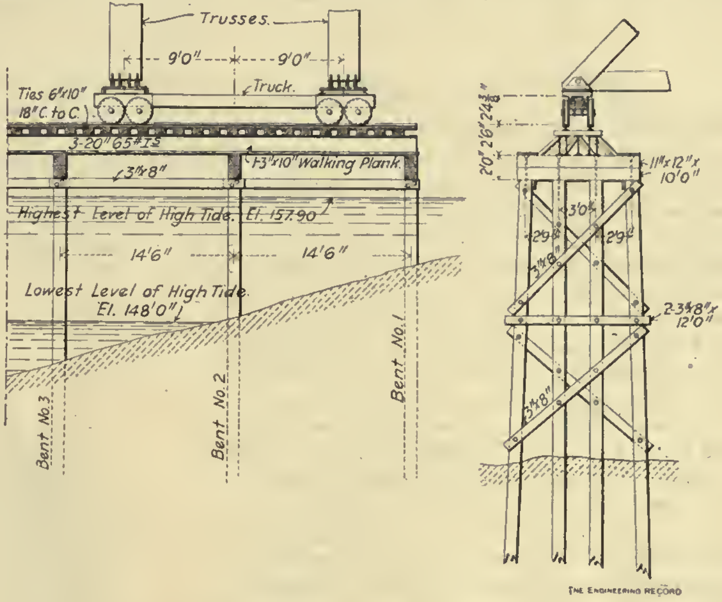
The spans are of standard construction for light railroad service and have plate-girder floor-beams riveted to the vertical posts above the lower chord pins. There is a stiff bottom lateral system of X-brace angles and a top lateral system of screw-ended diagonal rods. These, with the overhead sway-bracing and the deep portal struts, make stiff spans which were able, without extra reinforcement, to endure the stresses caused by moving them in the erection operations finally undertaken.

The river bottom under the first two spans at one end of the bridge is compact clay and gravel, with very irregular surface, exposed at low tide, and on it a special steel falsework was built. Each bent consisted of two vertical posts connected by transverse timber struts and diagonal rods as indicated in the transverse elevation. The 45-foot posts had closed rectangular cross-sections made with a pair of 9-inch channels and two 13x⅜-inch cover-plates. Spur castings were bolted to the bottom flanges to give them secure bearing on the hard ground. Nine 2⅜-inch holes 8 inches apart were bored through the lower ends of the cover-plates to receive the connection bolts for the loop eyes of the diagonal rods. In the upper ends of the posts there were thirty-six 3 9/16-inch holes 12 inches apart to receive the pins for the pairs of 20-inch adjustable cap beams. The upper ends of the diagonal rods had sleeve-nut connections to 5x½-inch bars with thirteen 2⅜-inch holes 6 inches apart which afforded ample adjustment corresponding to the different lengths of rod required by the irregularities of the bottom.

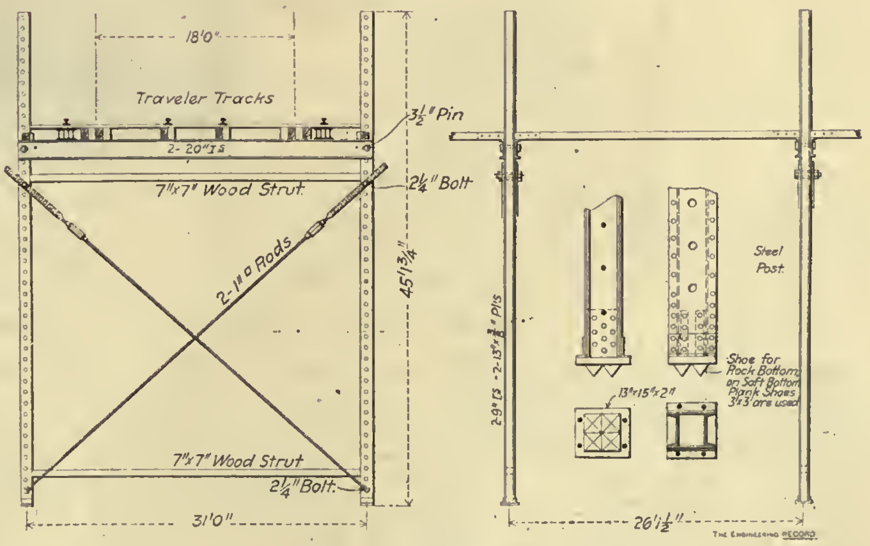
The posts were set in place with the diagonal rods bolted to the lower ends and were after-



Pier and Truss Bracing to Resist Hauling Stresses.



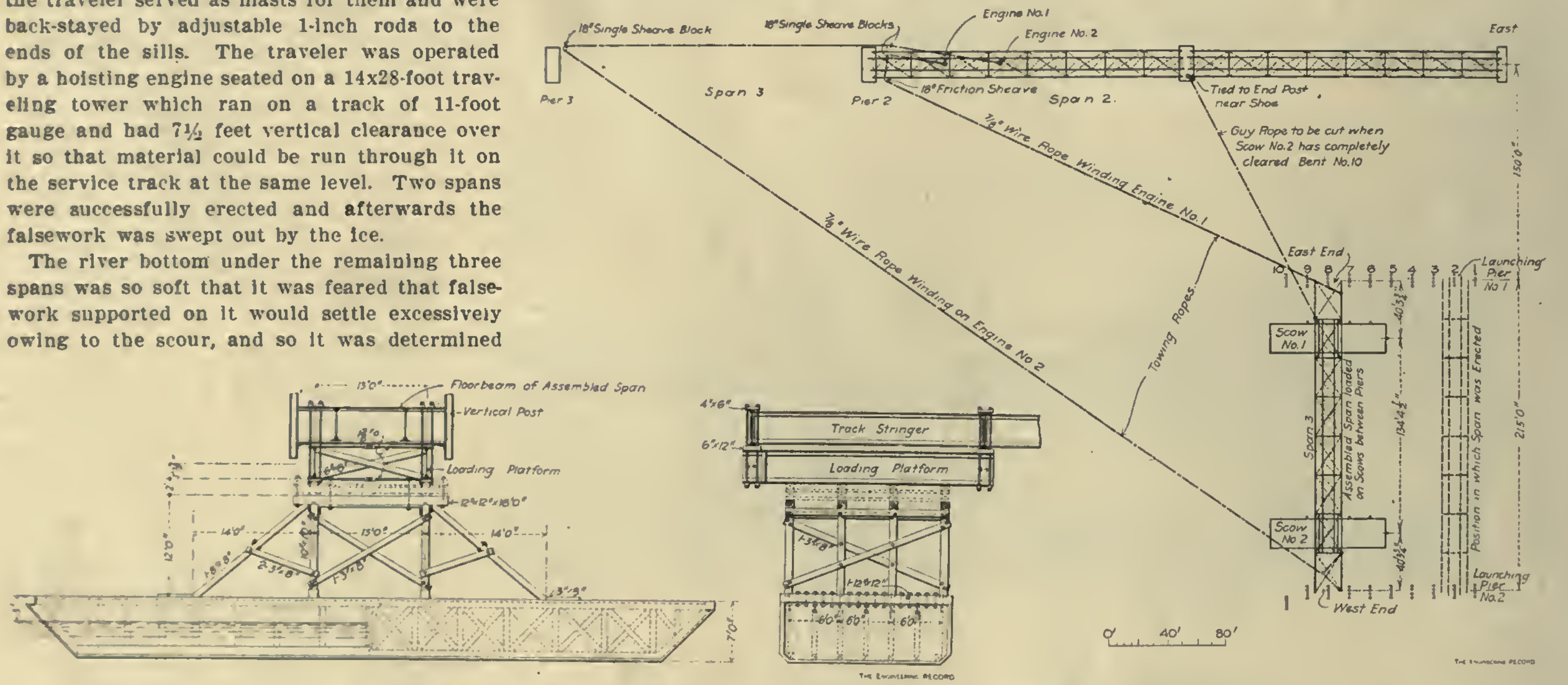
Launching Pier and Truck.



Steel Falsework for End Spans.

wards plumbed and connected to the upper ends of the diagonal rods just above high water level, the adjustments making the columns interchangeable. The lower struts were set between the channel flanges and pushed down to position just above the base plates when the latter were exposed at low tide. The caps consisted of pairs of 20-inch I-beams 32 feet long over all with the flanges cut off at both ends on one side so that the web would fit against the side of the column, where it was secured by a 3½-inch pin through the column and both beams. The bents had no longitudinal X-bracing, but were connected by 8x8-inch timbers bolted to the columns and by the track and floor stringers. The former each consisted of 12-inch I-beams spaced 32 feet apart on centers which carried long transverse planks receiving the traveler rails and the rails of the material track.

The traveler was of the ordinary two-bent striding type built entirely of timber and having vertical and horizontal inside clearances of about 49 feet and 22½ feet respectively. At the front ends of the sills it supported two derrick booms 32 feet long, which were used for the erection of the falsework. The corner posts of the traveler served as masts for them and were back-stayed by adjustable 1-inch rods to the ends of the sills. The traveler was operated by a hoisting engine seated on a 14x28-foot traveling tower which ran on a track of 11-foot gauge and had 7½ feet vertical clearance over it so that material could be run through it on the service track at the same level. Two spans were successfully erected and afterwards the falsework was swept out by the ice.



Shubenacadie Bridge: Scow and Tower for Floating Span; Arrangement of Hauling Lines.

The river bottom under the remaining three spans was so soft that it was feared that falsework supported on it would settle excessively owing to the scour, and so it was determined to erect the spans on falsework located just above the site and parallel to the river bank, and to float them into position at high tide. Ordinary pile falsework was accordingly built in shallow water at right angles to the axis of the bridge, and about 200 feet in the clear upstream from it. From each end of the falsework a ten-bent timber pile trestle or pier was built at right angles to it extending 146 feet further into the river, where the high-tide depth of the water was about 15 feet. The bents were X-braced in two stories, the submerged lower story braces being put on when exposed at low tide. The double caps of the bents carried double and triple lines of 20-inch I-beam stringers. These supported cross-ties with 2-foot gauge tracks on each of which a special eight-wheel truck was seated. The body of the truck consisted of a single 12x12-inch timber 22 feet long, but it was widened at each end by two 3x12-inch filler planks 5 feet long bolted to the sides. An 18x⅜-inch cover plate 5 feet long was put on top of the beam at each end and through it two pairs of vertical U-bolts were set at each end to engage each of the two axles, which had semi-circular bearings in cast-iron blocks on the under side of the timber and engaged a pair of double flange wheels 24 inches in diameter.

Jacks were placed under the ends of the completed span and it was swung in the usual way by slacking off the camber wedges. The trucks were run underneath the end panel points so that the seats were centered with the trusses and the span was lowered to bearing on them by slacking off the jacks. It was then moved forward by operating tackles attached to the trucks and anchored to the river ends of the trestles. The movement was made slowly and the trucks were advanced until they engaged timber stops bolted across the ends of the tracks. Scows previously used on the caisson work, were then floated under the bridge in the second panel from each end and with the rising tide lifted it clear off the trucks. At the slack water of high tide they were pulled around into position between the piers, by means of lines operated by stationary hoisting engines, and safely deposited the span in its final position as they were lowered by the falling tide.

The 20x80-foot wooden scows 7 feet deep were stiffened by five longitudinal full depth Howe trusses with their top and bottom chords spiked to the deck and bottom planking. Timber towers 14 feet high and 41 feet long were built on the decks of the scows to receive the span. The tower bents had timber longitudinal caps 18 feet long supporting 2 to 4 feet of removable blocking, on which rested a pair of transverse plate-girders 4 feet deep and 29 feet long. At their ends the girders had timber X-braces bearing against the flange angles, held in position by horizontal hook bolts engaging the flanges and adjusted by turn-buckles. These girders were the end track stringers of the span and were suspended at each end from the floor-beams of the bridge by four ⅞-inch vertical bolts engaging 4x6-inch top and bottom oak yokes. Oak cushion blocks were inserted for bearing between the top flanges of the girders and the lower flanges of the floorbeams, and the bolts were screwed up to produce compression on them. The girders were attached to the floor-beams before the scows were floated under the span.

Before the span was lifted, the cast-iron bed plates were secured in position to the pedestals at the fixed end by means of vertical bolts through the anchor bolt holes which engaged special nuts placed in recesses in the cast plates. After the bridge was seated in final position, these bolts were removed leaving the nuts in the bed plates. At the expansion end of the span the roller nests and bed plates were secured to the shoes by tap bolts, and after the span was seated in final position, the tap bolts were removed and the anchor-bolt holes were drilled in the positions they had occupied. Very careful provision was made for the connections, lead and reactions for the lines used to pull the bridge from the position on the falsework piers to its position on the masonry piers. The span was towed by two ⅞-inch wire ropes led through the sheave blocks on the piers, as indicated in the diagram. The ropes were operated by two Beatty hoisting engines on trucks on the permanent track of the finished spans. The trucks were clamped to the bridge floor and had solid timber platforms to which the engines were bolted and which were set skewed with the track so that the axis of the engine was parallel with the lead of the lines.

For moving span No. 3 the lines were led through snatch blocks attached to the end posts of span No. 2. The end posts were braced by a horizontal timber lashed to them at the points where the snatch blocks were attached. Block No. 1 was lashed directly to the end post and was free to adjust itself to the varying angle of the line. Block No. 2 was journaled rigidly in a horizontal timber bolted longitudinally across vertical posts No. 1 and 2 of span No. 2. The lines were attached to the end posts of span No. 3 as indicated in the diagram. At the west end of the span the line passed around a snatch block having a long flexible connection to the foot of the end post, thus making a sort of bridle which was adjustable to correspond with the variation of the angle with the moving span. At pier No. 3 the line from the west end of span No. 3 passed around a snatch block lashed to the timber framework bolted to the pier so as to enclose it and distribute the reaction around the masonry, as indicated on the elevations of the pier. At this point there was also a stop built of vertical timbers thoroughly braced to the crib work to engage the truss and prevent the bridge from being pulled too far over. A similar framework and stop was provided at pier No. 2. Span No. 3 was braced by horizontal transverse timbers between the pedestals at each end and by longitudinal timbers bolted across the end panels, as indicated in the sketch of pier No. 3.

For span No. 4 the lengths of the hauling cables were respectively about 400 and 940 feet, and the greater portion of each rested on the river bottom between the finished span and the moving span while the latter was in transit. Before the span was floated these parts of the cables were suspended from the lower chords of the spans Nos. 5 and 6. As soon as the floating span had cleared the ends of the parallel piers, the cables were successively dropped and each one in falling to the river bottom gave a strong impulse to its end of the floating span so that it zigzagged instead of progressing steadily and the hoisting engines had little more to do than to wind up slack, the weight of the sagging cables supplying a large part of the traction required.

For spans Nos. 1 and 2 the lengths of the cables were increased to correspond with the distances of their piers from the erection piers, and the river bottom was roughly leveled and cleared of obstructions in those places where the cables would drag during the floating operations. It was found impossible to remove a crib anchor which obstructed the line of the cable for span 2 and it was planked over so as to provide a smooth surface on which the cable would slip freely. When, however, the span was moving satisfactorily in the middle of the river, one of the cables fouled on this crib and had to be cut away at the floating span. A reserve tug boat was in readiness for an emergency and immediately towed the disconnected scow while the other one was hauled by the remaining cable and so the span was landed on its piers without trouble.

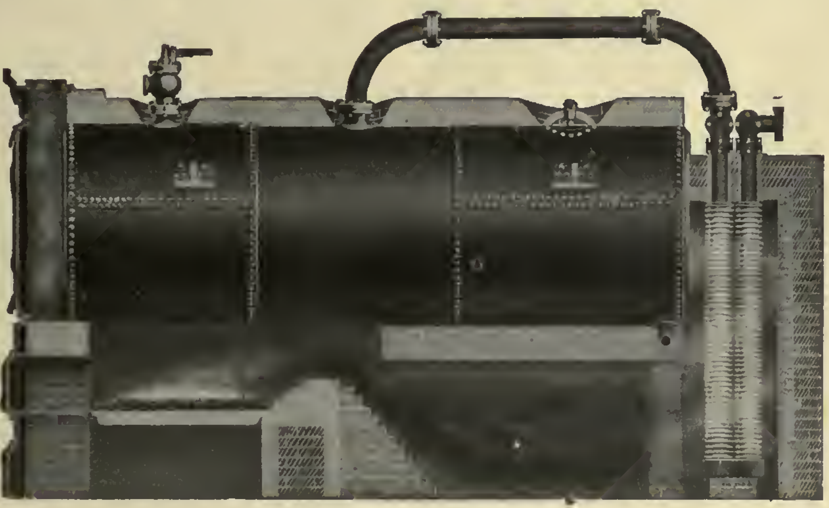
The spans were floated out from between the parallel piers on the last of the flood tide so that it would carry them away from the bridge and they could be positively controlled by pulling them to position against the current. While the spans were floating between their piers they were kept in position laterally by bearing against the vertical stop-timbers already mentioned. They were adjusted accurately longitudinally by four men with bars at each shoe who easily guided the shoes to their seats as they were lowered by the falling tide. In a few minutes after the spans were landed on the piers the scows dropped clear of them and were beached just below the bridge in positions whence they were easily towed back to the erection piers at the next flood tide. Span No. 3 was raised from its trucks at 12:19 P. M., August 14; it was started out from between the ends of the parallel piers at 12:47½; at 1:20 was in position between the piers, and was seated on them at 2:15, thus completing the whole operation in 1 hour and 57 minutes. Spans Nos. 4 and 2 were floated to position July 30 and August 28, respectively, and required 1 hour and 42 minutes and 1 hour and 50 minutes, for the complete operations. Span No. 4 was pulled from the parallel piers to position in 8 minutes.

The superstructure was built and erected by the Dominion Bridge Company, of Montreal, Mr. Phelps Johnson, M. Am. Soc. C. E., manager. At the time this work was executed, Mr. G. H. Duggan was chief engineer. This description has been prepared from original data received from Mr. Johnson, and from a paper presented to the Canadian Society of Civil Engineers by Mr. J. J. Taylor.

Superheated Steam at a Water-Works Pumping Station.

In the early part of this year, one of the boilers at the Spring Creek pumping station of the Brooklyn, N. Y., water-works was equipped with a Foster superheater, the idea being to determine by comparative tests the amount of saving due to superheating the steam. The pumping plant is one of a number of small stations which secure their supply from driven wells and discharge into a conduit which carries the water to the Ridgewood pumping station. From there it is delivered to the reservoir by more economical engines of larger size and power.

The equipment of the Spring Creek station consists of two horizontal return tubular boilers, each 60 inches in diameter by 15 feet long, having sixty-six 3-inch tubes and 914 square feet of heating surface. Each boiler has 25 square feet of grate and natural draft. The fuel burned was large-size, white-ash anthracite.


Arrangement of Superheater.

The pumping plant consists of two Knowles compound condensing direct-acting duplex pumps, size 6½ and 11½x16x24 inches, and one Davidson triple condensing direct-acting simplex pump, size 8 and 14 and 24x24x24-inches. These three pumps are equipped with independent jet condensers, the exhaust steam from which is used to heat the feed-water to the boilers. These pumps get their water through a common suction pipe from the driven wells and deliver it through separate delivery pipes into the conduit, the total head against which they work being in the neighborhood of 30 feet. On its way to the conduit the water flows over a weir, making it easy to check the plunger displacement. One of the boilers was equipped with a Foster superheater, as shown in the illustration. The superheater was connected up to the old steam main, making it possible to make a test on each boiler under the same conditions.

It was decided to run two tests, one using the boiler containing the Foster superheater and a second using the boiler without the superheater. In both tests the main object was to determine the amount of work which could be developed per 100 pounds of coal. It was determined to base the results on the weir measurement and careful measurements were taken and checked by plunger displacement. In the first test the slip was 22.3 per cent., in the second 22.2 per cent., checking very closely. That these figures are so high is explained by the fact that the water as it comes from the walls contains a very large quantity of air, and further, that the pumps did not make full stroke. The coal and feed water supplied to the boiler during both tests were carefully weighed. The station was in charge of the regular crew and no attempt was made to direct their handling of the plant during either test.

The first test was made using the boiler containing the Foster superheater and lasted for 24 hours, starting at noon, February 8, and ending noon, February 9. The boiler without the superheater was then cut in and the other shut down. After running a few days to get properly warmed up, a 24-hour test was started, using the boiler without the superheater, starting at 11 A. M., February 11 and ending 11 A. M., February 12.

The results obtained on the two tests were figured back to the same basis for comparison, that is, the foot-pounds of work done by the pumps (as measured by the weir and the total head pumped against) per 100 pounds of coal and per 1,000 pounds of steam, termed duty of the pump. It was shown by this comparison that 25½ per cent. more work was developed from 100 pounds of coal and 30.2 per cent. more work was developed from 1,000 pounds of steam when superheated about 200 degrees than was developed when the steam was saturated. Also that the same amount of work was accomplished with a saving in coal of 20.2 per cent. and a saving in feed water of 23.2 per cent.

Since making the above tests a five-day run was made with, and an equally long run without, the superheater and the station records show that during the five days without the superheater the station pumped 21,956,400 gallons of water with 31,780 pounds of coal, and that with the superheater the station pumped 22,337,500 gallons of water and burned 23,730 pounds of coal, showing a saving of about 25 per cent.

Results of Twenty-four Hour Tests With and Without Superheating.

Condition of steam.	Superheated.	Saturated.
Av. steam pressure, lbs..	79.3	79.4
Total head triple, ft....	29.05	29.46
Total head comp'd, ft...	33.04	33.39
Pumpage by weir, gals..	4.492,680	4,549,480
Work done, ft.-lbs......	1,163,815,819	1,184,983,596
Total coal consumed, lbs.	5,015	6,410
Total refuse, lbs.......	1,188	1.203
Total feed water, lbs....	38,399	50,960
Duty per 100 lbs. coal..	23,206,696	18,486,483
Duty per 1,000 lbs. steam	30,308,498	23,253,213
Av. temp. steam leaving superheater, degs.	527.4	
Av. temp. steam entering superheater, degs.	320.1	
Av. deg. superheat, degs.	207.3	

These tests are particularly interesting as showing the value of superheated steam in a plant which is of an ordinary low-duty type and has been in operation for several years on regular city service. No special arrangements were made for the introduction of superheated steam and no special oil or stuffing box packing nor steam pipe gaskets were used. The plant is in the same condition as it has been running for years past. Mr. Dean remarked in a recent address before the New England Water Works Association that one of the most promising fields for increasing the duty of steam pumping engines, and in fact about the only remaining correction or radical improvement, was using superheated steam in place of saturated steam. The results obtained in Brooklyn would seem to bear out this opinion with greater positiveness.

Blank Forms for Reports and Accounts in a Large Engineering Office.

Probably few persons will dispute the statement that the prime requisite, or at least one of the most important elements, in the successful and efficient accomplishment of any large engineering project is an able chief engineer. The man who is well fitted to fill such a position will naturally surround himself with as capable assistants as he can employ and will arrange them into a properly subordinated and closely articulated organization in which each member will have as definite functions and responsibilities as practicable. For the economical and efficient performance of its various duties such an organization will require reasonably commodious and convenient quarters and a sufficient equipment of furniture, instruments and tools. Furthermore, it is necessary that the chief engineer should keep constantly posted on the operations of his staff, the doings of his contractors and the receipt and use of materials and machinery, and, besides, that the accountants should have the necessary information.

Much of the work of collecting and recording information in an orderly manner is jocularly termed "red tape," and, unfortunately, is sometimes regarded as more or less unnecessary by men with a certain turn of mind. The receiving of complete and accurate reports promptly and regularly by the chief engineer and the heads of departments greatly facilitates the orderly conduct of any large work. Uniformity, also, is to be desired in these reports, as it saves time and is a great aid to the avoidance of mistakes, both in the making and the interpreting of the reports.

This element of uniformity in reports as well as those of punctuality, completeness and accuracy, is probably most readily secured by the use of a set of printed forms, each of which has been well considered and carefully prepared with a keen regard for the way it will "work" in everyday use. Such minutiæ sometimes seems trivial to the busy man who finds office details irksome and prefers the more active parts of the work; but a proper attention to these matters early in the development of the organization, and as new features of the work are introduced, will save time and annoyance later. In some cases it may be wise to put this duty upon an assistant who has taste and skill for it. Report blanks should be made as simple and convenient as practicable in shape and arrangement, and they should not be unnecessarily increased in number, lest a snarl of red tape result. The column headings, directions and other matter printed upon them should be as plain and terse as may be. Good typography is an aid not to be despised, and different colors of paper and ink are sometimes useful.

To be sure, the form of organization, the equipment and the methods which may be very successful for a given undertaking or in a certain part of the world may not be well adapted to a different class of work or even to the same kind of work in a different place having other conditions. However, one of the best ways to present a method or principle intelligibly is to illustrate it by the description of a concrete example. Hence, in this instance, a number of the blank forms used in the office of the Metropolitan Water Works, Boston, will be forced into service. So many articles have been printed describing not only the extensive works of this system, but also the organization of the engineering force and the office furniture and equipment, that they all are familiar to the readers of this journal. Consequently, the purposes of the various forms described below will be the more readily understood. Many other offices, no doubt, are using blanks which might serve as useful models or suggestions to other engineers if brought to their knowledge. Why not make them known?

To describe or reproduce all the forms used on the Metropolitan Water Works would fill a number of pages of The Engineering Record, and so several of those of a more general character have been selected for description below. The detailed descriptions may be prefaced by a few statements applicable to all forms. Every form has a heading containing the words "Commonwealth of Massachusetts," which are followed by "Metropolitan Water and Sewerage Board," or "Metropolitan Water Works," together with the name of the department, as, for example, "Distribution Department." These lines are usually followed by a line in bold type indicating the purpose of the form. A standard height of about 10½ inches has been adopted for all forms for which some decidedly different dimension is not necessary or especially desirable. The regular width is 8 inches; a number of forms, however, which are, of necessity, much wider, are made so that they can be folded to file with 8x10½ inch sheets, if desired, either in gummed invoice files or other kinds of files.

Weekly and other reports by assistant or division engineers to the department engineers, and of the department engineers to the chief, are usually written upon plain 8x10½-inch sheets, as uniform an arrangement of statements being followed as the nature of the work, varying in different cases and from time to time, will permit. Each man retains a carbon copy of each report that he makes. From these, largely, the annual reports are prepared.

Progress of construction work is reported by the inspectors on standard printed blanks adapted to the general class of work in hand. For example, the distribution department uses, for reporting the laying of pipe, a form which may be outlined as follows: Under the general heading is a prominent line, Progress Report, Section.........., followed by.........Street; City or Town, ..., and Contractor, ...; For week ending ...., 190.., on two lines. Below a double red line are the following statements, without column rulings, with short spaces for figures after each, On the left side: Number of Working Days; Men employed for the Week, Pipes (Delivered, Returned) (full lengths); Specials and Cut Pipes (Delivered, Returned); Specials Laid; Pipes Laid (cut pieces); Joints run; Joints Caulked; Pipes Broken; Trench Open to Sta.; Number of Brick Chambers built; Bbls. Cement used (brick masonry, concrete); Descriptions and Stas. of valves set; Explosives on hand...... lbs. On the right side: Serial No. of Last Pipe Laid (Main Line); Horses Employed for the Week; Pipes Laid (full lengths); Joints run solid; Joints caulked and not covered; Trench excavated to grade to Sta.; Trench backfilled to subgrade, to Sta.; Trench resurfaced to Sta.; Pigs of Lead used. At the bottom are a few lines for remarks and a place for signature by the inspector, followed by the following line at the lower edge of the sheet: Note.—Report to be filled out and mailed to the Assistant Engineer in charge of Section not later than 6 P. M. Sunday.

For the smaller jobs done by the day labor force of the distribution department, a simpler form is used. Its sub-heading is: Report of Pipe Laid and Materials Used. This is followed by several blank lines for the description of the work and its location, the last line having For week ending ......, 190... Below a double red line the following words are spaced across the sheet so as to serve as column headings although there are no vertical rulings: Size; Pipe and Specials; Length; Class; Weight; Cost, and a few lines farther down are the following words, similarly arranged, with two lines beneath them: Size; Valve; Make; Weight; Cost. Below a single red line are the following statements, each having a line half across the page: Lead used, ... lbs.; Yarn used, ... lbs.; Coke used, ... lbs.; Kerosene oil used, ... gals.; Gasoline used, ... gals.; Sand, loads, ... 40 cu. ft.; Brick used, ...; Tools sharpened, ...; Cement, Portland, bbls., ...; Cement, American, bbls., ...; Lumber, ...ft. at ....; Wooden wedges .... at ....; No. chambers built, ...; Paving blocks, ...; Cement used in concrete, bbls., ... Below are four lines for remarks.

For reporting progress on the construction of the Wachusett reservoir, forms similar to the following were employed, the example at hand being one of the earliest and printed before the present name of the reservoir was adopted. The sub-heading is Force Report, Section 1, Nashua Reservoir. Beneath this is printed on one line, at the left, Contractor, Joseph D. Gennaro, and at the right, For week ending .... 189... Below the general heading the sheet is divided into a number of columns of suitable widths headed as follows: Description of work; Class of Labor; Sun.; Mon.; Tue.; Wed.; Thu.; Fri.; Sat.; Total; Rate; Amount; Total; Remarks. Above the heading of the second column are printed the words, Day of Month, opposite which, over the columns headed for the days of the week, are small spaces for the date figures. In the first column are designations for the different classes of work, such as Clearing; Grubbing; Soil Excavations; Dry Rubble Masonry. In the second column are printed: Gen. Foremen; Time Keeper, on the first two lines, and below, in connection with the designations in the first column, are groups of words like the following, each on one line: Laborers; Water boys; Plow teams; Two-horse carts; One-horse carts. This form consists of several attached sheets, the amount in each column being carried forward and summarized in the spaces provided at the bottom of the last inside page. The back of this form is endorsed: Reservoir Department; Force Report; Section 1; For week ending ...., 189.., arranged so that the sheet may be folded to one-third its height.

In order to determine as nearly as practicable the actual cost of contract work, forms like the following were provided. The sheets are of the standard height, but 24 inches wide, divided longitudinally into an upper and a lower part, the former for Labor and the latter for Materials. The sub-heading reads: Statement of Force employed, Material Delivered, and Work done during the .... ending .... 189 , Section ..... At the left of the upper part of the sheet, under the column heading, Labor, are, printed on separate lines, the words, Foremen, Sub-foremen, Mason, Tender, Machinist, Carpenter, Caulkers, Blacksmith, Derrick-men, Teamsters, Time-keepers, Laborers, Water-boy, Horses, with two blank lines and a line for totals. At the right are twelve wide columns headed respectively: Earth Excavation, Rock Excavation, Pipe Laying, Refilling, Resurfacing, Brick Masonry, Concrete Masonry, Timber Foundations, Sheeting and Bracing, Handling Water, with the last two columns blank. Each of these wide columns is subdivided under the headings Day's Work, Rate, Amount. The lower part of the sheet is divided into columns similar to those above, but no headings nor designations are printed. At the bottom of the sheet, on separate lines, are Total Cost, Quantities, Cost per unit, Per cent. of total cost. There are a few lines left at the bottom of the sheet for remarks.

A much simpler form is used for weekly returns on the force account. Under the general heading is a blank line for a brief description of the piece of work, below which is a line for Contract No. ...., at the left, and Contractor, at the right. Under this, in bold type, is the line: Force Account for Week ending ...... 1...., with the last line of the heading devoted to Class of Work......Sub-Division...... At the left is a wide column headed Class of Labor, and containing designating words like the following, each on a separate line: Gen. Foreman; Time-keeper; Carpenter; Engineer; Laborer, pick; Laborer, shovel; Horses. There are twenty-eight of these, separated into class groups by skipping a line after each group. The bottom two lines are marked Total Men and Total Horses. Narrow columns at the right are headed with the days of the week, with spaces above for figures for the day of the month, and are followed by other columns headed, respectively, Total, Rate, Amount, Total, Remarks. These reports are signed by the inspectors. Summary Force Account sheets are provided to be used with these weekly sheets on each contract. The left-hand column is like that of the weekly report sheet, and several columns at the right provide for summation under the headings Days, Amount.

For the regular day labor force of the distribution department a very simple Force Report form is used. The last line of the heading reads Distribution of time for....ending... In a wide column at the left are the names of the pumping stations, reservoirs and other properties under the care of the department, opposite which against the words Construction and Maintenance, on separate lines, entries of time can be made in one of seven columns, each headed Days at, with space in the heading for the rate of wage. At the extreme right are two columns headed Horses, Single Team; Horses, Double Team. The back of the sheet is ruled horizontally and bears the heading, Foreman's Report, and has a place for signature.

To assist in reporting progress on the construction of large buildings, like pumping stations, which it was sometimes difficult to make clear in words, diagrammatic plans and elevations were made on a small scale so that they could be printed in blue or brown lines on a white background, using the ordinary blueprint or Van Dyke print methods. A few lines and figures placed on such prints from week to week would make apparent at a glance the approximate condition of the building at the time of report and the part of the structure remaining to be built.

Pile-driving was reported by the inspector on a sheet 16 inches wide of the standard height, divided into two pages. The left-hand page had the subheading: Record of Pile-Driving; Section....... A line below read, Work at......,......;....189.. The page is divided into twenty columns, the first twelve of which have the following headings: Station; Pile Number; Bent Number; No. of the Pile in Bent from East or North; Kind of Timber; Total Length of Pile, Feet; Length of Cut-Off, Feet; Diam. of Butt Below Cut-Off, Ins.; Diam. of Point, Ins.; Elev. of Top of Ground; Elev. of Top of Pile Below Cut-Off. The remaining columns are grouped under the heading, Data on Penetration, sub-divided into two minor groups, Consecutive Blows; Last Blows. Under Consecutive Blows there are four columns in which the regular horizontal spaces are divided into two and over these columns is printed the instruction: Use upper space for number of blows and lower space for penetration in feet. Beneath this the first of the four columns has the heading: Mud or Peat; and the other three columns have the common heading: Harder Material. The fifth column under Consecutive Blows is headed Average Fall in Feet. Under Last Blows the three columns are headed: Number, Penetration in Inches, Fall in Feet. At the bottom of the page is the half line, Weight of Hammer, ...pounds, with a place for the inspector's signature at the right. At the head of the right-hand page the first line reads, Actual Load per Pile,....tons;.... Below this is a statement of the formula as follows: Figure on worst case, safe load = 2 (weight of hammer in pounds) × (fall in feet) ÷ (last sinking in inches + 1.) = ... Beneath the formula there is a place for signature by the assistant engineer. A column 2½ inches wide at the left is provided for Remarks, and the rest of the page is reserved for such comment or general description of the work as may be desired.

Estimates for monthly payments on contract work are made in triplicate. For minor contracts on which there will probably be but few payments, standard blanks are provided which can be used for any class of work or materials. For large contracts requiring a considerable number of estimates, much writing is saved from month to month by printing the contract number, contractor's name, designation of the work and list of items with prices so as to leave only the quantities and amounts of the payment to be filled in. These blanks, as well as some others, are printed in copying ink, so that a letter-press copy may be made in the "Estimate Book," or other copy book.

For pipe inspectors at the foundries, forms 8 inches high and 11½ inches wide have been used. Beneath the general heading these forms read, Report of ....inch pipes; class......tested at......Foundry during week ending...... 189.. Length of pipe, exclusive of socket.... maximum weight......lbs.; minimum weight ......lbs. Note—Return the different sizes and classes of pipes on separate sheets. These statements are arranged on three lines. Below this heading the sheet is divided into two parts exactly alike, each of which is sub-divided into three columns about 1 inch wide, headed respectively, Date; Number of the Pipe; Weight, lbs.; and a column 2¼ inches wide for Remarks. At the bottom of the sheet is the statement: I certify that the above weights are correct, and that the pipes have passed the contract tests. This is followed by a place for the inspector's signature. Similar blanks with the obvious changes necessary are used for special castings. Special castings blanks, however, are 8x10½ inches.

To aid the auditor of the Board in keeping proper cost accounts for the works, printed backers were provided to be attached to each bill approved for payment. These forms have two pages. On the first page the amount of the bill is divided between General Construction Accounts and General Maintenance Accounts or charged wholly to one or the other, as the case may be. Under the former are the general subdivisions, Administration, Engineering, Real Estate, and Construction, under which the charge is itemized opposite such words as Commissioners; Clerks and Stenographers; Chief Engineer and Department Engineer; Engineering Assistants; Instruments and Tools; Advertising; Day Work; Tools, machinery, etc.; Contracts. General Maintenance Accounts are classified in a somewhat similar way. The second page is arranged so that the bill can be properly divided among the different parts of the works, under Construction and Maintenance. Some of the sub-headings on this page, on the form used for the Distribution Department, are Low Service, Northern High Service, Stock, Glenwood Pipe Yard.

During the most active periods of pipe-laying, several yards for the storing and delivering of pipe and special castings were in use. All pipes, special castings and other stock received at these yards were promptly reported to the department engineer on simple blanks, for Pipes Received, Pipes Delivered, Special Castings Received, Special Castings Delivered, Miscellaneous Stock Received, Miscellaneous Stock Delivered. To properly provide for pipe-laying to be done it was very important to have accurate information at frequent intervals of the stock of various kinds on hand at each of the yards. For this purpose a four-page folded form was devised and reports were usually prepared monthly. The sub-heading read: Report of Stock on Hand (date), at........Yard. Two pages were divided into groups of columns; in the first column of each group were printed the designations for the pipes and special castings, and the other four columns of the group were headed, Last Report, Received Since, Delivered Since, On Hand. Pipes were designated by a number representing the diameter in inches and a letter for the class. Special castings were grouped according to their kinds, such as ¼ Curves, Reducers, Caps, etc., under each being a list of sizes and classes. As the patterns of branches and Y-branches were numerous, a page was devoted to them, but the sizes were not printed, it being found simpler to list only those patterns which were actually on hand. The last page was conveniently ruled for a statement of Miscellaneous Stock.

While actual specimens of the various forms would, of course, be more satisfactory than descriptions, most of those mentioned above have been described in adequate fulness, it is believed, to enable anyone sufficiently interested to block out the sheet, by the exercise of a little judgment as to the widths of columns and horizontal rulings and the sizes of spaces devoted to headings.

Metallic Office Furniture was given a good trial in a recent fire in the office building of the American Sheet & Tin Plate Company, at Wellsville, Ohio. There were several metallic desks among the furnishings in rooms badly damaged by the flames. In one of these rooms all of the wooden furniture was completely destroyed, but only the wooden top and outside finish of the metal desk were in any way injured, while its contents were preserved intact. The desks were supplied by the Art Metal Construction Company, of Jamestown, N. Y.

The Origin of the U. S. Land Survey System was the subject of an interesting talk by Mr. W. A. Truesdell before a recent meeting of the Civil Engineers' Society of St. Paul. The germ of the scheme seems to have originated, he stated, in 1764, with Thomas Hutchins, afterward the U. S. geographer, and the first official surveyor of the public lands. His successor, Rufus Putnam, the first surveyor-general, apparently was the first to suggest the 6-mile township of 36 lots laid out in ranges. The present system was established in 1785, and Hutchins surveyed the seven ranges in Eastern Ohio during the following year. Putnam, his successor, continued the Ohio survey in 1796, his townships being groups of sections instead of lots and numbered in the order of to-day. The military bounty lands were laid out in that year in townships 5 miles square. Jefferson deposed Putnam after six years' service for accepting careless work, and his successor was Richard Mansfield, a careful and expert surveyor. He introduced the correction lines and spherical provisions, and perfected the system in its minor details.

Ballast.

Among the interesting reports presented at the meeting of the American Railway Engineering and Maintenance of Way Association, was one by a committee on ballasting, which has been considering the subject since 1899. In 1902, this committee presented a number of definitions and recommendations, which were adopted at the convention of that year. In the convention of 1903, the committee's report was not considered from lack of time, while the action taken this year is reported in the account of the meeting in this week's Current News Supplement. The report contains an interesting historical introduction, largely contributed by Mr. Octave Chanute, and is signed by J. V. Hanna, assistant chief engineer, St. Louis & San Francisco R. R.; C. A. Paquette, superintendent, Big Four R. R.; W. W. Colpitts, assistant chief engineer, Kansas City, Mexico & Orient Ry.; F. T. Hatch, superintendent, Vandalia Line; E. Holbrook, chief engineer, Missouri, Oklahoma & Kansas City R. R.; J. O. Osgood, chief engineer, Central R. R. of New Jersey; J. G. Sullivan, division engineer, Canadian Pacific Ry.; G. M. Walker, Jr., assistant engineer, Kansas City Belt Ry.

The prime object in the use of ballast, the report states, is economy in the maintenance of line and surface. Good ballast will resist any tendency to displacement in the ties; will distribute the weight on the ties over the roadbed beneath them; will prolong the life of the tie and rail by conveying water away from them; will prevent the growth of weeds; will be sufficiently pliable to yield under the blow given the rails by moving load and thus prevent or lessen injury to them, and will be sufficiently elastic to return to its original position after the blow. To resist abrasion when handled, it must be hard and tough. Sharp corners increase friction between ballast and ties and between the particles of the ballast themselves. This in turn increases the capacity of the ballast to distribute weight over the roadbed. Large interstices between particles of the ballast facilitate the passage of water. Good drainage tends to lengthen their life, to prevent churning and heaving by frost, and is the most important single requisite for economical maintenance.

The presence of earth, sand or fine particles of any sort tends to lessen friction between adjacent larger particles of the ballast and to prevent drainage, and is consequently detrimental. Chemical constituents which prevent growth of weeds may also injure ties and rail, and thus offset the advantage gained.

Heavy ballast is less easily displaced than light, hence weight is an advantage. Resistance to decay is essential on account of the expense of renewal. Freedom from dust is desirable on account of comfort of passenger and the fact that dust increases wear of rail and rolling stock.

Having set forth the requirements of good ballast, it is next in order to consider the materials available for the purpose and see how nearly they fill them.

Crushed Rock.—In general, crushed rock comes nearer to filling the requirements of an ideal ballast than any other material. Trap rock, granite, limestone and sandstone are all used. Some limestones and most sandstones make poor ballast, the latter being apt to wear into round form under tamping. Trap and granite are probably most satisfactory on account of hardness and toughness. It will not entirely prevent growth of weeds, but is much more effective in this regard when clean than when the spaces are filled with dirt. Complete filling of the spaces in crushed rock almost entirely destroys its usefulness, and it then becomes necessary to put new ballast on top of the old or to clean it. It is the Committee's opinion that it is cheaper to put in new ballast than to take out and clean the old, but an additional raise may be objectionable, particularly on the approach to a large bridge which cannot be raised without great expense.

With broken stone, the question of what kind of stone to use may be one of availability, but the size to which the stone shall be crushed and the size of the particles to be screened out are matters upon which there is room for argument. Advocates of the larger sizes of stone contend that they give larger spaces between the stones, thus affording better drainage; also that the spaces are longer in filling up with dirt, thus giving longer life to the ballast and reducing cost of cleaning where this is practiced. The larger sizes of crushed rock also cost less to produce. The advocates of the smaller sizes admit the greater first cost, but contend that the labor of surfacing is less to begin with and the cost of maintenance is also less thereafter. With smaller rock, joints can be picked up and put in shape, which could not be handled with larger rock except by making a uniform raise of two inches or more and a general surface. It is claimed that the filling of the ballast with dirt is too slow a process to offset the advantages of light surfacing afforded by the finer sizes. Advocates of a minimum size of screen hole of ¾-inch contend that, with smaller holes in wet weather the fine screenings stick together and do not go through the holes at all, thus making dirty ballast to begin with. So far as the Committee knows, it has not been shown that there is any advantage in retaining particles less than ¾-inch in size unless it be in the matter of cost.

In crushing rock, many fine particles are made and usually screened out. The screenings must be disposed of in some manner, and the question of their suitability for ballast arises. They can be used in ballasting sidetracks, for leveling up between tracks in yards and for making platforms at unimportant stations. Used as ballast, they form a firm bed around the tie, but do not drain well, and consequently churn when wet. They are unsuitable for main line work. Specifications for stone ballast are submitted as follows:

(1) Quality—a. Stone should be durable enough to resist the disintegrating influences of the climate where it is used. b. It should be hard enough to prevent pulverizing under the class of traffic to which it is subjected. c. It should break in angular pieces when crushed.

(2) Size.—a. It is recommended that the maximum size of ballast shall not exceed pieces which will pass through a 1¾-inch ring, but a ring of 1½-inch diameter is preferred as the maximum measure of size. b. It is recommended that the minimum size should not pass through a screen with ¾-inch holes.

(3) Quantity in Track.—a. It is recommended that the minimum thickness of 6 inches under the tie be considered as ballasted track, but that a minimum thickness of 8 inches under the tie is preferred. b. The extreme maximum thickness of 18 inches under the tie is recommended, with an ordinary maximum of 12 inches. c. The upper surface of the ballast should be level with the top of the ties. d. The upper surface of the ballast should extend 9 inches beyond the ends of the ties. e. The slope should not be steeper than 1½ to 1.

Gravel.—Gravel cannot be procured ordinarily in a form which will satisfy definite specifications, therefore it is not worth while to draw them. The most desirable gravel ballast consists of a clean uncementing gravel, varying in size from coarse sand to stone 2 inches in diameter. With gravel of the above quality available, track can be held in line by shoulders of gravel put up to the elevation of top of tie and varying in width, depending on quality of road and traffic on same.

When it is necessary to use gravel containing clay or cementing material, where it is impracticable to wash same, it is better to depend on friction to hold track in line and place the ballast so that after settlement has taken place the ends of ties will not be imbedded more than one inch in ballast. The Committee believes that the practice of surfacing new track with earth and loam is not economical when gravel is available with a haul of not over 100 miles.

Sand.—Coarse sand, where the particles are regular, with proper care will maintain track in good line and surface, but is liable to wash easily and is apt to blow in dry weather. Under rapidly moving trains it is dusty and has an appreciable influence in increasing the wear on the rails and rolling stock. Sand which has a tendency to cement together is largely free from these detrimental influences.

Burnt Clay.—The employment of burnt clay as ballast dates prior to 1857, but has not until recent years been used extensively in this country and has been practically confined to the great central basin, where sufficient quantities of good stone or gravel are not available without excessive cost. Its use has met with varying results, largely due to the quality of the material burned and the manner of burning. When the clay contains little sand and a sufficient quantity of fluxing material to produce a semivitreous mass, a very good quality of ballast will be produced, giving good results on roads with comparatively light traffic, and is to be commended because of the ease with which it can be worked. On roads with heavy traffic and heavy rolling stock burnt clay ballast has not given good satisfaction because of being too soft to stand the load and the disintegrating effect of the weather. The clay may be burned in a kiln or in the open, in which case a length of pile of one-half mile is possible.

The Committee suggests the following specifications for burnt clay ballast: (a) The material should preferably be black gumbo from river-bottom lands. It should be free from sand or silt, and should be thoroughly tested in small test kilns before establishing a ballast kiln. (b) The material should be burned hard. (c) The fuel used must be fresh and clean enough to burn with a clean fire. (d) The quantity of fuel and time of burning will vary with the moisture in the clay and the weather conditions. (e) Burning should be done under the supervision of an experienced and competent burner. (f) Care should be taken that fuel is always on hand when required. (g) Ballast should not be loaded out of the pit hot. (h) Absorption of water should not exceed 15 per ment.

When fuel is cheap and suitable material at hand, burnt clay ballast may be produced f. o. b. cars at about the cost of crushed rock. The cost of placing under track is much less than stone and it is for a time more easily maintained. The life of burnt clay ballast varies from four to eight years, depending on the quality of the material and the amount of traffic it has to sustain.

Engine Cinders.—Since the advent of coal burning in locomotives, engine cinders have been used for ballast, and until within recent years as generally on main line as elsewhere. Roads having a total of 72,055 miles (46,894 miles main line), report 5,186 miles of cinders, 7,753 miles of stone, and 16,331 miles of gravel ballast. Like gravel, cinders cannot be produced to conform to definite specifications, but it may be remarked that if cinders are wet down immediately after being drawn, their quality as ballast will be greatly improved. Anthracite coal cinders make a better ballast than soft coal cinders, and there is considerable difference in the quality of cinders produced from different kinds of soft coal.

Cinders as ballast find their greatest use in the following situations: On branch lines with a light traffic; on sidings and yard tracks near point of production; in wet, spongy places in cuts and on bad fills; as sub-ballast on new work where dumps are settling; at places where the track heaves from frost; in retarding vegetable growth.

When the cost of loading cinders from the ash pit and laying down on the side of the track is charged against the ballast, it will not be found economical to haul cinders more than twenty miles, and consequently they are used mostly in the vicinity of division points.

The remarkable capacity of cinder ballast for absorbing water renders it more valuable than either stone or gravel in maintaining a dry track. During a heavy rain the water will seldom penetrate more than two inches from the top and dries out rapidly when exposed to the sun.

Cinder ballast has the disadvantage of being dusty in dry weather, and the sulphur it contains is generally conceded to have an injurious effect, tending to shorten both the life of the tie and the rail. The latter may very largely be obviated by so forming the ballast section that the bottom of the rail will be from two to three inches above the cinder. Cinders are also objectionable where track circuits, in connection with crossing bells, signals, etc., are maintained, on account of the readiness with which short circuits are formed. [Mr. Walter G. Berg has pointed out that the injurious action of the cinders on ties is offset by their tendency to keep down weeds.]

Chats.—Chats are tailings from mills in which zinc and lead ores are separated from the rock in which they occur, and their value as ballast is dependent on their hardness and size. There is considerable variety in these respects, though practically all of the product of the lead and zinc mines of Southwestern Missouri and Southeastern Kansas is suitable for ballast purposes. It gives a fair idea of the size to say it is about the same as shelled corn, or will pass a screen with half-inch mesh or possibly a little smaller. Chats are elastic; not dusty except at high speeds, and then only slightly; cheap to load, unload and handle under ties; hold well in both line and surface and particularly check growth of vegetation. They practically prevent the latter entirely. They wash more easily than stone or gravel of larger size; settle somewhat when first put in track and require a second surfacing to hold well; do not drain so well as larger crushed rock, and consequently churn when soil gets mixed with them or there is an insufficient thickness under the tie. To hold line on curves there should be a wider shoulder than with crushed rock, preferably 12 inches. Minimum thickness under tie for good results, 8 inches. The cost may be as low as 25 cents per yard in track. They are easily and cheaply loaded by hand. At the larger piles the steam shovel is economical.

Chert.—(Extract from letter addressed to R. Montfort, Chief Engineer, Louisville & Nashville Railroad, by T. D. Harrison, Assistant Engineer.) Chert is almost all pure silica and in this district (Birmingham, Ala.) is of three kinds—white, yellow, and pink—all of which are used for building roads. White chert is a clean chert and is not much account for building roads. Yellow chert and pink chert contain more or less clay and consequently pack and make an excellent road. Some of the chert in this district is found in strata, while that which is worked is principally drift chert, and found in large beds, broken up to a great extent, and can be worked easily by blasting from a large face.

Chert is similar in action under track to gravel containing clay, but on account of the stone begin sharp, where gravel is rounded off, the chert holds better than the gravel.

Slag.—Slag which is most uniform in size and heaviest in weight is most valuable for ballast purposes. These qualities depend largely on how it is made. Sometimes the slag is drawn from the furnace and run directly into long depressions or shallow ditches. This gives a number of slabs of half round section, 10 or 12 inches wide, sometimes called "hog wallow" slag, from the form of the depressions. This, of course, must be broken up with hammers or crushers before it is used. The large pieces may be used at the foot of the slope of the ballast to hold the smaller pieces in place, but are a decided disadvantage when they get under the tie. They must then be broken up with sledge before track can be surfaced.

The product is much more satisfactory where the slag is carried in a hot pot from the furnace and poured upon a dump. The dump, by reason of continued additions, may become almost a mountain, and many very large ones may be seen in the iron district of Alabama. While it might seem that this dump would be as solid as rock, having solidified from a melted state, this is not the fact. The application of a hot upper layer upon a cold one beneath appears to crack the latter in all directions, much as cold glass is cracked by hot water. The result is that the mass may, although with difficulty, be worked with pick and shovel. The usual way of loading is by steam shovel. A little powder is a decided help toward loosening and breaking the mass, whether for hand or shovel loading.

When the slag contains an excess of free lime or has been formed in thick layers, a large portion will be found to be spongy. This is likely to become pulverized under the track, cementing together, becoming difficult to work and churning in wet weather. The vitreous or glassy slag often breaks into pieces nearly cubical in form and of remarkable uniformity in size, the pieces being about one inch in each dimension. A slag dump will not run uniformly to one size or kind, however, and the run of the pile must be taken as it comes. There is a great deal of difference in the slag from different furnaces. To some extent it may be said that those that make the most perfect separation of iron from ore and flux make best slag for ballast. It is certain that any scattered masses of metallic iron are objectionable.

Slag ballast track usually requires a lift of 2 or 3 inches, and to be surfaced out of face at intervals of two to six years, depending on the quality of the material and the traffic it sustains.

Slag is cheaper in first cost than broken stone, but the cost of maintenance is somewhat higher and the effect upon the ties is said to be detrimental because of the chemical action.

Conclusions.—While there is great variation in the qualities of the different natural materials for ballast, the choice of these qualities is not usually left to the engineer, but has been made already by nature, and all that is left to decide is what is most available or most expedient. This each one must decide for himself in the light of his own circumstances. The question of finance may be a ruling consideration or there may be but one thing to be had, and he must take that or nothing.

In the case of crushed rock, however, there is a choice, and it is the conclusion of the Committee, in the light of arguments presented, that stone ballast made from hard, durable stone, broken in sizes from ¾-inch to 1½ inches, having a depth under tie of 12 inches, resting on a firm, well-drained roadbed, will best meet the requirements of roads with heavy traffic, large engines and fast survice.

Standard Regulations for Fire-Proof Buildings.

Abstract of the National Board of Fire Underwriters' Suggestions to be Incorporated in Building Laws.

Elevator Inclosures.—All elevators placed in any building shall be entirely inclosed in suitable walls of brick, or with a suitable framework of iron and burnt clay filling, or with such other fireproof material and form of construction as may be approved by the Inspector of Buildings, except that the inclosure walls of elevators in non-fireproof buildings exceeding 3 stories in height and used as ware-houses, factories, and stores shall be of brick. In fireproof buildings, when the construction of the elevator inclosure is of iron and burnt clay filling or other approved materials the said construction shall not be less than 6 inches in thickness. Said walls or construction in all cases shall extend through and at least 3 feet above the roof.

All door openings in any said inclosures shall be provided with approved fireproof doors made solid for their full height and hung to rabbited iron frames or to eyes built into the wall, and shall have iron door sills of the full width and length of the openings. Lights of wired glass, in approved metal frames, may be placed in such doors, but no one pane shall exceed in area 250 square inches between muntins or dividing bars.

All window openings in any said inclosing walls or construction opening from the shaft to within the building shall have window frames of metal or of wood covered with metal and fixed sash of metal of the kind approved by the National Board of Fire Underwriters, and the sash shall be glazed with wired glass, no pane of which shall exceed 250 inches between dividing bars.

The roofs over all elevator inclosures shall be made of fireproof materials, with a metal skylight at least three-fourths the area of the shaft and glazed with glass not over one-twelfth of an inch thick covered above and below with strong wire netting, but wired glass shall not be used in lieu of this requirement.

Openings in Floors and Roofs for Light.—All openings in floors for the transmission of light to floors below shall be covered over with floor lights constructed of metal frames and bars and glazed with suitable glass not less than three-quarters of an inch in thickness, and the floor lights shall be of the same proportional strength as the floors in which they are placed.

All openings in roofs for the transmission of light other than elsewhere provided in this ordinance over elevator and stair shafts shall have metal frames and sash, glazed with not less than one-quarter-inch thick wired glass or with glass protected above with wire screens.

Every fireproof roof hereafter placed on any building shall have, besides the usual scuttle or bulkhead, a skylight or skylights of a superficial area equal to not less than one-fiftieth the superficial area of such fireproof roof, and glazed as other skylights are required to be in this section.

Ducts for Pipes.—All ducts for pipes, wires, and other similar purposes shall be inclosed on all sides with fireproof materials, and the opening through each floor shall be properly fire-stopped. Any door opening in such duct shall be provided with a fireproof self-closing door. If the area of such duct exceeds four square feet the thickness of such fireproof inclosure shall be not less than four inches, and shall extend by a proper fireproof outlet to and through the roof.

Ducts for Ventilation.—Ducts for the removal of foul or vitiated air in which the temperature of the air cannot exceed the temperature of the room, if passing through any door, partition, room, or roof shall be constructed of suitable incombustible material. In buildings of fireproof construction ventilating shafts passing through floors shall be constructed of fireproof material not less than 4 inches in thickness, and any opening in same shall be protected by automatic closing doors or by metal louvres riveted into metal frames.

Pipes Passing Through Floors.—In chases in walls for water or other pipes, the chases around said pipes shall be filled up with solid fireproof material for the space of one foot at the top and bottom of each story.

Steam or hot-water heating pipes, passing through floors, shall be provided both at the floor and ceiling line with metal caps of sufficient size to fully cover the open space surrounding any and all such pipes; and any cold water or other exposed plumbing pipes shall have the surrounding air space closed off at the ceiling and floor line of any floor through which any such pipe or pipes shall be carried.

No opening in any floor or roof shall be without a solid covering or an inclosure, as provided in this ordinance, to prevent the communication of fire from story to story.

Stair Hall Inclosures.—In all stores, warehouses and factories the staircase halls shall be inclosed with suitable walls of brick, or with burnt clay blocks set in iron frames, or such other fireproof materials and forms of construction as may be approved by the Inspector of Buildings, except that the inclosure walls in such buildings exceeding three stories in height shall be of brick. Said walls or construction shall be continuous and extend at least 3 feet above the roof. The roof over the stair hall inclosure shall be covered with a metal and glass skylight at least three-eighths of the area of the inclosure, and constructed and glazed as required for skylights over elevator inclosures. All door openings in such stair hall inclosures shall be provided with self-closing fireproof doors and frames, and all window openings shall have window frames of metal or wood covered with metal, and the window sash shall be fixed sash of metal and glazed with wired glass. At least one of such inclosed stair halls in each of said buildings shall have a like connecting inclosure hallway in the first story and extend to the street, and all door or window openings in the same shall be provided with doors and windows as provided for openings in the stair hall inclosures.

In all fireproof buildings, other than stores, warehouses and factories, if exceeding three stories and 40 feet in height, the stair halls shall be inclosed on each story with fireproof material, same as required for elevators, to so form an inclosure the floor area of which shall not be more than three times the united area of the floor openings for the elevators and stairs.

Fireproof Buildings.—Every building hereafter erected or altered to be used as a theatre, lodging-house, school, jail, public station, hospital, asylum, institution for the use, care or treatment of persons, the height of which exceeds three stories and not more than 40 feet in height, and every building hereafter erected or altered to be used as a hotel, which exceeds four stories and not more than 50 feet in height, excepting all buildings for which specifications and plans have been heretofore approved by the proper authorities, and every other building the height of which exceeds 55 feet or more than four stories in height, shall be built fireproof, that is to say—

They shall be constructed with walls of brick, stone, Portland cement concrete, iron or steel in which wood beams or lintels shall not be placed, and in which the floors and roofs shall be constructed with rolled wrought-iron or steel floor beams, so arranged as to spacing and length of beams that the load to be supported by them, together with the weights of the materials used in the construction of the said floors shall not cause a greater deflection of the said beams than one-thirtieth of an inch per foot of span under the total load; and they shall be tied together at intervals of not more than eight times the depth of the beam with suitable tie-rods.

Between the floorbeams shall be placed brick arches springing from the lower flanges of the steel beams, or the spaces between the beams may be filled with hollow tile arches of hard-burnt clay or porous terra cotta, or arches of Portland cement reinforced with metal, or such other fireproof composition may be used, provided that in each and all cases the strength and method of construction shall be acceptable to the Inspector of Buildings.

The stairs and staircase landings shall be entirely of brick, stone, Portland cement concrete, iron or steel.

No woodwork or other inflammable material shall be used in any of the partitions, furrings or ceilings in any such fireproof buildings, excepting, however, that when the height of the building does not exceed eight stories nor more than 100 feet, the doors and windows and their frames and trims, the casings, the interior finish when filled solidly at the back with fireproof material, and the floor boards and sleepers directly thereunder, may be of wood, but the space between the sleepers shall be solidly filled with fireproof materials and extend up to the floor boards.

When the height of a fireproof building exceeds eight stories, or more than 100 feet, the floor surfaces shall be of stone, cement, rock asphalt, tiling or similar incombustible material, or the sleepers and floor boards may be of wood treated by some process approved by the Inspector of Buildings, to render the same fire-retarding. All outside window frames and sash shall be of metal, or of wood covered with metal.

The inside window frames and sash, doors, trim and other interior finish may be of wood covered with metal, or of wood treated by some process approved by the Inspector of Buildings to render the same fire-retarding.

All hall partitions or permanent partitions between rooms in fireproof buildings shall be built of fireproof material, and shall not be started on wood sills, nor on wood boards, but be built upon the fireproof construction of the floor and extend to the fireproof beam filling above.

The tops of all door and window openings in such partitions shall be at least 12 inches below the ceiling line.

Incasing Structural Iron and Steel Work.—The bottom flanges of all wrought-iron or rolled steel floor and flat roof beams, and all exposed portions of such beams below the abutments of the floor arches shall be entirely incased with hard-burnt clay, porous terra cotta or other fireproof material corresponding to the filling between the beams, such incasing material to be properly secured to the beams. The exposed sides and bottom plates or flanges of wrought-iron or rolled steel girders supporting iron, or steel floorbeams, or supporting floor arches or floors, shall be entirely incased in the same manner.

All cast-iron, wrought-iron or rolled steel columns, including the lugs and brackets on same, used in the interior of any fireproof building, or used in any building to support any fireproof floor shall be protected with not less than 4 inches of fireproof material, securely applied. The extreme outer edge of lugs, brackets and similar supporting metal may project to within seven-eighths of an inch of the surface of the fireproofing.

In skeleton constructions where columns are used to support iron or steel girders carrying inclosure walls, the said columns shall be of cast-iron, wrought-iron, or rolled steel, and on their exposed outer and inner surfaces be constructed to resist fire by having a casing of brickwork not less than 8 inches in thickness on the outer surfaces, nor less than 4 inches in thickness on the inner surfaces, and all bonded into the brickwork of the inclosure walls. The exposed sides of the iron or steel girders shall be similarly covered in with brickwork not less than 4 inches in thickness on the outer surfaces and tied and bonded, but the extreme outer edge of the flanges of beams, or plates or angles connected to the beams, may project to within 2 inches of the outside surface of the brick casing. The inside surfaces of the girders may be similarly covered with brickwork, or if projecting inside of the wall, they shall be protected by terra cotta, concrete or other fireproof material.

In all buildings hereafter erected or altered, where any iron or steel column or columns are used to support a wall or part thereof, whether the same be an exterior or an interior wall, and columns located below the level of the sidewalk which are used to support exterior walls or arches over vaults, the said column or columns shall be protected with not less than 4 inches of fireproof material securely applied, except protected columns shall not be required for walls fronting on streets or courts.

Floor Areas in Stores, Warehouses and Factories.—In all non-fireproof stores, warehouses and factories, in case iron, steel or wood columns, or piers of masonry, are used in place of brick partition walls the buildings between partition walls of a thickness corresponding to the main bearing walls—

When extending from street to street may cover an area of not more than 6,000 square feet;

Or when otherwise located fronting on one street only, may cover an area of not more than 5,000 square feet;

Or when such a building fronts on three streets it may cover an area of not more than 7,500 square feet;

Or if a corner building fronting on two streets it may cover not more than 6,000 square feet;

In all stores, warehouses and factories, not exceeding 55 feet in height which may be built fireproof, the areas between brick partition walls of a thickness corresponding to the main bearing walls, may be 100 per cent. greater than the areas stated hereinbefore in this section for non-fireproof buildings. But in case any such fireproof building exceeds the height of 55 feet, the areas between brick partition walls of a thickness corresponding to the main bearing walls may be the same, but no greater, than the areas hereinbefore stated in this section for non-fireproof construction;

Provided, however, in case the foregoing described buildings are completely equipped with a system of automatic sprinklers in a manner approved by the......................Board of Fire Underwriters, the areas between the brick partition walls may be increased as follows:

For the non-fireproof constructed buildings, the respective areas hereinbefore stated may be increased 50 per cent.;

For fireproof constructed buildings not exceeding 55 feet in height, the respective areas hereinbefore stated may be increased 33 1/3 per cent.; and,

For the fireproof constructed buildings exceeding 55 feet in height, the respective areas hereinbefore stated may be increased 33 1/3 per cent.

The automatic sprinkler system hereby required shall be installed and kept in perfect working order by the owner, lessee or occupant of the premises.

Openings in the brick partition walls of buildings specified in this section shall in no case exceed 8 feet in width, and above each such opening there shall be a brick curtain wall between the top of the opening and the ceiling line of at least 3 feet. The openings shall be provided with approved automatic self-closing fireproof doors on both sides of the openings.

When more than two fireproof or non-fireproof buildings communicate although protected by double fireproof doors, they shall be provided with a system of approved automatic sprinklers where occupied as stores, warehouses and factories.

Stairs, Number of, in Proportion to Floor Areas.—In any building hereafter erected to be used as an office building, a store, factory, hotel, lodging-house, or school covering a lot area—

Exceeding 2,500 feet and not exceeding 5,000 feet, there shall be provided at least two continuous lines of stairs remote from each other;

And every such building shall have at least one continuous line of stairs for each 5,000 feet of lot area covered, or part thereof, in excess of that required for 5,000 feet of area.

When any such building covers an area of lot greater than 15,000 feet the number of stairs shall be increased proportionately, or as will meet with the approval of the Inspector of Buildings.

Electrical Work.—No electrical wiring or installation of electrical apparatus or appliances for furnishing light, heat and power shall be introduced into or placed in any building or structure in the city of.............., except in compliance with the rules and regulations of the National Board of Fire Underwriters, known as the "National Electric Code," and the said rules and regulations are hereby made a part of the requirements of this ordinance. No such electrical wiring, apparatus or appliances shall be placed in service until a certificate of approval of same has been issued by the ....Board of Fire Underwriters. The installation of all such electrical work shall be subject to the approval of the Inspector of Buildings.

Fireproof Shutters and Doors.—Every building which is more than two stories in height above the curb level, except dwelling-houses, hotels, schoolhouses and churches, shall have fireproof doors, blinds or shutters hung to iron hanging frames or to iron eyes built into the wall, on every exterior window and opening above the first story thereof, and excepting on the front openings of buildings fronting on streets which are more than 30 feet in width, or where no other buildings are within 30 feet of such openings.

The said doors, blinds or shutters may be constructed of pine or other soft wood of two thicknesses of matched boards at right angles with each other, and securely covered with tin, on both sides and edges, with folded lapped joints, the nails for fastening the same being driven inside the lap; the hinges and bolts or latches shall be secured or fastened to the door or shutter after the same has been covered with tin, and such doors or shutters shall be hung upon an iron frame, independent of the woodwork of the windows and doors, or to iron hinges securely fastened to the masonry; or such frames, if of wood, shall be covered with tin in the same manner as the doors and shutters.

On any opening where the window frame and sash are of metal, or of wood covered on the outside with metal, and the sashes are glazed with wired glass not less than one-quarter of an inch in thickness, and each pane measuring not more than 600 square inches, no fireproof shutters shall be required.

All shutters opening on fire-escapes, and at least one row, vertically, in every three rows on the front window openings above the first story of any building, shall be so arranged that they can be readily opened from the outside by firemen.

All rolling iron or steel shutters hereafter placed in the first story of any building, shall be counter-balanced so that said rolling shutters may be readily opened by firemen.

No building hereafter erected, other than a dwelling-house or fireproof building, shall have inside iron, steel or other fireproof shutters to windows above the first story.

All windows and openings above the first story of any building may be exempted from having shutters by the Inspector of Buildings upon filing in the Department of Buildings a petition on suitable blanks to be furnished to applicants by the said department, by the owner or lessee of the property, or the agent of either, requesting exemption, or a partial exemption, or a modification of the requirement for shutters; but no such exemption or modification shall be granted by the Inspector of Buildings until such petition shall have been referred by him to the Chief of the Fire Department for examination, and a report and recommendation thereon is received from the said Chief.

All buildings specified in this section, hereafter erected or altered, having openings in interior walls, shall be provided with suitable fireproof doors where deemed necessary by the Inspector of Buildings, and to be provided with approved automatic self-closing devices.

All occupants of buildings shall close all exterior and interior fireproof shutter, doors and blinds at the close of the business of each day.

Fire Appliances.—Every building unless already provided with a 3-inch or larger vertical pipe, which exceeds 100 ft. in height and in every building hereafter to be erected exceeding 85 feet in height and when any such building does not exceed 125 feet in height it shall be provided with a 4-inch stand-pipe, running from cellar to roof, with one two-way 3-inch Siamese connection to be placed on street above the curb level, and with one 2½-inch outlet, with hose attached thereto on each floor, placed as near the stairs as practicable; and all buildings now erected, or hereafter to be erected, unless already provided with a 3-inch or larger vertical pipe, exceeding 100 feet in height, shall be provided with an auxiliary fire apparatus and appliances, consisting of water tank on roof, or in cellar, stand-pipes, hose, nozzles, wrenches, fire extinguishers, hooks, axes and such other appliances as may be required by the Fire Department; all to be of the best material and of the sizes, patterns and regulation kinds used and required by the Fire Department.

In every building exceeding 100 feet in height a power pump and at least one passenger elevator shall be kept in readiness for immediate use by the Fire Department during all hours of the night and day, including holidays and Sundays. The said pumps, if located in the lowest story, shall be placed not less than 2 feet above the floor level. The boilers which supply power to the passenger elevators and pumps, if located in the lowest story, shall be so surrounded by a dwarf brick wall laid in cement mortar, or other suitable permanent waterproof construction, as to exclude water to the depth of 2 feet above the floor level from flowing into the ash pits of said boilers. When the level of the floor of the lowest story is above the level of the sewer in the street, a large cesspool shall be placed in said floor and connected by a 4-inch cast-iron drain pipe with the street sewer.

Any building which may have been erected prior to the enactment of this ordinance, exceeding 125 feet in height, and not now equipped with stand-pipes, shall be provided with such pipes not less than 6 inches in diameter. All stand-pipes shall extend to the street and there be provided at or near the sidewalk level with Siamese connections. Said stand-pipes shall also extend to the roof. Valve outlets shall be provided on each and every story, including the basement and cellar, and on the roof.

If any of the said buildings extend from street to street, or form an L shape, they shall be provided with stand-pipes for each street frontage.

In such buildings as are used or occupied for business or manufacturing purposes there shall be provided, in connection with said stand-pipe or pipes, 2½ automatic sprinkler pipes placed on and along the ceiling line of each floor below the first floor and extending to the full depth of the building. Said sprinkler pipes shall be provided with a valve placed at or near the stand-pipes, so that water can be let into same when deemed necessary by the firemen. When the building is 25 feet or less in width, two lines of sprinkler pipe shall be provided, and one line additionally for each 12½ feet or part thereof that the building is wider than 25 feet. A suitable iron plate with raised letters shall be fastened to the wall near said stand-pipe to read: "This stand-pipe connects to sprinkler pipes in cellar."

Book Notes.

The New York State Engineer has issued a 104-page pamphlet containing a full report of the proceedings of the fifth annual good roads convention of the boards of supervisors in the State. This meeting was held to discuss all the aspects of road building under the State-aid law, and is correspondingly valuable as indicating the condition of such work at the present time. Most of the discussions related to financial affairs, but some engineering information is given and there are many excellent engravings of highways built under the State Engineer's supervision. The illustrations of roads are accompanied by notes explaining the construction used in each case and occasionally furnishing a statement of the amount of repairs needed since the road was put in service.

A fifteenth edition of A. E. Seaton's "Manual of Marine Engineering," a work long and favorably known as a standard in the field of marine design, has just appeared. The work as a whole is divided into 26 chapters of which three are new, while three in particular contain important new material. Of the new chapters, one deals with the weight of marine machinery in its various relations to the performance of the ship, and as affected by the various circumstances of the design, and the second with inertia forces and the balancing of engines. This general topic has become of the greatest importance in recent years, and every marine designer must be competent to deal intelligently with the problems which the investigation of the balancing of inertia forces presents. Both analytical and vector methods are given, the latter being naturally preferred for obtaining combination effects. The treatment is clear and sufficiently comprehensive for all usual purposes of the designer of marine engines. In the third new chapter the author gives an interesting and valuable discussion of oils and lubrication, a topic to which usually but scant reference is made in the general literature of engine design. As a whole, this book covers the broad field of the design of marine machinery, including engines, boilers, auxiliaries and fittings, as well as propellers and paddle wheels, and with reference to both general dimension and structural detail. The high favor in which it has been held from the first edition in 1883 is an index of the need for such a work and of the satisfactory manner in which this has filled the requirements. The present edition marks a most decided advance over the preceding editions. [New York, D. Van Nostrand Co.; 700 pages, $6.]

The "Proceedings" of the eleventh annual meeting of the Society for the Promotion of Engineering Education, which has just appeared, was sent out for review accompanied by a statement that one of the most important papers in it was "a valuable report by a strong committee on technical books for public libraries." As the reviewer has but recently been compiling some notes from practicing engineers of large experience regarding the books they found most useful, he naturally turned to this pedagogical list. The number of important books omitted and poor ones given is surprising. Burr's "Materials of Engineering," one of the most scholarly and scientific as well as practical American works, is omitted under "Materials;" in the section on drawing no mention is made of Wilson's "Free-hand Perspective" and "Free-hand Lettering," two books that every young engineer should master thoroughly; under steam and gas engineering, Monroe's unique book on heating and ventilation is overlooked as is Seaton's famous treatise on the marine engine; Richard's book on compressed air, everywhere acknowledged to be the best work on the subject, is unnoticed; in the numerous divisions of electricity, the search for Steinmetz's classic treatises will prove vain; Merriman's "Treatise on Hydraulics," a book no engineering library should be without, has been forgotten. In fact, the list is a very poor one and no public library should adopt it. The portion of the book relating to the teaching of engineering is very interesting, and it is encouraging to notice running through all the volume an evident spirit of high endeavor to make instruction in technical schools thoroughly scientific yet distinctively useful, as compared with what are commonly called culture studies. [New York, Engineering News Pub. Co., cloth, 9x6 ins., 400 pages, $2.50.]

At the meeting of the British Association last year, Prof. James Swinburne read a paper on the reversibility of thermodynamics, which was presented to draw from specialists in that subject criticisms of the author's views on teaching this branch of physics to engineering students. The criticisms amounted to little, however, so the author's views were subsequently presented much more fully in a series of papers in "Engineering," of London. These have since been arranged for publication in a small book entitled "Entropy, or Thermodynamics from an Engineer's Standpoint." The author's reason for continuing to urge the subject in the face of some coldness from others is explained as follows: "As a young man I tried to read thermodynamics, but I always came up against entropy as a brick wall that stopped my further progress. I found the ordinary mathematical explanation, of course, but no sort of physical idea underlying it. No author seemed even to try to give any physical idea. Having in those days great respect for text-books, I concluded that the physical meaning must be so obvious that it needs no explanation, and that I was especially stupid on that particular subject. After a few years I would tackle the subject again, and always was brought up dead by the idea of entropy. I asked people, but I never met any one who could tell me, and I met one, an engineer, who admitted he did not know. Not only could I get no physical idea of entropy, but the definition of entropy and the statements about it did not make sense as soon as one tried to understand irreversible changes. Later on, instead of making the common mistake that elementary books are easy to understand I got into the study of irreversible thermodynamics by the road of physical chemistry, and found that my previous troubles were due to inaccurate definitions and faulty analogies on the part of writers who had an incomplete grasp of thermodynamics. Having once got accurate and consistent definitions, it is not so difficult to get some sort of physical idea of entropy." The book is very interesting and written in a style most unusual and outspoken. Of the theta-phi diagram, for example, it is said: "It will be treated with great respect, because people always respect what they do not understand, especially if it looks at all mathematical." The author believes in the diagram, but not as it is usually taught. As for entropy, he considers it as the sum of quantities having only one property in common and therefore without any single physical meaning except as regards the results of its increase. Splitting up heat into factors and abolishing the idea of entropy except as the sum of the quantity factors and the expansion function will, he is convinced, make the study of thermodynamics more simple. At a later time, these views may be considered more in detail; the purpose of this note is merely to call attention to this interesting book. [London, Archibald Constable & Co.; cloth, 7x5 ins., 150 pages, 4s. 6d.]

The Non-Metallic Minerals. Their Occurrence and Uses. By Geo. P. Merrill. New York, John Wiley & Sons; cloth, 9x6 ins., 422 pages, $4.

In the discharge of his official duties as head curator of geology in the U. S. National Museum, Mr. Merrill prepared several years ago a guide to the study of the collections of that institution. In the course of this work he collected a great number of notes and references relative to the occurrences and uses of valuable minerals other than ores of metals. This material has been utilized as the basis of the volume bearing the above title. In its general character it is throughout a compilation rather than a new treatise, which is fortunate because such a broad subject can only be handled satisfactorily by many references to other publications. It is evident in some places that the author's information was derived from antiquated sources; on page 143, for example, occurs the following paragraph: "Several brands of Portland cement are manufactured in America, usually from a mixture of materials, the proportions of which have been worked out by experiment. At the Coplay cement works, in Lehigh County, Pa., a blue-gray crystalline limestone and dark-gray more siliceous variety are ground and mixed in the desired proportions, molded into a brick and burnt to the condition of a slag. The material is then ground to a powder and forms the cement." While these statements are true they give a wholly erroneous idea of the American cement industry.

The minerals are classified according to their chemical nature and not by the element at their base; accordingly the various sections are arranged so as to present together all non-metallic elements occurring naturally, then the sulphides and arsenides, halides, oxides, carbonates, silicates, niobates and allied groups, phosphates and vanadates, nitrates, borates, uranates, sulphates, the hydrocarbon group and finally the miscellaneous minerals that fall under none of the preceding heads. The physical properties of each mineral are described, the places where it is found are mentioned, and its uses are explained in a very general way. The style is sketchy throughout, and it would be impossible to recognize some of the minerals from the descriptions of them in this book.

The Truth About the Trusts. A Description and Analysis of the American Trust Movement. By John Moody. New York, Moody Publishing Co.; cloth, 6x9 ins., 536 pages, numerous plates, $5.00.

There are to-day in this country about 450 corporations of a trust character having a floating capital considerably over $20,000,000,000. Of these there are seven so great as to far overshadow the others, and at their present market value, considerably over a half are more or less controlled by a small group of men of whom John D. Rockefeller is the head. The remainder are largely influenced by the group of financiers who look to J. P. Morgan for inspiration. In the minor industrial, public service and railway trusts the same division of control probably exists, although it is not so directly apparent. It is self-evident that these facts merit the careful attention of everybody. The centralization of power has been so rapid that it is inevitable that it should be abused and that it should be foolishly criticised.

In order to study any subject successfully it is absolutely essential to have facts as a basis of the investigation. Almost all discussion of the trust problem is based on prejudice and political aspirations, and is correspondingly dangerous. At the present time this is particularly so, for great wealth and powerful newspapers will shortly be used to inflame public opinion against capital in the approaching presidential campaign. Under the circumstances Mr. Moody's statistical and historical work is of timely value, particularly as it carries the authority for accuracy which his name guarantees and is written in a sane and scientific spirit.

A large part of the work is devoted to the seven great industrial trusts, their history and analysis of their position. The minor industrial trusts, over eighty in number, are then taken up in a similar manner, but more briefly. Finally the industrial trusts in process of reorganization are discussed thoroughly. The public service and railway trusts are next taken up, and a large amount of statistical information regarding them is introduced in a clear and readable manner. Charts are employed to emphasize the importance of some of the figures, and some very instructive diagrams are given to show the relations of various companies. A condensed table is also given of the financial affairs of all the companies of a trust character.

The book closes with a general review of the trust movement, the magnitude and dominating influences of these corporations, their chief characteristics and the so-called remedies. In these chapters, Mr. Moody shows that the trust was the result of evolution, which has steadily worked to place the control of affairs in the hands of the men with power to exercise it. Legislation, in his opinion, cannot prevent evolution, and the only successful laws will be those which preserve equal individual liberty and the free working of natural tendencies. Otherwise socialism and all it signifies may be expected in a few generations.

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The Pioneer Steam Road to Run Electric Trains in Suburban Service.

It is certainly somewhat disconcerting to a belief in American precedence in matters electrical to notice the approaching successful termination of the arrangements for handling the heavy suburban traffic from and into the Liverpool terminus of the Lancashire & Yorkshire Railway. Although the New Haven road made experiments with electricity at Nantasket Beach and is running an interurban electric line in Connecticut and the Pennsylvania road conducted experiments on its Mount Holly branch, it has been reserved for two English companies to lead in substituting electricity for steam for important main line business. It might as well be acknowledged that the Lancashire & Yorkshire Railway, or possibly the North Eastern Railway, will be the pioneer in this particular branch of service, and content ourselves with the confident expectation that while America is not the first it will soon be the leading exponent of this method of handling the local business of important cities.

In the case of the Lancashire road, the new system of operation was forced upon the company as an alternative to very costly additions to its tracks and terminal facilities. Its suburban business into Liverpool from Southport, 18½ miles distant, and intermediate points was as heavy as could be handled by locomotives with the existing facilities. There were 74 trains each way daily for this traffic, and two platform tracks were set apart for it at the Liverpool station. The handling of the trains into and out of this station, which is a terminal one, involved four distant operations, and the time required for them limited the capacity of the station in this respect. To secure more land for additional tracks would be very costly, and the general manager, Mr. J. A. F. Aspinall, accordingly recommended the adoption of electric means for increasing the service. Engineers who recall the prolonged controversy over the operation of trains on the Brooklyn Bridge will understand that the situation in Liverpool was the same as that in New York, and its solution has been the same, viz., the reduction of terminal switching movements by eliminating the locomotive and the operations entailed by its use. This makes it possible to handle approximately double the number of trains in the same time, and it is interesting to learn that as a result of the installation of its electrical system the Lancashire & Yorkshire management proposes to increase its suburban service from 74 to 119 trains daily each way.

There is another feature of this change that appeals strongly to the local passenger. It is perfectly well known to those who read the comic papers that the amenities of life in the suburbs are rudely jarred at times by the lack of respect shown for the running schedules by those who control the destinies of these local trains. This unfortunate fact may add to the printed humor of the land, but it does not appeal in such a ludicrous manner to those who wait in the trains wondering what has happened. The Engineering Record has long been confident that the running of suburban trains by electricity would prove a great success, when the equipment is well designed for the purpose, on account of the increased facility afforded by it for the actual management of trains. A proper equipment should enable the engineer to accelerate his trains far more rapidly than is possible with a steam locomotive and also stop them more quickly. It has been found that with the 140-ton Liverpool trains, which were briefly described on February 6 in this journal, a speed of 34 miles an hour can be reached in half a minute. It is not proposed to make any such starts in practice, of course, for their effect on the central station would be too severe, but they show what can be done in an emergency. Consequently, the handling of the trains along the line will be so improved that delays at stations can be made up in a manner impossible with steam locomotives where stops are frequent, and in this way one of the greatest drawbacks of suburban traffic can be reduced.

It has been mentioned that the Lancashire & Yorkshire directors are not the only board in England which have determined to operate main-line trains electrically. The directors of the North Eastern road decided some time ago to follow this plan and their installation is so far advanced that it is possible they will have the honor of running the first trains electrically in regular service. Just which company actually wins the honor is not so much a question to Americans, however, as the fact that the honor will not come to this country.

The Portland Landslide.

Several months ago, The Engineering Record took occasion, in connection with some comments on the landslide at the railway tracks at Cleveland, to point out the dearth of information on this subject in American technical literature. It is therefore proper to call attention to a very valuable paper by Mr. D. D. Clarke on "A Phenomenal Landslide," which will be presented before the American Society of Civil Engineers next Wednesday. Readers of this journal have had some information concerning this remarkable landslide, but comparatively few facts concerning it have ever been made public up to the present time. In some respects the phenomenon is the most important of its character that ever occurred in this country. The city of Portland built ten years ago four reservoirs, of which two, with a joint capacity of about 24,000,000 gallons, occupy a narrow ravine about two miles west of the business center of the city. One of these basins was about 70 feet above the other, and the two were formed by dressing down the banks of the ravine. After their completion, their western slopes were seriously injured by a movement of the adjacent hillside. For a time this movement was not at all understood, and was believed to be due to faulty construction, although this is now known to be an unwarranted supposition. Since then the slip has been found to extend nearly the full length of both reservoirs, a distance of about 1,100 feet. This sliding tract covers about 30 acres and the volume of the moving mass has been estimated at 3,400,000 cubic yards.

This slide has prevented the use of the reservoirs and brought prolonged litigation on the city. Fortunately, it has now been thoroughly investigated and remedied, and Mr. Clarke's valuable paper gives a full account of the manner in which the investigations were carried out and the many important results they yielded. In some respects the information he affords exceeds in value that in any of the foreign publications on the subject. The German literature mainly relates to very small landslides or those in rock. This is a case of a vast slide in which a mass of rotten rock and clay slipped over a hard rock surface. Water was present and it is interesting to learn that the final remedy for the condition has been drainage, the remedy that almost invariably proves most successful in smaller work.

In this particular case drainage tunnels have been run in various directions over the hard rock surface, amounting in all to about 2,500 feet and costing an average of $5.65 per foot. Very careful observations have been made to show the effect of these tunnels on the sliding mass, and it was soon discovered that the movement decreased regularly as the tunnel work progressed. The average flow of water from the tunnels varies from 10,000 gallons a day in summer to 50,000 gallons in winter, and may rise to 75,000 gallons during short periods after heavy rainfalls. The results achieved have been particularly gratifying, for at an expense of only $31,000, this enormous slip has now been stopped and the two basins affected, supplying the western district of the city, will become serviceable as soon as their linings have been repaired. For a number of years statements appeared more or less regularly to the effect that the two reservoirs could never be used and that their location and construction was a huge engineering blunder. They are not yet in use, it is true, but the voluminous data which Mr. Clarke has furnished on this very important subject leave little reason for doubt that the outcome of these many years of skilful patient engineering work will be satisfactory.

The Flood Danger at Kansas City.

The terrible floods that occurred at Kansas City last year are still fresh in the minds of every one, and for this reason attention is particularly called to a report recently made by Col. Amos Stickney, Major J. G. Warren and Capt. H. M. Chittenden, Corps of Engineers U. S. A., on the reasons for the great damage done to that city and in the vicinity. They report, in effect, that the Kaw River for a distance of about three miles above its mouth, is in a condition constituting a positive menace to life and property on its banks. The channel has been encroached upon by riparian owners until its normal average width of about 850 feet (minimum 540 feet) as shown by surveys of 1856, is reduced to an average of about 590 feet, with a minimum at one place of 420 feet. As if that were not enough, bridges have been built with more piers than are necessary, and these have not been carried down to rock but have been founded on piles which were protected against scour by enormous quantities of loose rock, forming little islands. Between these piers the piling of the falsework used in erection has often been left, the tops being at about low-water level where the upper part was cut off. In addition to these obstructions dikes have been run out into the river from both banks.

As a result of this encroachment, the natural channel of the stream has been materially diminished, its bottom made so rigid that it will not yield to scour during high water and its original flood-carrying capacity reduced probably about one-half. At the present time, its condition is even worse, for over a dozen bridges lie in the bed of the stream, clogged with the enormous mass of wreckage brought down by the last flood. The sites of these bridges are occupied by the piling for new structures and the resulting situation is said to be such that even an ordinary flood will cause serious damage.

The restriction of the waterway by so many and such important interests makes the problem of its improvement a difficult one. The engineer officers suggest that if the channel is to be left in its present location the following measures must be taken: "The river to be restored to a width of at least 734 feet; masonry walls to be built on each bank, reaching to an approximate height of 30 feet above low water and extending for a distance of 17,000 feet above the mouth; the bed of the river to be dredged free of all solid obstructions to a depth of 15 feet below low water; bridges to be limited to two river piers 300 feet apart, measured in a line perpendicular to the center line of the channel and to be carried down to rock, and the lowest points of the superstructure to be above the flood line of the improved channel; above the place where the pressure for space necessitates river walls earth levees with paved slopes to be carried to bluff contacts above Argentine and Armourdale."

Such a program is a radical and expensive one which will take a long time to carry out, even if it is ever forced upon those interested, which is problematical. Until it is adopted, however, the board advises that further encroachments on the banks be stopped and those now existing be removed so as to give the channel a free average width of 600 feet. The channel should also be cleared of obstructions to a depth of 15 feet below low water and the bridge owners should "be required to remove obstructions around or between existing piers and to reconstruct their bridges with only two piers" as before mentioned. The subject is one that should receive immediate attention, in the opinion of these engineers, who consider the present situation fraught with great danger. Either the government or the city should take action without delay, in their opinion, and the general desire is said to be for the federal authorities to take the work in hand. It is stated that any such undertaking will be opposed, however, by the parties who have encroached on the river, for they fear the expense of removing the obstructions.

These statements are of far more than local importance. They indicate that, in the opinion of eminent engineers, the damage from the floods at Kansas City last year were mainly due to the obstruction of the normal river channel by various works which should never have been placed there. This opinion other engineers also have expressed. Many times it has been predicted that the railways whose bridges and bridge approaches were obstructing the channel of the Kaw would pay dearly for their encroachment on its natural waterway, for it is an elementary axiom of engineering that nature can be teased in this way until she passes into a condition of ungovernable fury against which man and his works are powerless. That is the lesson of the Kansas City floods, and the fact that a board of engineer officers, wholly impartial in their views, have repeated it officially ought to carry great weight. The proposed improvements will be very costly, but what is their expense to the loss of life and property that a repetition of the flood of last year will bring upon the cities at the mouth of the Kaw?

Methods of Carrying on Construction.

As the season approaches when construction will again be undertaken vigorously, The Engineering Record desires to urge its readers connected with such work, both engineers and contractors, to send it for publication notes, sketches and photographs concerning all interesting methods of conducting work. No inconsiderable portion of the success attending the execution of engineering works in this country is due to the methods and plant employed in the field. In fact, there are certain branches, particularly bridge work, in which satisfactory designing is only possible when methods of construction are fully understood in detail. It sometimes happens that even in such simple work as pipe laying and sewer construction, the cost would have been much lower and the results as good had the designs been drawn with more complete knowledge of the best methods of meeting the local conditions. In foundation work it is often desirable to give a contractor great leeway, for the original plans and specifications may impose conditions making the cost far greater than necessary. This is particularly true in soils containing much groundwater, where such novelties as concrete piling, for example, may be able to secure desired results with unexpected economy.

The most serious defect in the literature of civil engineering to-day is the paucity of reliable data concerning the construction of different classes of works of a civil engineering nature. Design is largely standardized and the real novelties of a character useful in the office are very few indeed. It is in the field that the great improvements are taking place, and it is for this reason that for many years past The Engineering Record has printed so much information about the manner in which construction is being carried on. It is believed that no other publication in any language has devoted so much space to articles of this nature, but even this showing is not satisfactory to the managers of the paper and the attention of its readers is particularly called to the following statement of the reason.

Construction work in all parts of this country cannot be properly covered by the permanent staff of a technical journal. The area of the country is too great for personal visits to all sections. The Engineering Record has editorial representatives engaged exclusively on such work in New York, Cleveland, Chicago and San Francisco, and it has arrangements with engineers in many other cities who give it a part of their time. In this way it is possible to keep in touch with what is going on in offices and to some extent in the field. But a great amount of information concerning novel methods of conducting construction and special plant is never printed, although it ought to be. The Engineering Record wishes to print it. The attention of the reader is drawn to the fact that although the price of the subscription has been decreased in the last year two-fifths, the number of reading pages has been increased three-quarters. There will always be room, for it will be made, for accounts of interesting construction, and The Engineering Record feels that what it has done of late for its readers is justification for a request to one and all to send it contributions of this nature. It is unnecessary to send finished articles; if the material for them is supplied, the editorial staff will attend to its preparation for publication. In this way alone will it be possible to furnish the complete review of field work which is desired for this journal. After a most careful analysis of the situation this decision seems unavoidable, and it is hoped that such a frank statement will result in numbering many more readers in the list of contributors.

Bids for Municipal Works.

The letter from Mr. Alexander Potter printed on page 436 of this issue, brings up a subject that has been discussed a number of times by The Engineering Record. It is claimed by this correspondent that the lists of bids received for sewerage and water-works construction are so incomplete when printed by themselves as to be misleading to engineers and contractors, unless accompanied by a large amount of information from the specifications and plans. Even then, it would seem, the data would not be satisfactory to this correspondent, for they would lack a statement of the wages of labor and the local prices for materials. This criticism would be an excellent one, provided it recognized what this journal intends to accomplish by publishing such tables of tenders. If it claimed that its Current News Supplement furnished a complete statement of the items of cost of such work, its readers would have just cause to complain about what they receive, but no such claim is made. The lists of bids received are simply what they purport to be, the tenders submitted for a specified piece of work. If an engineer or contractor desires to know more about the work he should secure a copy of the specifications and a set of plans if possible. In this way he will learn in a general way what the completed work is expected to be and how it must be constructed. If he wishes still more information he must visit the site of the work and find out for himself what local conditions, such as those mentioned by Mr. Potter, influence the cost of the work.

The prices published in these lists of bids received should never be used by any one, engineer or contractor, without a thorough investigation of just what they represent. They have a very important purpose in indicating to readers those pieces of work on which construction will shortly begin that it may pay them to look into. They also interest engineers and contractors in the vicinity, who are more or less acquainted with the enterprise and desire to know how much various men believe it would cost. Still other people who are desirous of obtaining sub-contracts and furnishing supplies will find such information of value. This statement is printed in order that no one may consider that such lists of bids received mean anything more than is stated. Every experienced engineer and contractor knows perfectly well that in themselves they are almost worthless as engineering data, and must be supplemented by further information before they pass from the field of business notes to that of technical information. If this journal claimed that they were in the latter class, they would not be printed in the Current News Supplement, but in the portion of the reading pages for permanent preservation.

The whole subject of estimates of cost of municipal work is one presenting many complications. For many years The Engineering Record has endeavored to secure really reliable figures of the cost of such construction. In a certain sense it has succeeded in this quest, but the editor would hesitate to print much of the information that has been secured because it would unquestionably be used sooner or later for purposes for which it is not adapted. All the investigations that this journal has made, coupled with the advice of experienced engineers and contractors, point to one conclusion, which is that all work presenting so many uncertainties as sewerage construction, water-main laying and the like must be investigated each case for itself. The cost of the materials employed in such work is a small fraction of the total cost, and a little water along a few hundred feet of trench may cause far more expense than the greatest variation in the price of pipe that has occurred in several years. The trouble that arises in such contracting work is due to two facts, one an insufficient examination of the ground by the engineer and his consequent unnecessary strictness in specifications to protect himself and his client against unforeseen difficulties during construction, and the second is the unfortunate practice of many contractors to hand in bids for work for which they have not made a thorough preliminary investigation of the specifications, plans and local conditions. When both these causes of trouble occur on the same piece of work, it is hardly necessary to state that subsequent proceedings are generally not marked by harmony.

Any kind of excavation is liable to encounter difficulties. Rock may be found where it was not expected, or be of a more troublesome character to remove than was anticipated, ground water may be found which will cause considerable expense for extra sheeting and pumping, quicksand may be discovered and the design of the conduits may have to be modified in consequence. In addition, the material in which the work is carried on may prove very hard to handle by ordinary methods for that class of excavation, and the safety of the work may depend on precautions being taken which no contractor, no matter how experienced, can foresee from the information afforded by the engineer. There is an unfortunate tendency on the part of some engineers, which is rapidly growing less marked, to shift the responsibility for all such unforeseen contingencies to the shoulders of the contractor. This is most unjust. The engineer is employed to see that good work is designed and built and not to force any man virtually to gamble with the city. Unless the plans, specifications and forms of contract provide for contingencies, guarantee to the contractor payment for extra work which may be necessary to carry out the construction properly and, in other respects, provide in advance a clean-cut method of estimating all reasonable expenses to which the contractor may be subject, the engineer is shirking his duty. There are certain classes of contracts in which it is desirable to call for lump sum bids or their equivalent, but in work where difficulties are always likely to occur, this is certainly not the best method of making contracts.

The unjustness of specifications in which no provision is made for probable difficulties is apparent on the slightest consideration. For example, take the case of a 6-inch pipe sewer in sandy soil in a trench 8 to 12 feet deep. The engineer may be led to believe that there will be no rock anywhere along this trench. The contractor may have a similar belief after talking with property owners on both sides of the street. He will accordingly estimate on a sheeted trench about 2 feet wide, say, but when he has reached a depth of 6 feet, he encounters dense limestone. It is impossible to get this material out to the remaining depth of the trench without enlarging its width, and the work is extremely costly in consequence. So far as the engineer and the contractor could learn in advance, there was no such trouble to be expected along the line of this work. The contractor, it is true, may have bid a certain sum for rock excavation, but his price was estimated on work in a different street under different conditions and was much lower than would be expected at this place. In consequence he may lose on this single street all the profit that was coming to him on the entire contract. The Engineering Record holds that contingencies like this should be provided for in the specifications.

Such a case as that just mentioned brings up the second cause of trouble, and that is the failure of many contractors to make a careful study of plans and specifications and an examination of local conditions before bidding on the work. There is a tendency among a good many experienced contractors to pay less attention to the specifications and more to the character of the engineer and the city officials, in preparing their estimates. If an engineer has a reputation of being a square man and the city officials generally of being fair in their estimates, specifications are not considered very strictly. The work is let, a new administration comes into office, a new engineer takes charge of the work and trouble descends on everybody, because the strict letter of the specifications is enforced.

This subject is one that might very well be discussed by the American Society of Civil Engineers, because at the present time, with so many men engaged in contracting who are graduates of technical schools and experienced engineers, the old unjust methods of carrying on work are bringing discredit on the engineering profession, and the contractors are sufficiently influential to make that fact well known. The time has gone by when any engineer can afford to tell a contractor that it is his business to take risks. No engineer for the class of work under consideration is justified in making such a claim. It is his business to provide in a measure for all complications that may arise, for he is paid by the city to do just that. He must make allowances for them in writing his specifications and provide in his form of contract methods for payment for extra work due to them. Otherwise the work of which he is in charge loses its engineering character and becomes guess-work. This is a discreditable condition, tending to make work expensive to the city and leading it to undertake construction in the belief that the price will be low, on which it would not embark were all the facts properly determined in advance and the true cost stated.

Notes.

Street Subways on an extensive scale are being constructed by the London County Council under its new streets, Aldwych and Kingsway. The latter, for example, has a 60-foot roadway with a 20-foot sidewalk on each side. Under the center of the roadway is a subway 20 feet wide and 16¼ feet high for a double line of street railway tracks. At a somewhat higher elevation and under each side of the roadway there is a full-centered arched subway 12 feet wide and 8 feet high for gas, water and electric service mains, while directly below each of these subways is a sewer. Running partly across the sidewalk every 30 feet there is a large vault connected with the subway by 12-inch pipes through which the service pipes and electric conductors can be taken, while below the vault a drain is laid into the sewer. The cost of this system of subways, which is constructed by the cut-and-cover method, is stated to be about $500 per linear foot of roadway.

The Slip of Pumping Engines is probably a very much larger quantity than the superintendents of water-works generally recognize. In most tests of old pumping plants, where an opportunity is given for measuring the discharge by means of a weir or some equally accurate method, it is found that from ten to twenty-five per cent. of the pumpage computed by measuring the plunger displacement and taking the number of strokes is not realized actually. For instance, a number of tests were made last month at one of the small pumping stations along the line of the Brooklyn, N. Y., aqueduct. These stations were built to pump water from driven wells and thus eke out the limited supply of surface water. Naturally the pumps are worn somewhat more than would be the case with water having less solid matter in suspension, and it is hardly surprising that the slip was found to be about twenty-two per cent. The actual amount is not particularly important, but the fact that it is large deserves the thoughtful attention of many superintendents. The reports of pumping station operations of many water-works are made out on the basis of the plunger displacement, without any allowance for slip. With such figures for the amount of water supplied to a community and with, say, only half the service pipes metered, it is not surprising that the amount of water unaccounted for reaches a large proportion of the total. The means for measuring the discharge of pipes are now so varied and cheap that there is no excuse for failure to know what the pumps are actually delivering and the mains discharging except such an abundant supply of water that its conservation is of no importance and such an abundance of money that nobody cares whether twice as much water is pumped as people really require.

Rebuilding the Portman Dam near Anderson, S. C.

By John L. Sheppard, Jr., M. E.

The failure of the Portman Shoals dam of the Anderson Water, Light & Power Company, Anderson, S. C., coming as it did, at a time when several similar disasters were recorded in the South, called forth interesting discussions in the engineering press.

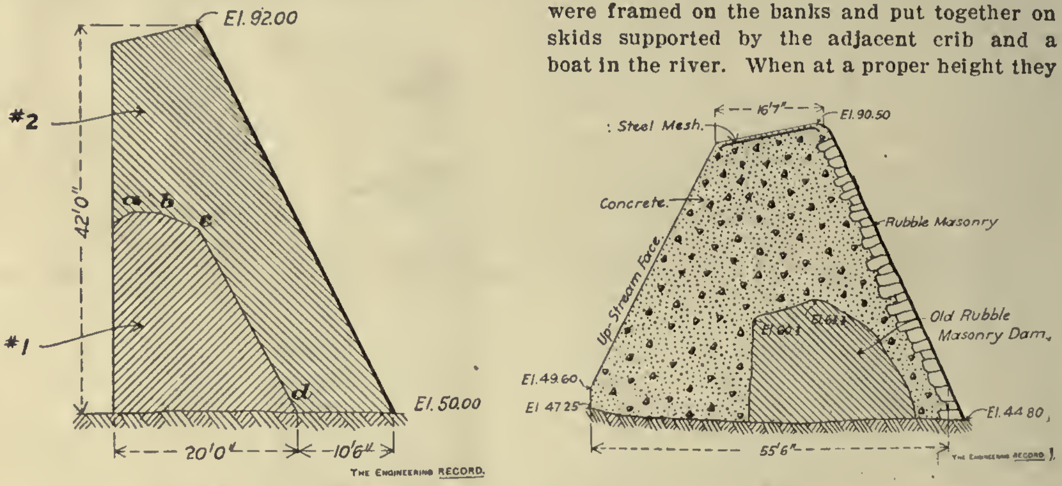
The Anderson dam is located on the Seneca River, at Portman Shoals, a distance of about twelve miles by wagon road from Anderson, which town, with its cotton mills and other manufacturing enterprises, is supplied with power and light from the plant at the dam.

The first development of water power at Portman Shoals was completed in October, 1896, and consisted of a dam 24 feet above the average bottom of the river. This dam gave a head on the wheels of about 28 feet with flash boards and developed, approximately, 1,600 horse-power. In July, 1900, the work of raising the height of the dam to 44 feet was begun. This gave an approximate head on the wheels of 47 feet. Work on the addition to the dam was about completed in November, 1901. On the 29th of the following December, at about 11 o'clock, P. M., the composite dam failed by a large break in the center, the line of the break varying in height about 4 to 25 feet above the bed of the river and extending for a length of about 260 feet.

The original section of the first dam, No. 1, and of the second dam, No. 2, is shown in an accompanying drawing. The rebuilt section, including the old masonry dam and the new concrete addition, is also shown in the engravings. The original dams were built of rubble masonry entirely. In the first dam, the stone was laid in a mortar bed, while in dam No. 2, part mortar and part grouting, was adopted. When the two dams, No. 1 and No. 2, were joined, the importance of making a joint as nearly as possible, water tight, was not realized. An accompanying photograph shows a view of the joint as it actually existed after the break. In it was a mass of spalls and cement in the shape of the bags, which mass, it may be stated, was of fairly good quality. On its removal it was found possible to thrust one's arm its full length, or to probe with a rod a distance of several feet between the two dams, indicating that there existed a free passage for water along the joint a-b-c-d of the cross-section of No. 1 and No. 2 dams. On either end of the break, the joints between the two dams in the lower face on the line c-d were so opened that it was almost possible for a man to crawl in and actually possible for one to probe with a rod a distance of upward of 10 feet. After a thorough investigation as to the cause of the failure of the dam, it can safely be said that had the plans and specifications for the second dam been carried out in accordance with the spirit in which they were intended, together with proper supervision of the work, the failure would never have occurred.

It was deemed advisable to remove all portions of No. 2 dam that showed any sign of weakness. The cracks were then picked, washed with a pressure hose and thoroughly grouted with a two to one mixture. New masonry was built on the lower side for 60 feet at both ends of the break and conforming to the old lines of the dam. The reason for this lay chiefly in the opportunity of utilizing the stone on hand, it being considered cheaper. With a back water distance of approximately 3½ miles, the volume of water stored in the pond was in the neighborhood of 203,000,000 cubic feet. With an 8-foot overflow on the spillway at the time of the break, this volume was increased to something like 265,000,000 cubic feet. This body of water sudenly liberated, washed all before it; and a steel bridge nearly one-half mile below the dam was completely demolished, hardly a piece of the steel work retaining its original shape and the piers being entirely obliterated. The flood in the power-house below the dam came up to the top of the generators, a distance of about ten feet above the floor line. However, it was found necessary to rewire only two of the machines. Outside of this, practically no damage was done to the power-house. There were three attendants in the building at the time, and owing to the machinery noise, their first knowledge of the break was the inrush of water through the door. All managed to escape without injury.

When it was decided to rebuild the dam, an examination of the stone available revealed the fact that practically not any of it was suitable. It was of an extremely knotty nature, hard, devoid of seams and contained in parts a quantity of rotten and sappy material. It was, therefore, decided that the only use which could be made of the available supply of rock in the vicinity was to crush it and to rebuild the dam of concrete with a stone facing, the material for the facing to be selected from that which was washed out of the dam at the time of the break. It was thought at first that sufficient dimension stone could be obtained from the quarry for a coping, but after investigation, as the quarry work progressed, this idea had to be abandoned. A coping of concrete was therefore decided on.



Section of Dams Number One and Two; Section of Dam Number Three.

The location of the dam made it necessary to haul all material a distance of twelve miles from Anderson, the contract price of 9 cents per hundred pounds amounting to several thousand dollars before the work was completed. The labor situation was an awkward one. Negro labor was practically the only kind available, white labor in this section, when obtainable, not being of much use. The out of the way location, the severity of some parts of the work, an abundance of employment elsewhere, such as farming, industrial developments, etc., made it hard to obtain men and to keep them for any length of time on the job. When it is stated there were very nearly three thousand different names on the pay roll from the beginning to the end of the work, with an approximate average of 350 men working per week, an idea of what had to be contended with can be appreciated.

Unfortunately, the break in the dam did not so reduce the depth of the water in the pond as to eliminate the necessity of coffer damming the river, with the exception of a hundred feet or so at the extremities of the dam where the mud sediment was used as a coffer dam. It was necessary to enclose the site near the ends of the mud bank with wooden structures.

The work of cofferdamming the river was fraught with many obstacles. The water, while not over ten to twelve feet in depth, rested on an uncertain bottom of mud and sand sediment. Some of this was washed from the center course of the river, but enough remained to cause troublesome leaks when the cribs were lowered upon it. Notwithstanding the fact that the cribs were heavily loaded with stone and every precaution, such as bracing, etc., was taken, it was necessary to give the cribs continued attention, both night and day, as a small leak would soon develop into a small flood, and delay the work in that section probably several days.

The cofferdamming of the river was accomplished in five sections as the work progressed, the ends of the dam being first enclosed and the concrete deposited therein. These sections varied in length from 70 to 200 feet, the shorter ones being in the center of the stream. The timber work was composed of cribs about 12x16 feet constructed of 8x8-inch timbers, bolted together with ¾-inch drift bolts. They were floored and provided with one outer chamber, for making them water tight. This chamber was lined with 1-inch matched boards, and when the crib was in position and filled with stone, usually of one "one man" size, it was filled with clay, sand bags and brush and generally an outer row of sheet piling was added. The cribs were framed on the banks and put together on skids supported by the adjacent crib and a boat in the river. When at a proper height they were launched, adjusted to a proper position and filled. Their height varied from 12 to 14 feet, leaving them about 3 feet above the average low water.

Although, several high stages of the river were experienced during the construction, practically little damage resulted to the coffer dams. Several leaks developed which caused the pits to be flooded from time to time and necessitated the removal of much extra material, but this was all the damage amounted to.

The quarry from which all of the rock for the concrete was obtained was located up a valley on line with the face of the dam and at a distance of about 1,400 feet from the center of the dam. About midway between the quarry and the dam was located the crushing plant and rock storage bin, the crushers being on the side of the hill and the rock bin just below. At a point on the lower elevation and about one hundred feet nearer the dam and the same distance to the side of the line, was located the cement storage sheds. All these points were connected by narrow-gauge railroad. The grades were planned so that gravity alone was employed in moving the loaded cars to their destinations, mules hauling them back over the dirt section of the road.

The rock was broken at the quarry to a one-man size, and loaded on dump cars of a capacity of 1 to 1½ cubic yards. The rock storage bin for the crushed material had a capacity of about 250 tons; after passing through this bin, it was deposited into steel measuring tubs, two of 21 cubic feet each being placed on a car, therefore delivering stone for two batches of concrete. After arriving at the lower base of the dam, these buckets were handled by derricks located on the top of the dam, and were placed by them on mixing platforms erected at the upstream face of the concrete part of the dam. From this point, together with the other concrete constituents, it was passed through a gravity mixer. The cement in 100-pound sacks was handled in a somewhat similar manner from the shed opposite the crushing plant, scale boxes being used in place of the steel tubs. The sand was obtained from points above and below the dam at distances varying from one to several hundred feet.. It was delivered to the foot of the dam by wheel-barrows and by mule-hauled railroad cars, the cost varying from 2 to 20 cents per yard. As a rule, the concrete was run from the mixer directly into wheelbarrows below, and wheeled where needed. In some instances, it was found expedient to deposit it in the steel buckets and handle those by means of the derricks which handled the concrete ingredients and the masonry facing. At times to facilitate the work it was found necessary to do the stone facing at night by the aid of electric lights. Night work in the quarry was also resorted to in order to keep the concrete force continually supplied with stone.

View of the Completed Water-Power Development.

The Portman Shoals Dam, near Anderson, S. C., before Reconstruction was Commenced.

Atlas Portland cement was used almost exclusively throughout the work of reconstruction. The cement was shipped in 100-pound bags to Anderson, S. C., and hauled to the dam. In all, about 25,000 barrels of cement were used. The rock was crushed to a 2½-inch size. The concrete mixture was one of 1:3:6, except in special cases where it was made stronger during the first part of the work. The rock dust was screened out and allowed to go to waste but proving such a nuisance, tests were made with briquettes of dust in place of sand. These tested up so high that it was decided to use the rock unscreened and make allowances in the sand quantities.

Results of tests of briquettes of Atlas cement and mixtures of standard quartz sand, sand used at dam and rock dust from crushers. Test of cement used: Residual in sieves, No. 50, 0.1 per cent.; No. 100, 8.8 per cent.; No. 200, 29 per cent. Time of setting: Initial, one hour; final, three hours; tensile strength, neat: one day, 615 pounds per square inch; seven days, 766 pounds; percentage of water, 17.7. Tensile strength using three parts of standard quartz sand: Seven days, 283 pounds; percentage of water, 9.2. Tensile strength using ingredients from work, after seven days' setting. Rock dust, 1:1 mixture, 530 pounds; per cent. water used, 15.3; rock dust, 1:3 mixture, 244 pounds; per cent. water used, 12.5. Sand, 1:1 mixture, 458 pounds; per cent. water used, 14.3; sand, 1:3 mixture, 190 pounds; per cent. water used, 11.2. These tests were made by the Atlas Portland Cement Company.

As a result of several tests to ascertain the proportion of dust in the crushed stone it was found that there was an average of about 20 per cent. Therefore, in the concrete proportions of 1:3:6, there were used 21 cubic feet of stone, including dust, 6.3 cubic feet of sand and four 100-pound bags of cement. By using the dust it was not only possible to save the cost of cleaning it out of the tail race, but there resulted a saving of 40 per cent. in sand cost. By the employment of automatic mixers, the work of making and placing the concrete was much facilitated; especially was this the case where the work of concrete sections became reduced as the height of the dam increased. The mixer platforms being placed on the upper side of the concrete dam gave ample room for hauling and placing of the mixed material. In the first stages of the work, it was possible with two

Spillway of the Completed Portman Dam.

hand-mixing gangs to do about the same amount of work as one mixer. But as the work progressed, the mixer easily led the hand work. With a force of 75 men on hand mixing, including all connected with the hauling and mixing of the materials, and a force of 61 men, under similar conditions, but using the gravity mixer, it was found that by hand it was barely possible, under the most favorable conditions, to turn out more than about 50 batches of concrete of 7/9 of a yard each, in ten hours, while, under the same conditions, the gravity mixing system would turn out about 110 batches. Taking into consideration the increased output, there was an average saving of $12.50 per day. With two mixers at work at the same time as was usually the case there, of course, resulted a daily saving of $25.

The bottom on which the concrete was placed at the Portman dam was an admirable one, exceedingly rough and containing many pockets. Especial care was taken in preparing this bottom. All boulders at all loose were removed, all crevices and holes were thoroughly cleaned and the surfaces washed, and in addition a coating of grout was poured over them. Extra effort was made to make the mass of concrete as compact as possible by thoroughly tamping. Where the concrete abutted against the old masonry dam, the joints were opened and well cleaned by hand and with a pressure hose. A V-shaped opening was left next the wall with each layer of concrete. This was filled with grout and then with concrete and the whole well tamped, thus insuring as far as practicable a solid bond between the old and new work. At the end of each day, the work of that day was left as rough as possible, ridges and holes in the concrete being left to accomplish this. Before again laying concrete this surface was swept clean, wet and washed over with grout, thereby endeavoring to bond one day's work with that of the next. When the joint between the first and the second masonry dams was reached, it was given especial attention. This was opened in a V-shaped section, the mouth of the opening varying from 2 to 3 feet and extending back as far as it was possible to go, in some cases as far as 3 feet. When well cleaned, it was washed out with the hose until all foreign matter was ejected. The concrete was stepped back to a height of 2½ to 3 feet and the joint taken in sections and filled with 1:2 grout, having a head of 2½ to 3 feet. When all the grout had filled the openings as much as it would, concrete was deposited and the whole made one mass of semi-liquid material. This method was adopted throughout the entire length of the face of the dam where the joint remained.

The greater part of the outfit used in the reconstruction of the dam was brought by the contractors, the Flynt Building & Construction Company, from their home office, at Palmer, Mass. The rock crushing plant was leased from the Georgia-Carolina Quarry Company, Charlotte, N. C. It consisted of two Champion crushers, Nos. 4 and 5, manufactured by the Good Roads Machinery Co., Kenneth Square, Pa. The maximum output under the conditions imposed was about 200 yards per 10 hours, crushing the stone to a 2½-inch size. The engine and boiler of the crushing plant were manufactured by A. B. Farquhar & Co., York, Pa. The cars used to convey the rock from the quarry to the crushers were purchased from J. C. Steel & Son, of Statesville, N. C., as were likewise the flat cars used for the crushed stone and cement, and the frogs and switches. Ingersoll-Sergeant and Sullivan drills were used in the quarry. Forty per cent. dynamite, manufactured by the Rand Powder Company, was used throughout the entire job. Five hoisting engines were used on the work, four of these being of the Mundy and one of the Morrison make. Most of the derricks were constructed on the spot and ranged in length from 50 to 60 feet. Contrary to general practice, these were rigged with manilla rope purchased from the Plymouth Cordage Company, Plymouth, Mass. The steel buckets were manufactured by Union Iron Works, Hoboken, N. J. For pumping out the coffer dams, etc., Knowles and Blake pumps were used, steam being supplied chiefly by a Hoadley combination engine and boiler furnished by George T. McLanthlin & Co., Boston. Practically all the concrete was put into the dam with the gravity mixer manufactured by the Contractors' Plant Company, of Boston.

In the reconstruction, there were put into the new dam 21,457 cubic yards of concrete. Taking everything into consideration, the cost per yard of the concrete was very close to $7.37. This figure will not be regarded high when it is remembered that everything used at the dam had to be hauled the 12 miles and also that the stone was expensive to get and crush. With so many men employed, together with the danger connected with the making and handling of the concrete and the varying of the stone, it can be said that the work was remarkably free from accidents. The only serious accident resulted in the death of two men, a white foreman and his negro helper. Both were killed by the premature explosion of a dynamite charge in the quarry, caused by careless tamping the charge with an iron bar. The present plant has been in full operation since the first of 1903 and no trouble has been experienced with the dam in any way. With a full pond, but no water running over the spillway after the completion of the dam, the lower face was found to be practically dry, very slight dampness appearing in some places, most of which dried off.

A condensed summary of the cost of rebuilding the Portman dam is as follows: Building shanties, railroad tracks, excavating for large piers and main dam, and removing crest from main dam, $10,252.05; building cofferdam, $18,279.07; broken stone, $31,608.73; main dam including cement, etc., $97,936.81; total, $158,076.66. As there were 21,457 yards of concrete, inclusive of 2,200 yards of rubble facing in this work, the cost per cubic yard was $7.37, as already stated. The tail-race wall cost $3,823.34, making a grand total of $161,900. As there were 1,070 cubic yards of rubble masonry in the tail-race wall, the cost per cubic yard was $3.57. The broken stone, as stated, cost $31,608; there were 19,257 cubic yards used, so that the unit cost was $1.64 per cubic yard.

The plans for the reconstruction of the Portman dam and the supervision of the work were executed by Mr. J. E. Sirrine, M. Am. Soc. C. E., mill architect and engineer, of Greenville, S. C. Mr. J. F. Howard and the author were resident engineers at different times. Mr. J. C. Sullivan was in charge of the work for the contractor.

Upstream View during Construction Showing Concrete Work.

Thermit, the welding compound in which aluminum is the leading ingredient, has been employed by the Pennsylvania Railroad Company in repairing broken locomotive frames. An engine repaired in this way about February 20 has been on the road ever since. The thermit employed in making this weld contained 2 per cent. of manganese free from carbon and 5 per cent. of iron punchings. Mr. A. W. Gibbs, superintendent of motive power of the company, states that the riser from the weld of a steel frame was drawn out under the hammer into a bar about 3 feet long, and turned down and broken. It showed a tensile strength of 91,600 pounds per square inch, an elongation of 21.5 per cent. in 8 inches, and a silky fracture. The analysis of the metal, in percentages, was as follows: Carbon, 0.102; manganese, 2.330; phosphorus, 0.070; silicon, 1.227; sulphur, 0.034. An explanation of the action of this material in welding was printed in this journal on November 28, 1903.

Refrigeration from a Compressed-Air Motor.

In the salesroom of a brewery in Paris, an old steam engine is employed as a compressed-air motor for driving an electric lighting generator. Exhaust from the air cylinder is utilized for refrigeration, partly for making ice and partly for cooling a beer-storage vault. The engine has a stroke of 35.4 inches and the cylinder diameter is 17.7 inches, and the machine makes 58 to 60 revolutions per minute. It was chosen on account of the large size of its exhaust pipe, which is 7 inches in diameter, for it was feared that should the air become too humid, masses of snow would form and obstruct too small a pipe. The motor receives compressed air at a pressure of 71 pounds per square inch and at a temperature of 53 to 59 degrees Fahrenheit, never rising above 68 degrees. It operates during the winter for 10 to 12 hours daily and in summer for 7 to 8 hours. For lubrication, glycerine is used, as mineral oils lent a disagreeable odor to the air of the exhaust and tended to spoil the manufactured ice. The machine develops ordinarily about 30 horse-power, but during Sundays from 40 to 45 horse-power and can furnish 60 horse-power. It drives a dynamo giving 300 amperes at 110 to 115 volts, which supplies some 45 arc lamps and 50 to 400 incandescent lamps of 10 to 16 candlepower.

The theoretical difference of temperature between the air admitted to the engine and escaping from it is about 176 degrees; as a matter of fact the temperature of the exhaust attains, according to "Revue Industrielle," from which this account is taken, —76 degrees. It happens in winter, after 13 to 14 hours' operation, that an alcohol thermometer, graduated to —49 degrees, is no longer readable. Besides making ice and cooling the storage vault, the temperature of which must not rise above 45 degrees Fahrenheit, an attempt was made to employ the cold air to cool the salesroom, but the consumers complained of cold feet and were annoyed by the noise of the exhaust which is effected at a little above atmospheric pressure.

The exhaust pipe is passed through the basement discharging into the freezing chamber toward the bottom of that room. This chamber is divisible into two parts by a movable partition, and the part receiving the exhaust directly is the freezing compartment, while the other is used for storing ice. The walls, ceiling and floor of both compartments, as well as the exterior wall of the beer cellar, are made of blocks of ground cork covered with wood sheathing. The freezing room and the ice storeroom are each 9.8 feet long, 14.75 feet wide and 5.75 feet high. The beer cellar is designed to hold about 2,650 gallons of beer in barrels.

The exhaust pipe expands from its general diameter of 7 inches to a diameter of 15¾ inches in the wall of the freezing chamber. The water for freezing is placed in cans containing 22 pounds each. The air for cooling the beer cellar passes from the freezing room in a pipe 15¾ inches in diameter and extends some distance within that room. In the passageway separating the cellar from the freezing room a sub-division is made in this pipe, one branch going to the cellar and the other connecting with a riser pipe discharging to the atmosphere. A butterfly valve is inserted in both branches for regulating the air supply to the cellar, so that it is possible to vary the volume of cold air passing into the cellar according to the needs by bypassing a portion of the total flow to the atmospheric discharge.

The utilization of the exhaust from the compressed-air motor which drives the lighting unit thus furnishes both ice and cold which it would otherwise be necessary to purchase. The compressed air costs at the rate of 4.45 cents per 1,000 cubic feet and the consumption per horse-power hour is about 847 cubic feet. The net cost per kilowatt-hour under these conditions amounts to 6.3 cents, indicating an efficiency of nearly 80 per cent. for the machine. Ice costs 44.7 cents per 100 pounds. It is stated that for cooling the cellar 0.415 pound of ice would be required per gallon on the basis of 7 hours operation in summer, or 1,100 pounds for the 2,650 gallons of beer which it holds. This means 157 pounds would be required per hour. The production of ice per horse-power per kilowatt-hour amounts to 14 pounds. This means when the lighting unit is supplying 300 amperes, or in other words an output of 34.5 kilowatts per hour, that the ice capacity is 485 pounds in one hour. The cost of this ice at 44.7 cents per 100 pounds is $2.17. The cost of the compressed air at 6.3 cents per kilowatthour for the 34.5 kilowatt-hours amounts also to $2.17. This indicates that the lighting service costs nothing, the unit supplying an amount of ice that would cost if purchased what the compressed air actually accepted did cost.

The Portman Dam: Downstream View during Construction; Joint between Old Dams on Upstream Face.

The Relative Costs of Electric Power for three different types of plant were estimated as follows by Mr. Ralph D. Mershon, M. Am. Soc. M. E., of New York, in a paper read before a recent meeting of the New York Electrical Society: A load factor of 0.5, a peak load of 1,500 kilowatts and an equipment of four generators having a rated capacity of 400 kilowatts each, was assumed for each case, the generators to operate when necessary at 25 per cent. overload and to be cut in and out in such a way that the average efficiency of each unit will be the same as though it ran continuously at 75 per cent. of rated capacity. The thermal value of the coal was taken at 12,500 British thermal units per pound, and the evaporation in steam boilers at 7 pounds per pound of coal, and the production of gas generators of a gas having 10,000 thermal units per pound of coal. A steam pressure of 150 pounds was assumed, superheated 150 degrees Fahr. above normal temperature. The steam engine was rated with 12 pounds of steam per brake horse-power-hour; the steam turbine with 18 pounds per kilowatt-hour; and the gas engine with 10,000 thermal units per brake horse-power-hour. Under the conditions assumed a chart was made for costs as influenced by the cost of coal, including interest, depreciation and renewals on the whole installation and supplies, labor and fuel, and it was found that the gas-engine plant and the steam engine were at a parity with coal costing about $1.85 per ton of 2,000 pounds, while the point of equality for the steam turbine and gas-engine plant occurred with coal at about $3 per ton. The estimates for the gas-engine plant were made without reference to recovery of by-products.

New Tie-Preserving Processes.

From an article by Dr. Hermann von Schrenck in the report of the Committee on Ties of the American Engineering and Maintenance of Way Association.

New Processes.—During the past year a number of new processes have been advocated for treating ties. Two of these deserve special attention. They are both still in the experimental stage and require careful testing before being adopted.

Rüping Process of Creosoting.—This process is one which aims to save a certain portion of the creosote now injected into the timber, thereby cheapening the process. Its method of operation may be briefly stated as follows: Absolutely dry air-seasoned wood is put into a treating cylinder, and compressed air pumped into the cylinder up to 5 atmospheres; this pressure is kept about one hour. Tar oil is then pumped in under a pressure of about 85 pounds until the cylinder is full, and the pressure is then raised to 14 or 15 atmospheres. This pressure is left on until the wood has absorbed as much of the oil as it can. The pressure is then taken off entirely, the oil is run out, and a vacuum is created. The compressed air contained in the wood cells then presses out any excess oil not held by the fibers of the wood. It is claimed that this process saves practically 50 to 60 per cent. of the quantity of oil ordinarily used for the treatment. Trial tests, made at Norfolk, Va., by the writer, and similar tests made near Berlin during the past summer, have, to a large extent, sustained these claims. Extensive tests are now under way with this process, and should it prove practical to treat American timbers so that they will absorb only a small quantity of tar oil and still give extensive penetration, this process would recommend itself highly. It would mean treating timbers with creosote for about the same price that it now costs to treat with zinc-chloride.

Chrome-alum Process.—The chrome-alum process is one invented by Kester, of Munich. The theory of the process is briefly as follows: The inventor states that the chief difficulty with salts of various kinds used for treating timber has been that the salts are soluble in water, and leach out. For a preserving solution, he uses chrome-alum and acid-sodium sulphate. These two salts, when in solution cold, do not unite, but when the solution is heated to 80 deg. C., the two salts unite and form an insoluble chromium salt. The manner in which this process is operated is as follows: The two salts are mixed in solution (cold) and are pressed into the wood under a pressure of about 4 atmospheres. Steam is then turned into the cylinder for the purpose of heating the wood, and when the same is heated to about 70 or 80 deg. C., the insoluble chorium salt is precipitated in the wood cells. The inventor claims that the treatment can be made for about 7 cents per tie. No practical tests have yet been made with the process beyond the treatment of 25 ties by the Bavarian State Railways during the past summer.

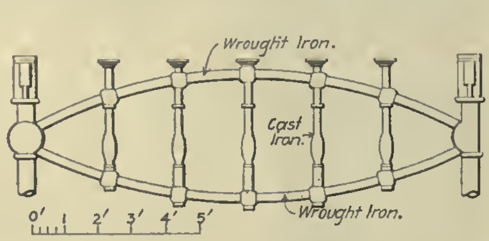
Giussani Process.—This is a process for which two large plants are now in operation on the Italian railroads. The treatment depends upon heating the air in the wood so that a portion escapes, making a partial vacuum. The wood is then dropped into a cold solution of tar oil or zinc-chloride, thereby bringing about a penetration of the preservative. The manner in which the treatment is carried on is as follows:

The ties are plunged into a hot bath of tar oil by automatic machinery and slowly moved through the tank for varying periods of time, when they are dropped into a tank containing cold tar oil. The hot oil having heated the tie, when it is dropped into the cold oil a partial vacuum is made in the tie, and the cold oil rushes in, securing a penetration of two to three inches. This process recommends itself because the plant required is very much cheaper than for the cylinder process. Tests are being planned with this process to determine the relative cost of treatment between it and the old cylinder process.

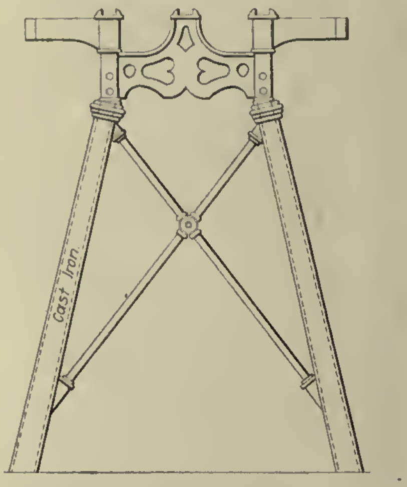
Mechanical Devices for Preventing Wear of Spikes.—A device has been in use in Europe for some years which has given such remarkable results that it is worthy of attention in this country. The great trouble with soft ties is, and always will be, the rate with which the wood around the spike wears out. Treated ties of softer pines and the inferior oaks are rapidly wearing out at the spike holes, necessitating respiking, and in many instances the entire removal of the ties, because of the decay which sets in at the spike holes. The device spoken of, which is called a screw dowel, or trenail, has now been in use in Germany and France for some 5 years, and has given the most satisfactory results. The screw dowel consists of a cylindrical piece of beech wood, provided with a broad thread. The upper part of the dowel is somewhat larger than the body. A hole somewhat less than the diameter of the screw or spike is bored through the center of the dowel. The dowel is heavily creosoted. The dowel is put into the tie in the following manner: A hole is bored somewhat less than the diameter of the dowel, and by means of a threading device a thread is cut in this hole. The dowel is then screwed in either by hand, when there are a few ties to be provided with dowels, or by machinery, when a large number are to be provided. In France and Germany the doweling process is usually carried out in connection with the treating plants. The dowel makes a perfect fit with the tie and prevents the water from getting into the space between the dowel and the tie. The screw or spike is inserted into the dowel much as it would be screwed or driven into the tie. Should any of the wood around the spike wear out, the dowel is removed and another is screwed in its place. The body of the tie is thereby saved from destruction. The tops of the dowels at the same time act as tie-plates, preventing the wearing out of the wood of the tie, and in many cases have rendered the use of the expensive steel plate almost unnecessary. A further advantage of the dowel consists in the very much increased holding power which the dowel gives to the spike or screw, principally in the matter of resisting the lateral pressure. The great area of surface of the dowel makes this possible. On recent high-speed tests made on the stretch Berlin-Zossen on the German military road, all the ties were provided with dowels, and the inspecting military officers report that there was practically no deviation from the normal gauge where these dowels were used, whereas in former years the difficulty had been that the track had spread so as to endanger the safety of the train. The dowels, when made in quantity, are extremely cheap, and it is believed that they ought to prove a valuable means for making possible the use of the softer wood timbers in this country. Extensive tests with the dowels are now being planned, and it is urged that short stretches of track be provided with them wherever possible.

A Primitive Iron Railroad Bridge.

A primitive iron railroad bridge which was built in the early part of the 19th century carried the Stockton & Darlington Railway across the River Gaundless, England, and was recently removed after being in continuous service nearly 80 years. Its design was attributed to the famous George Stephenson, and it consisted of four 12½-foot spans, each of which had a pair of curved-chord trusses supported on two-post trestle bents. The trusses consisted of curved wrought-iron top and bottom chords united by cast-iron verticals without diagonals. The verticals were cast in place around the chords and the ends of the latter fitted sockets in the castings at the tops of the trestle bents, as shown in the diagram. The trusses were apparently devoid of lateral or transverse bracing, and were put together without bolts or rivets. The trestle bents were made with pairs of inclined cast-iron columns connected at the top by a casting somewhat like a double cantilever floorbeam and transversely braced by diagonal rods engaging sockets on the sides of the columns. The bridge is illustrated by a photograph and detail drawings in a recent issue of London "Engineering."



Elevation of Span.



Elevation of Trestle Bent.

Primitive Iron Railroad Bridge across the River Gaundless, England.

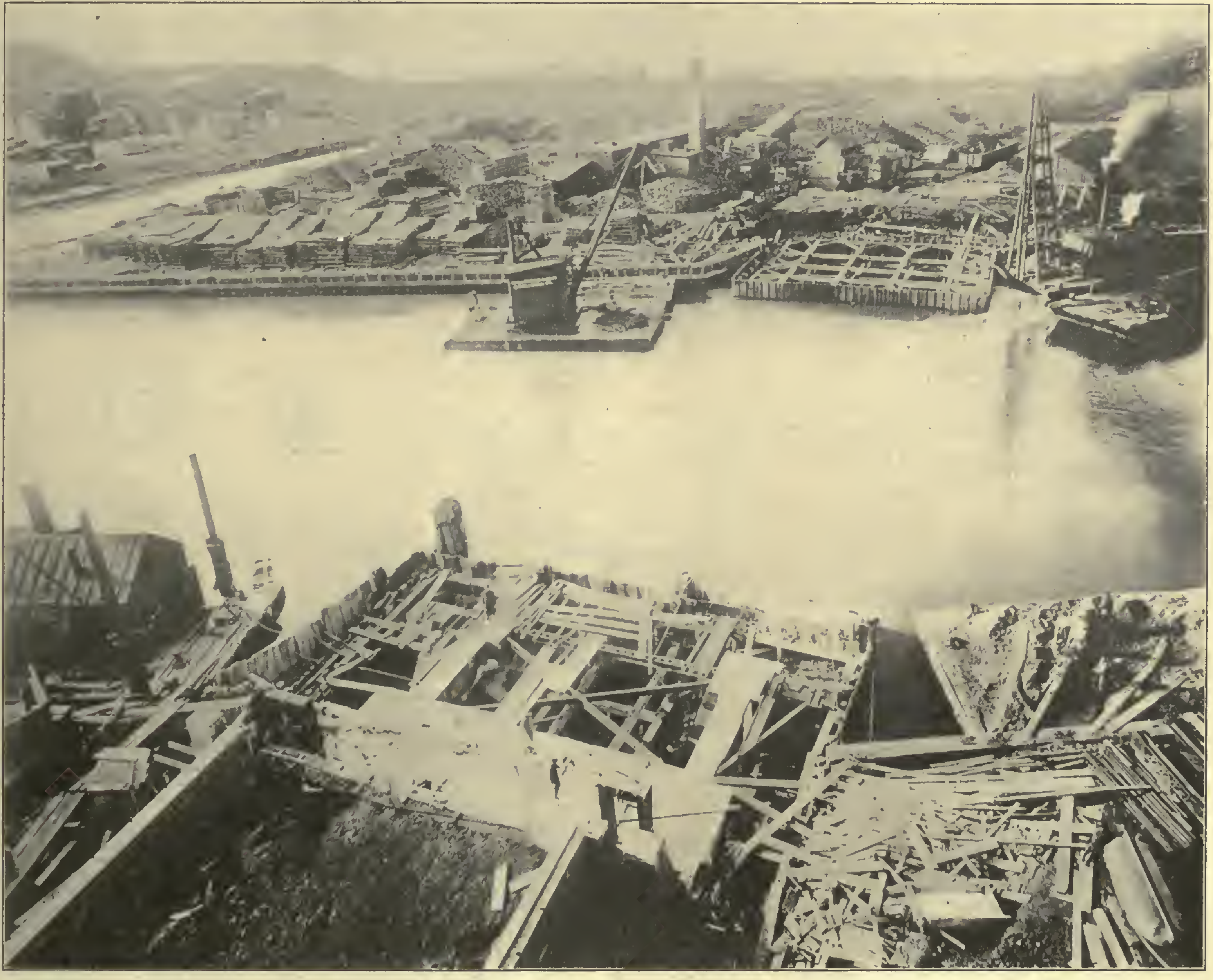
For Oil Burning under the steam boilers of the new plant of the Pacific Electric Railway Company, at Los Angeles, Cal., an elaborate system of tanks has been provided for handling and storage. The oil house has been located back of the station and the lower part of the building consists of a concrete tank, with walls 8 feet high, forming a pit which is divided by cross walls of concrete. The oil is allowed to settle in the compartments, the lighter oil being run off into the last, from which it is pumped into two storage tanks. Each of these is 40 feet in diameter and 35 feet high, and has a capacity of 7,800 barrels. The oil flows by gravity from the storage tanks to three so-called burning tanks situated in the oil house. Each of these hold about 500 barrels and they contain steam coils designed to warm the oil to about 124 degrees, when it is pumped to the boilers. A double-pipe system is used for distributing the oil to the boilers and the oil is kept in constant circulation under about 35 pounds pressure. Hammel burners are employed with steam at boiler pressure, or 150 pounds. The boiler plant includes ten 250-horse-power Stirling boilers, fourteen 400-horse-power Babcock & Wilcox boilers and ten 400-horse-power Edgemoor boilers.

Steel Piling for the Coffer-Dams of a Chicago Bridge.

A few months ago there was printed in this journal a description of some unusual coffer-dam work for the foundation of a St. Louis power-house, for which interlocking channel-bar piling was employed. Some equally interesting work with this material has lately been done in connection with the coffer-dams for the substructure of the Loomis Street bridge in Chicago, sometimes called the Deering Street bridge. The contractors for the work, the Chicago & Great Lakes Dredge & Dock Company, began the coffer-dam on the south side of the river, that in the foreground of the accompanying picture, with wooden sheeting, but experienced so much difficulty that they were glad to try the interlocking channel-bar construction as soon as it was brought to their attention. At this time about 35 feet of the wooden sheeting had been driven on the shore side of the enclosure. Through some mistake the steel piling was ordered in two lengths, 30 and 35 feet, although only the latter size was adapted for the situation. When the piling had been driven and the excavation carried along, it was found necessary to dig almost 7 feet below the bottom of the short piles on the river front, with the result that the coffer-dam was undermined in two places, the interior flooded and two puddle dams became necessary. These were made with wood plank, and are shown in the illustration running along the left side of the coffer-dam and at the right-hand end of its river front. This was the only unfortunate experience with the steel piling, and was not attributable to any defect in the interlocking principle.

The steel for this coffer-dam was ordered in September, and proved so satisfactory that steel for a similar coffer-dam for the north substructure was ordered the following month, from the Friestedt Interlocking Channel Bar Company, of Chicago. All the piling in this case was of the 35-foot length and no trouble has been experienced with it. Both of these dams are 40x60 feet, and particular attention is called to the comparatively small space they take up in comparison with the old type of puddle dam. In some places where the working room along a river front is crowded with piers and storage yards this consideration may be an important one. At the present time the excavation within the north coffer-dam has been completed, and the forms for the concrete are being put in place.

In the case of the work on the south side of the river the piling was provided with calking strips for the purpose of making the work tight, but this attachment was found to be unnecessary, as manure thrown on the water side of the enclosure made it impervious. On the north side of the river, no calking strips were used and no trouble has been experienced in consequence. It should be added that the piling in both coffer-dams is driven through river silt into hard-pan.



COFFER-DAMS OF INTERLOCKING CHANNEL BAR PILING AT THE LOOMIS STREET BRIDGE, CHICAGO.

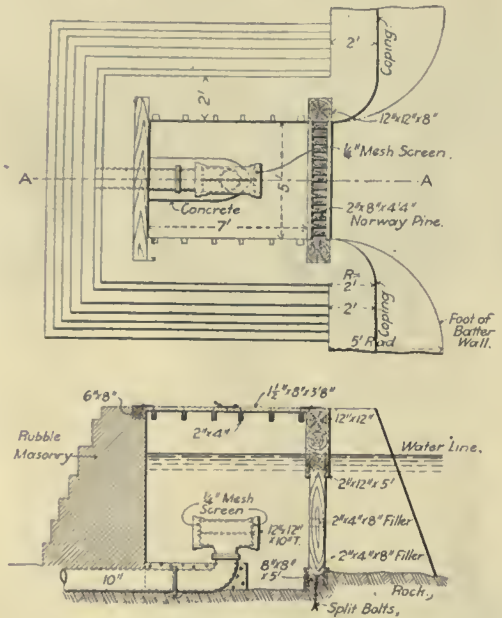
The Engineering Service of the U. S. Geological Survey affords unusually interesting work, and it will doubtless be welcome news to many young men that examinations will be held in all the leading cities of the country for filling a number of positions in it. Secondary places in the engineering and hydrographic corps will be filled at a salary of $900, while the positions of assistant engineer and hydrographer carry salaries of $1,000 to $2,000 and upward. Subsistence and traveling expenses are paid to the men on field duty. The purpose of the examinations is to draw out the qualifications of the applicants, so that those who are successful may be assigned to the work for which they are best fitted. The examinations for engineering and hydrographic service and the relative importance of the subjects are as follows: Mathematics, 15; theory and practice of engineering construction, 20; applied mechanics, 20; topographic and mechanical drawing, 15; technical training and experience, 10. The examinations for irrigation engineer will embrace mathematics, 10; topographic sketching, 5; hydrographic and topographic U. S. and general surveying, 15; general engineering and hydrographic construction, 15; training and experience, 35. The examinations will begin April 19 and last two days of seven consecutive hours each. Only physically strong men will be selected.

Village Water-Works of Geneva, Ohio.

Geneva, Ohio, is a town of about 2,500 inhabitants, in the extreme northeastern part of the State, about four miles from Lake Erie and three miles from the Grand River, which, for a considerable part of its course, flows approximately parallel to the lake shore. After studies and discussions at different times for several years, the construction of a system of waterworks was begun in August, 1901, and completed in October, 1902. The supply is drawn from the Grand River at a point about three miles from the village, filtered, pumped to a reservoir, and distributed by gravity, the power for pumping being furnished by a turbine water wheel with a gasoline engine as a reserve.

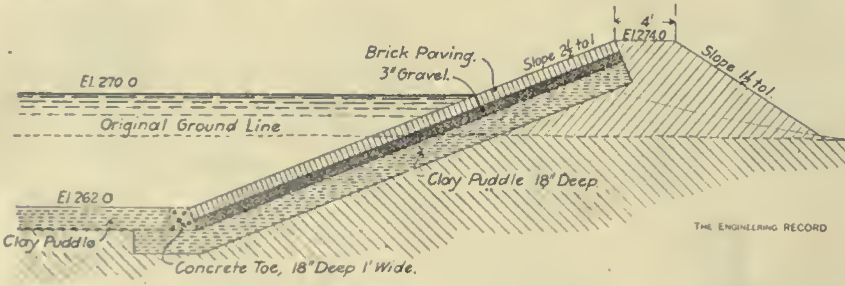
The intake is situated in the bank of the river just above a timber crib dam built to divert water into a headrace about 800 feet long leading to Clark's mill site, at which the pumping station and filter plant were built. A plan and section show the arrangement of the intake, which is quite simple and has given no trouble on account of ice or sediment during the year and a half that it has been in use. From this intake a 10-inch cast-iron pipe leads the water by gravity to a 5-inch Worthington conoidal centrifugal pump, located in the basement of the filter house and driven by an 8-inch leather belt from a 43-inch diameter pulley with an 8-inch face on the shaft actuated by the turbine or engine. This pump raises the water through a 6-inch pipe into the sedimentation tank, just outside the filter house. A 1½-inch pipe leading from the pump case to the tailrace makes it possible to drain the pump and the pipe. A ¾-inch lead pipe connects the float box of the alum tanks to the suction of the centrifugal pump, and the action of this pump stirs the coagulant with the raw water very thoroughly.

Accompanying drawings of the station show the relative positions of the sedimentation tank, the filter, the pumping machinery and the more important piping. The sedimentation tank is 24 feet in diameter outside and 20 feet deep, made of 3-inch wooden staves. Its capacity is 64,000 gallons, and the water requires ordinarily two hours to pass through it. The water enters at a point 6 feet above the bottom of the tank and is drawn off to the filter through an 8-inch pipe at a level 3 feet 4 inches below the top of the tank. This tank is not covered.



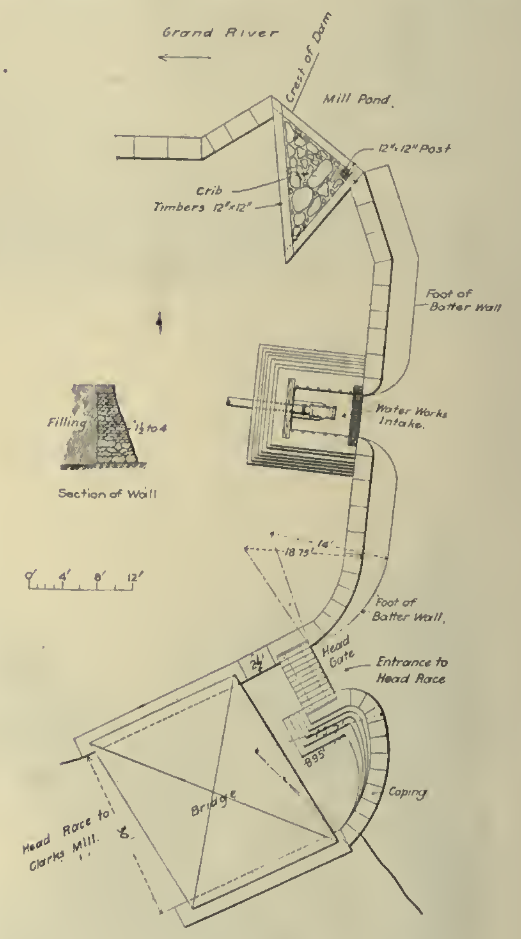
Section A-A.
Intake at River.

THE ENGINEERING RECORD.



THE ENGINEERING RECORD

Section of Reservoir Embankment.



Location of Intake and Entrance to Head-Race.

THE ENGINEERING RECORD

Details of Reservoir and Intake of the Water-Works of Geneva, Ohio.

An 8-inch pipe leading from its bottom near one side and controlled by a valve, provides means for blowing out the sediment or emptying the tank, the dirty water flowing to the tail-race. From the sedimentation tank the raw water flows by gravity to the filter through an 8-inch pipe controlled by a valve operated by a float in the filter. The filter tank is 17 feet in diameter outside and 8 feet high.

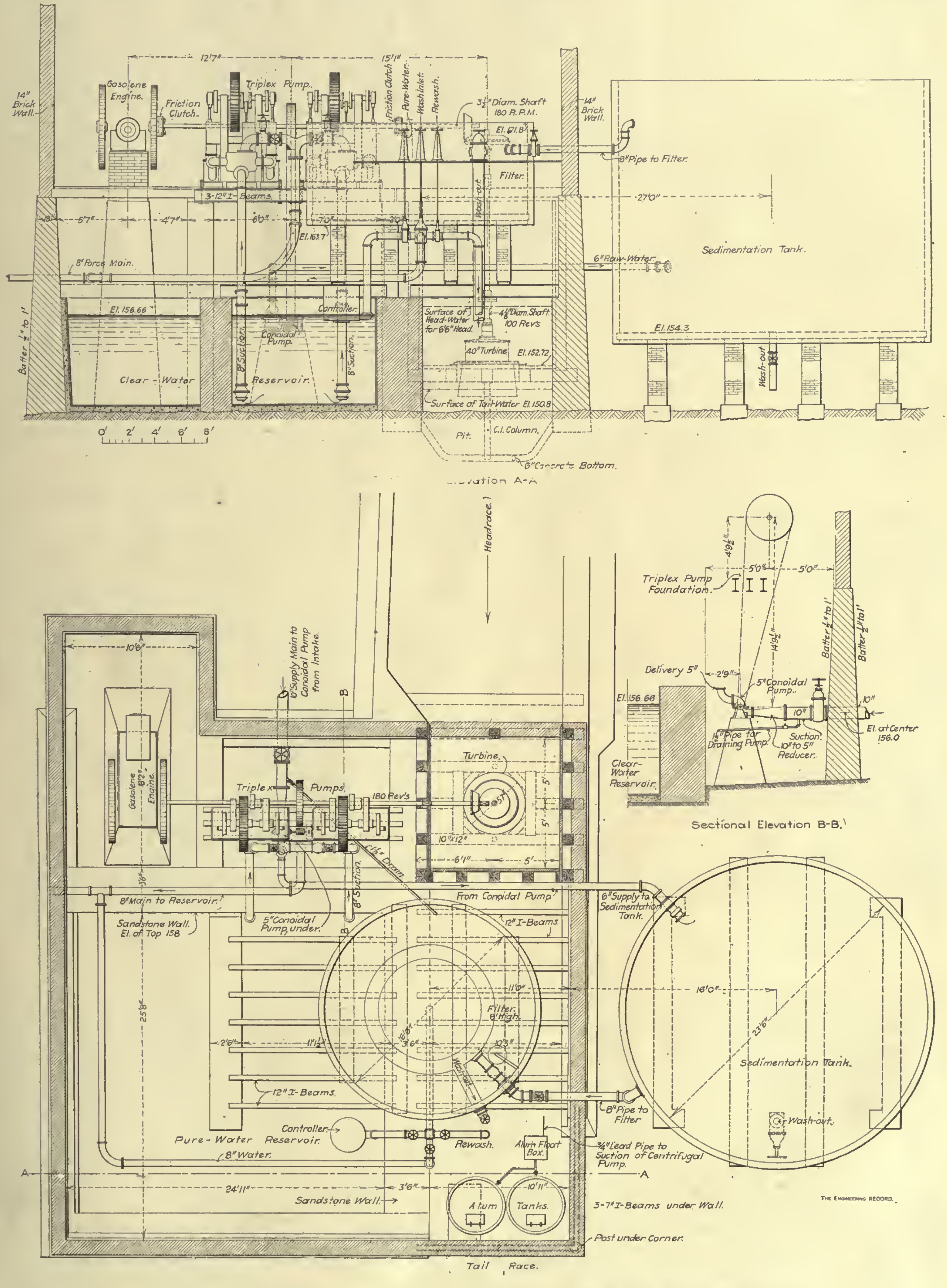
The sedimentation and filter tanks are each supported on I-beams built into the tops of four masonry walls. Beneath the sedimentation tank the foundation walls extend down to a firm bearing on shale rock, below frost level, the portions from the bottoms to a level about 1 foot above the ground surface being 2 feet thick and the upper portions 4½ feet high, 17 inches thick. These walls are spaced 4½ feet apart in the clear and have sixteen 5-inch 9¾-pound I-beams built into them with the top flanges of the beams flush with the tops of the wall. The bottom of the sedimentation tank is at an elevation 9½ feet lower than that of the bottom of the filters. One of the 13-inch walls supporting the filter tank rises from one of the walls of the substructure which forms one side of the clear-water reservoir and separates it from the tailrace of the turbine; the other three walls are carried on fourteen 15-inch I-beams spaced 18 inches apart on centers which span the tailrace and a portion of the clear-water reservoir, as shown. The ends of one set of seven beams are supported on a wall built in the clear-water reservoir for this purpose.

The filter is of the New York type, and, together with the sedimentation tank and other appurtenances, was furnished by the New York Continental Jewell Filtration Company. It has a filtering capacity of 750,000 gallons per twenty-four hours. From the filter the effluent passes downwards through a Weston controller into the clear-water reservoir beneath the filter room. On top of the filter sand is an annular trough of sheet-iron, through the side of which the 8-inch raw-water pipe discharges. When the filter is being washed this trough serves as a collector for the dirty water, which it discharges through an 8-inch pipe at the side of the filter tank into the tailrace. This pipe is controlled by a valve at the side of the filter.

Filtered water under pressure, for washing purposes, is supplied to the center of the bottom of the filter through an 8-inch pipe connected to the 8-inch force main of the pumps. The re-wash waste pipe also discharges directly into the tailrace. The clear-water reservoir is 23x39 feet and 8½ feet deep, having a capacity of 40,000 gallons with the normal depth of water of 6 feet below the bottom of the filter controller. Its walls are of stone masonry laid in Portland cement mortar and lined with a ½-inch coat of Portland cement plaster. The bottom is on the ledge rock, which is leveled up with Portland cement concrete. It is covered with a layer of Portland cement mortar 1½ inches thick.

The superstructure of the station is a one-story brick building 42 feet square, with an 8x13-foot ell, covered with a shingle roof on a wooden frame. The main floor is of 3-inch boards on 2x8-inch joists carried by 6x10-inch beams. As indicated by the plan, there is sufficient space for an additional filter beside the one already installed. The pumping machinery is all at the other end of the room in a smaller space than that reserved for the filters. Two triplex single-acting power pumps, built by the Deane Steam Pump Company, of Holyoke, Mass., have been put in. Each pump draws water directly from the clear-water reservoir through an 8-inch suction pipe with a foot valve, and both discharge through a Y into one 8-inch force main leading to the reservoir. Each has a nominal capacity of 525 gallons per minute, or 756,000 gallons per twenty-four hours, and works against a head of about 110 feet. Usually only one pump is run at a time. Both pumps are supported on three 12-inch I-beams resting on the masonry walls of the substructure.

To drive the pumps a 40-inch vertical Samson turbine, made by James Leffel & Company, of Springfield, Ohio, has been installed in a wheel-pit beneath one corner of the building. It is supplied with water from the headrace under a head of about 9½ feet and makes 100 revolutions per minute, developing about 75 horsepower. Its vertical shaft connects through bevel gears to a 3½-inch horizontal main shaft making 180 revolutions per minute, supported on posts at a height of 4 feet 9½ inches above the floor of the main room. Thus far the turbine has furnished all the power needed, but to guard against a shut-down of the station in case of accident to the turbine or lack of water, a 50-horse-power New Era gasoline engine, made by the New Era Iron Works Company, of Dayton, Ohio, has been installed at the opposite side of the room on a tall concrete pier, and likewise connected to the main shaft. The two pumps are between the engine and turbine and are driven by a pinion gear on the main shaft. The turbine and the engine are each separated



Elevation A-A.

Sectional Elevation B-B.

GENEVA WATER-WORKS: PLAN AND SECTION OF PUMPING AND FILTRATION PLANT.

from the part of the shaft carrying the pinion gear by a New Era friction clutch coupling, so that either prime mover may be cut out as desired.

The reservoir is about 3,500 feet from the pumping station beside the road leading directly to the village, from the center of which it is distant about 3 miles. Full reservoir level is 104 feet above the floor of the engine room and 180 feet above the level of the village. The reservoir, which was made partly by excavating and partly by embanking, is 220 feet square at the inside of the top of the embankment and has a capacity of 2,800,000 gallons. As the present daily average consumption of the village is about 100,000 gallons, the reservoir is large enough to carry the draft of the evening, night and early morning period, hence no night engineer is required. The day engineer pumps the reservoir full and then shuts down, running usually about 3½ hours. This makes possible a large saving in the operating expenses.

The reservoir was excavated in a stiff clay formation to a maximum depth of about 6 or 7 feet, and the top of the embankment is 4 feet above full reservoir level. The embankment is 4 feet wide on top and has slopes of 1 on 2½ inside and 1 on 1½ outside, as shown by the section, which also shows the method of lining. The banks were built, in accordance with current practice, of selected material deposited in layers and rolled; the top and outside slopes are grassed; the inside slope is lined with 18 inches of clay puddle and covered with one course of paving bricks laid on 3 inches of screened gravel. The joints between the bricks are filled with Portland cement mortar. A concrete toe wall 18 inches high and 12 inches wide extends around the bottom of the inside slope and acts as a footing for the brick paving. The floor of the reservoir also is covered with 18 inches of puddle. The puddle of the slope extends beneath the toe wall and for 2 feet under the edge of the puddle on the floor on all four sides. During the time the reservoir has been in service it has proved satisfactorily water-tight and there has been no trouble with the lining from slipping or action of ice.

Water is fed into the reservoir through an 8-inch branch from the force main laid in a trench beneath the embankment near the corner of the reservoir toward the pumping station. This pipe has an 18-inch concrete cut-off wall under the middle of the embankment and another under the middle of the inner slope; it is controlled by an 8-inch valve at the toe of the outer slope and ends in a concrete inlet pit 5 feet square and 2 feet deep in the corner of the bottom of the reservoir. Water is drawn from the corner of the reservoir nearer the village through a 12-inch pipe arranged similarly to the inlet pipe, and the force main is continued parallel to the side of the reservoir to join this pipe, thus providing a by-pass so that water can be pumped directly into the distribution system whenever it is necessary to cut out the reservoir.

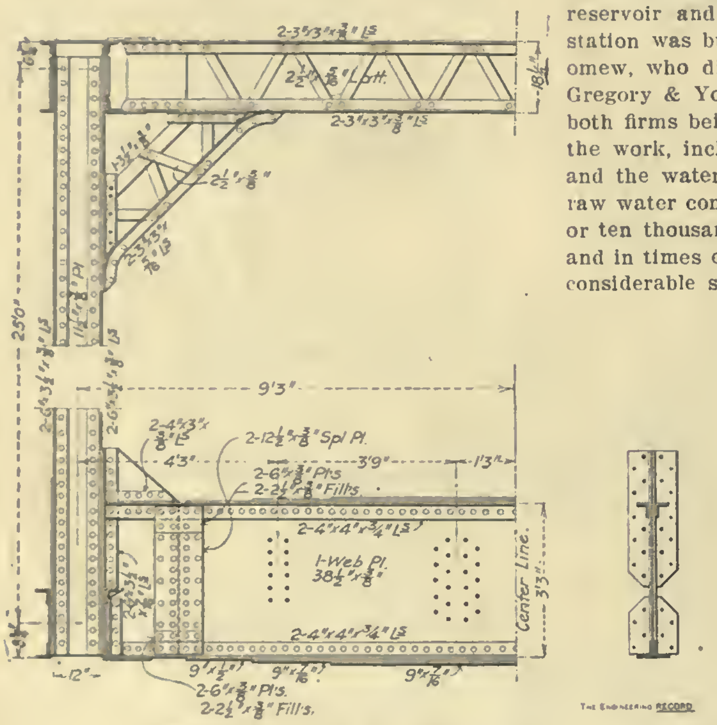
From the reservoir the 12-inch main extends to the center of the village, feeding one mile of 8-inch, four miles of 6-inch, and one-fifth mile of 4-inch pipes, making a total of 8 3/5 miles of cast-iron pipe in the system, including the intake and force mains. There are 225 water-takers connected with the works, and all services are metered, Union and a few Niagara meters being used. Fire hydrants to the number of 62 have been installed. The cast-iron pipes, about 1,200 tons in all, were furnished by the United States Cast-Iron Pipe & Foundry Company; the Cayuta Wheel & Foundry Company, of Sayre, Pa., supplied the valves, and the hydrants were made by R. D. Wood & Company, of Philadelphia. Messrs. Baldwin Brothers & Graham, of Collinwood, Ohio, were the contractors for the construction of the reservoir and laying the pipe; the pumping station was built by Messrs. Tilden & Bartholomew, who did the mason work, and Messrs. Gregory & York, who did the carpenter work, both firms being of Geneva. The total cost of the work, including the land for the reservoir and the water rights, was about $80,000. The raw water contains from a few hundred to nine or ten thousand bacteria per cubic centimeter, and in times of rain is frequently charged with considerable sediment, largely clay. The effluent delivered by the filter, however, is of a very satisfactory quality. The Walter P. Rice Engineering Company, of Cleveland, Ohio, performed the duties of consulting engineer, and the work was executed under the supervision of Mr. B. F. Hewit, village engineer of Geneva.

Destruction Tests of Emery Wheels were described some time ago in the "Zeitschrift" of the Society of German Engineers, by Prof. M. Grübler. Some 57 wheels, 20 inches in diameter, were broken. The highest speed attained was 4,340 revolutions per minute, corresponding to a peripheral velocity of 375 feet per second. The author presented the following as safe centrifugal speed valves: For wheels with vegetable cement, 102 feet per second; for wheels with mineral cement, 88.5 feet per second; for wheels with ceramic cement, 78 feet per second.

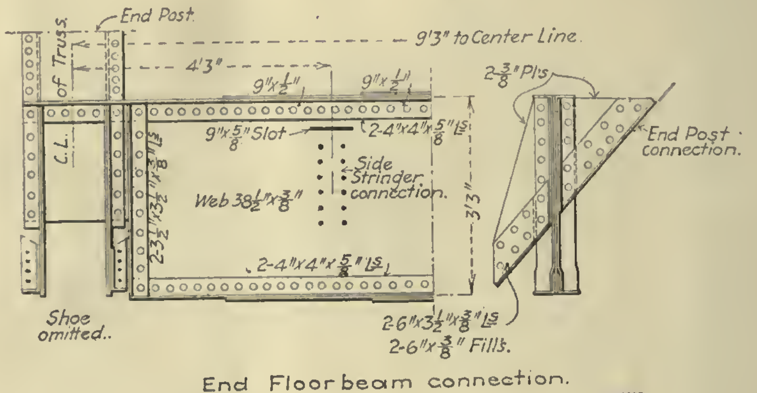
Floorbeam and Lateral-Strut Connections to Riveted Trusses.

The through riveted truss spans of the Canadian Pacific Railway have rigid connections with all field rivets located so as to be advantageously driven. The designs have been developed under the direction of Chief Engineer E. H. McHenry and Mr. C. N. Monsarrat, engineer of bridges, and are used in the standard or a modified form for all of the new work. Intermediate floorbeams are slightly notched to clear the lower chord top flanges and are web-connected to the vertical posts through the end stiffener angles, which are made in two sections slightly offset so that the lower pieces connect to the webs of the lower chords. The upper pieces are riveted to the floorbeam webs without fillers and extend continuously to their upper edges passing under the top flange angles of the floorbeams which are crimped over them. The floorbeam webs have no vertical web-stiffener angles and are made with short end sections spliced to the middle sections by three plates on each side. The end floorbeams have drop ends notched to clear the pedestals and are supported at each end by four web-connected vertical gusset-plates with inclined angles field-riveted to the cover-plates of the inclined end posts. These floorbeams have slots through the web just below the top flanges to receive tension plates which splice the top flanges of the end stringers and of the cantilever brackets which carry the track across the piers or abutments.

The upper transverse struts have I-shaped cross-sections made with pairs of angles back to back, latticed, and of the same depth as the top chords, to which they are secured by horizontal jaw-plates field-riveted to the upper and lower flanges of both members and serving for lateral connections. In short spans the sway-bracing is effected by special built kneebraces with their flange angles curved tangent to the flanges of the strut and of the vertical post and field-riveted with bearings about 2 feet long.



Intermediate Floorbeam and Top Strut.



End Floorbeam connection.

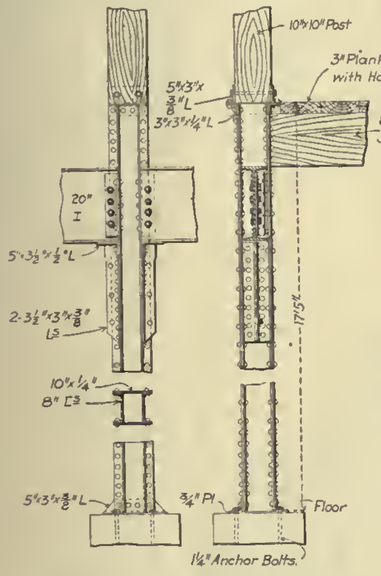
Standard Details of Short Span Double-Track Bridges on the Canadian Pacific Railway.

The Positive Ventilation of Gassing Rooms in textile mills has recently been effected by using fans, and a great improvement in the working conditions has resulted. In the process of singeing the threads over the gas machines the room becomes filled with gas and fumes. Generally disk or propeller fans are placed in the walls, but operators are usually able to work in rooms thus ventilated only about an hour at a time. The B. F. Sturtevant Company has designed a system for the Arlington Mills at Lawrence and other factories, which changes the air in the room at short intervals. The fresh supply is drawn from out-of-doors and forced into the room through a number of well-distributed openings, while the smoky air is exhausted to the outside.

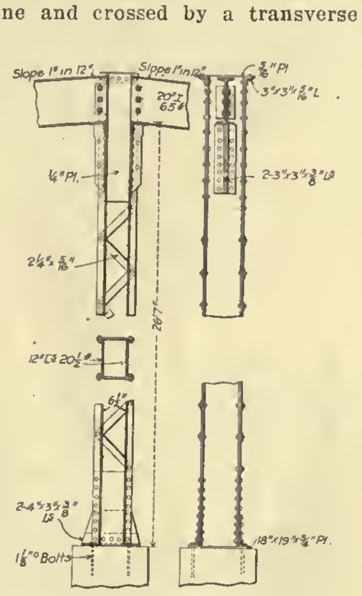
The Canadian Pacific Railway Shops at Montreal.

PART III.—STRUCTURAL FEATURES OF THE BLACKSMITH, MACHINE, WOOD-WORKING AND OTHER SHOPS.

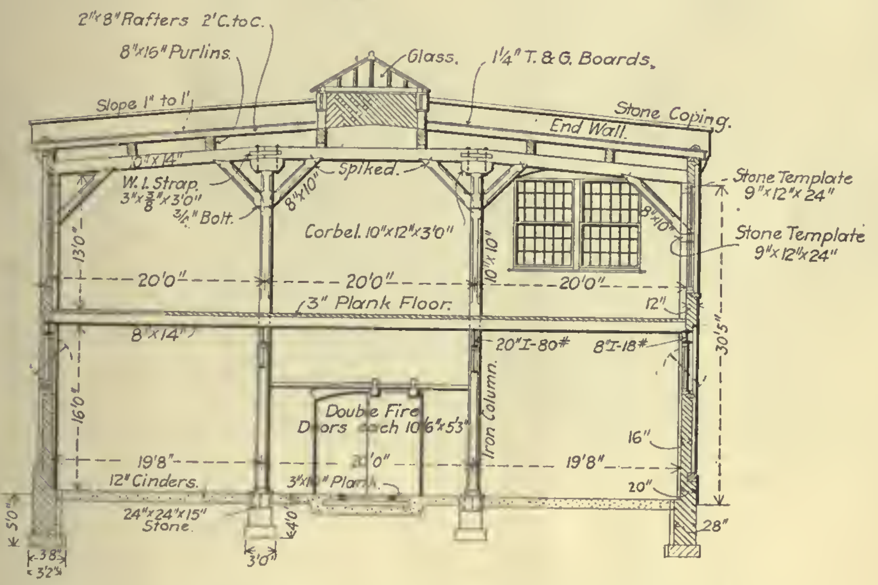
Blacksmith Shop.—The L-shaped blacksmith shop has extreme dimensions of about 434x303 feet, one wing being 146 feet 8 inches wide and the other wing 130 feet wide. The long side faces on the Midway opposite the gray-iron foundry and car machine shop. The building is served by six lines of standard-gauge surface tracks passing through it parallel to the short side and three lines passing through it parallel to the long side, one of the latter being supplied with turntables at its intersections. The L shape was adopted because it was not desirable to have the shop built in a single long line, and in order to arrange for the practical separation of different classes of work under the same roof. By this means the operations in one wing are substantially independent of those in the other and the result is that there are two nearly separate shops in the same building. The wings have hip roofs, and each is divided into three equal aisles by two longitudinal rows of columns supporting the roof trusses. The center aisle roofs are higher than those in the side aisles so as to give clere-stories equal to the depths of the trusses. In each center aisle there is a standard 14-foot monitor extending nearly the full length. The transverse bents of the framework are braced with eight lines of lattice-girder purlins connected to the vertical members of the roof trusses and to the tops of the columns. The trusses correspond to those already described and the columns are made with pairs of channels latticed. The building covers an area of 84,208 square feet and has 360 tons of structural steel, which was built by the Canada Foundry Company.



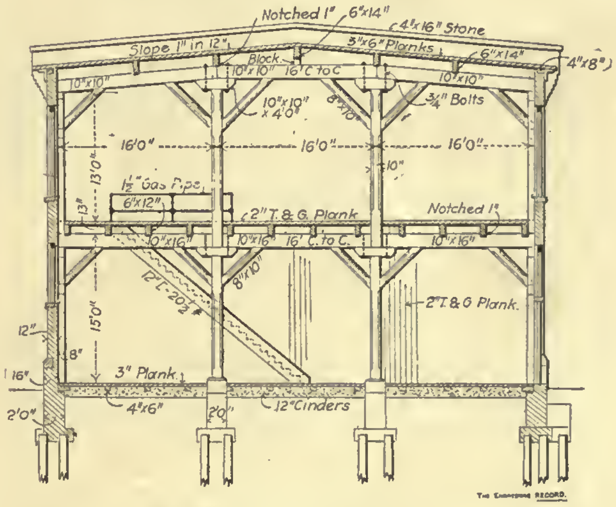
Column and Girder connections in Hardwood Storage Building



Column in Pattern Storage House



Cabinet, Upholstering and Hardwood Storage Building.



Cross-Section of Pattern Shop.

Woodworking Shops, with Wood and Steel Columns.

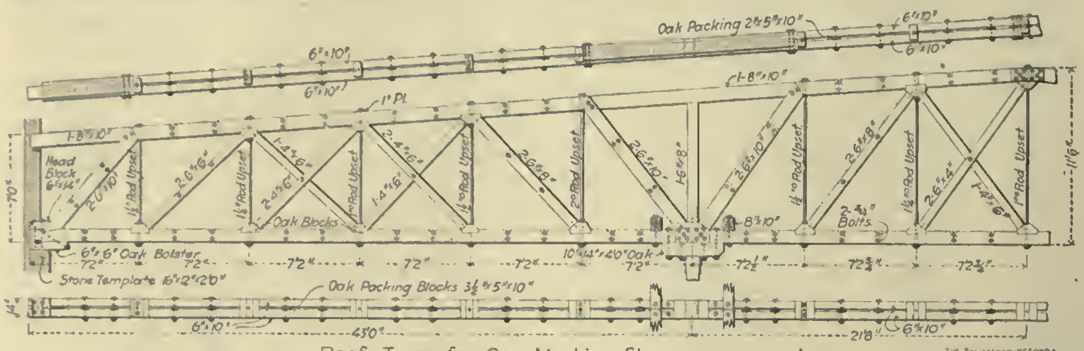
Car Machine Shop.—The 130x288-foot car machine shop has one end facing the Midway. It is served by its girder crane and by three lines of standard-gauge surface tracks passing through it from end to end at right angles to the crane and crossed by a transverse track near the center with turntables at the intersections. This building is of mixed construction, having combination roof trusses continuous across the full width of the building and supported on two equi-distant longitudinal rows of steel columns. The bearings of the trusses are on heavy corbel timbers seated across the column caps and projecting from wall buttresses so as to afford ample bearing for the lower chords and somewhat diminish the span. The compression members in the trusses, except the counterbraces, are made with double pieces, and the tension verticals are made with upset screw rods. The inclined web members take bearing against oak angle blocks, to which they are secured by 1½-inch dowel pins 6 inches long. The trusses are spaced 24 feet apart and support on their top chords fifteen lines of purlins about 6 feet apart. The purlins are 7x16-inch timbers dapped 1-inch over the chords and bolted to them. At the peak the purlins are double and the lines 30 feet each side of the axis of the building are made special to carry the ends of the frames of the 12x60-foot transverse standard monitors. The special purlins have double timbers queenpost trussed with screw-ended bent rods and cast-iron vertical posts, as shown in the detail. The trusses have no lateral nor sway-bracing, but their lower chords are stayed by two lines of 8x10-inch longitudinal timbers bolted to them at each row of columns.

The building has a plank floor, flush with the tops of the surface tracks, laid on a 12-inch bed of rammed cinders. On one side there is a 12x 51-foot lavatory and toilet room and on the opposite side a 16x24-foot fan room. The construction of the monitors in this roof and in that of the other wooden buildings is made special and involves some unusual features. The monitor is set on the center line of the panel with spaces of about 6 feet between its walls and the main roof trusses. Its entire weight is carried by the trussed purlins in the center and at both ends. The long walls of the monitor are not only self-supporting, but carry the ends of the intermediate purlins, which are supported from them by bent hangers. These walls are practically made in two wedge-shaped portions meeting at the axis of the building. They have a framework of top, bottom and vertical timbers 4 inches thick which is covered on the outside with a double course of crossed 1-inch diagonal boards and a single course on the inside, thus making virtually wooden plate girders which prove rigid and satisfactory. Above the upper edge of this girder there is a space of about 15 inches under the eaves of the skylight in which there are several openings closed by hinged ventilating doors. This type of skylight curb has been used with the wooden buildings throughout the plant.

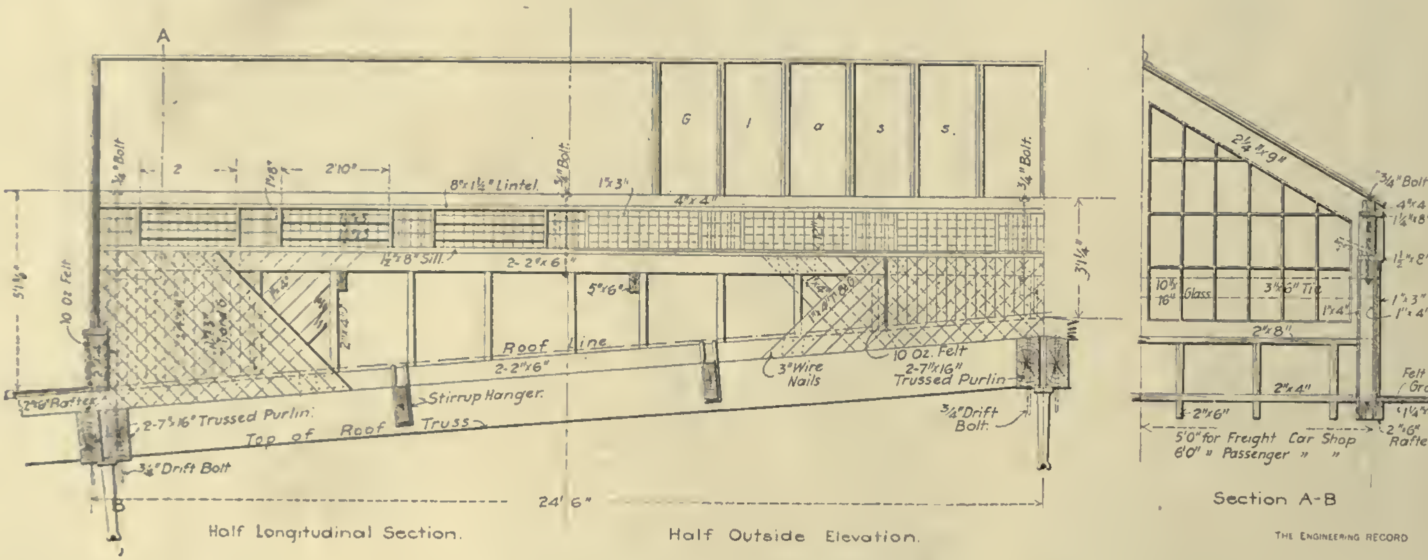
Planing Mill.—The 126x500-foot planing mill is of similar construction to the car machine shop, except that it only has one row of columns, which divides it into two equal longitudinal aisles. It is served by two lines of longitudinal tracks passing through it from end to end and one transverse track with turntables at the intersections, which connects it with the drying kiln. The roof trusses are 20 feet apart and the purlins carry 2x6-inch rafters 2 feet apart. The trusses are 62 feet 8 inches long over all, 15 feet deep in the middle and 7 feet deep at the ends, and have sway-bracing between their top and bottom chords in alternate panels. The details correspond with those of the car machine shop, but the timbers are spliced with pairs of oak fish-plates, as shown in the detail. This building is provided with a 12x 18½-foot lavatory in the middle of one long side.

Freight Car Shop.—The 107x540-foot freight car shop is served by the Midway yard crane across one end and by four longitudinal tracks running through it from end to end. It has side walls about 26 feet high pierced with 12x 21-foot windows 8 feet apart in the clear. In the center of each panel of the roof, except at the ends, there is a 10x48-foot standard transverse monitor, and on one side of the building there are two 16x24-foot fan houses, one 12x41-foot lavatory and toilet room and one 12x40-foot office, all built as one-story lean-tos against the side wall. The combination roof trusses are spaced 20 feet apart and correspond with those in the planing mill. They are supported on steel columns, which also carry the 12-inch runway girders for three one-ton traveling air-hoists in each aisle of the building. The wall girders for the runway are carried on steel brackets bolted through the pilasters.

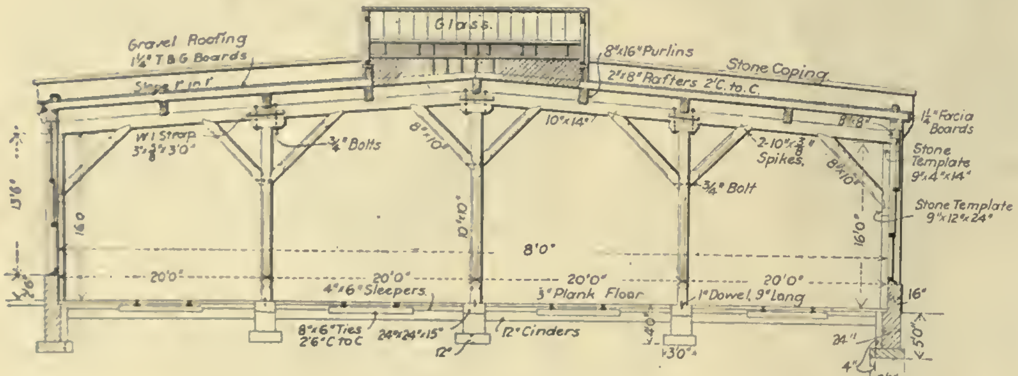
Pattern Shop.—The two-story 50x82-foot pattern shop has wooden floor and roof beams in three spans supported by two longitudinal rows of kneebraced columns, as shown in the cross-section. The 50x150-foot pattern storage building has 20-inch I-beam roof girders 15 feet apart supported on the side walls and by a center row of steel columns. The walls are made solid with the exception of the door openings. They are paneled by outside buttresses in the planes of the roof girders. The building is lighted by four 8x3-foot skylights in every



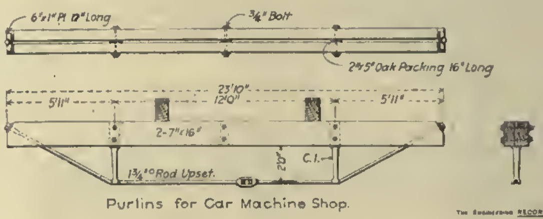
Roof Truss for Car Machine Shop.



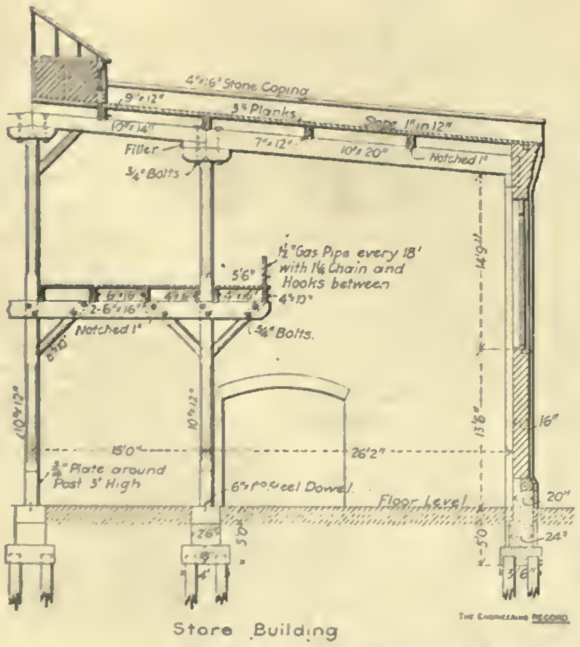
Wooden Column Connection for Monitor Walls.



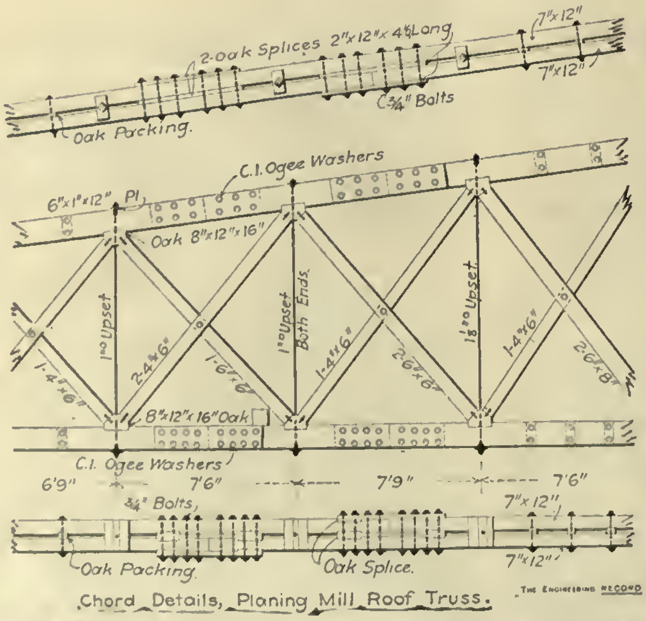
Truck Shop.



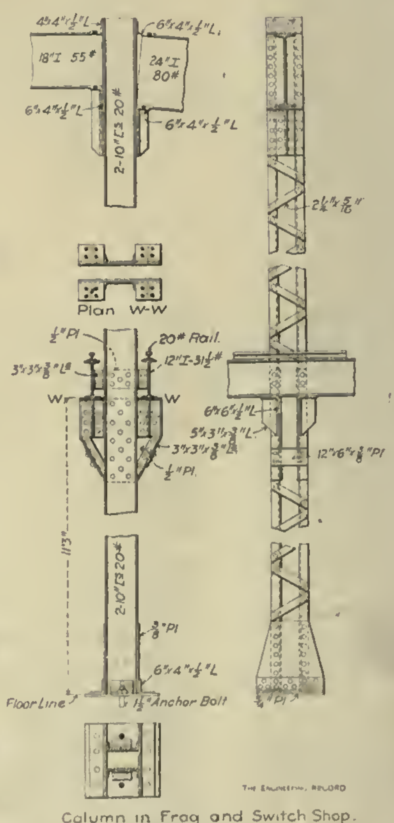
Purlins for Car Machine Shop.



Store Building.



Chord Details, Planing Mill Roof Truss.



Column in Frog and Switch Shop.

TIMBER CONSTRUCTION FOR FLOORS AND ROOFS OF SHOPS OF CANADIAN PACIFIC RAILWAY AT MONTREAL.

alternate panel of the roof. The foundations are carried on piles driven about 4 feet apart in staggered rows under the walls and in groups of four under the columns.

Frog and Switch Shop.—The 102x264-foot frog and switch shop is served by a single longitudinal surface track and by 33-foot 2-ton traveling cranes in two of the three panels into which it is divided by the two longitudinal rows of steel columns which carry the 24-inch I-beam roof girders 24 feet apart. The walls are pierced by windows about 8½ feet wide, 15 feet high and 3 feet apart in the clear, and there is a standard monitor 15 feet wide extending nearly from end to end of the building. There is a 12x24-foot lavatory and toilet room, a 14x110-foot lean-to which also contains the tool room and furnaces. The columns are made with pairs of 10-inch channels latticed and carry the runway girders on bracket plates riveted to the channel webs. The wall girders for the runway are seated on stone templates capping the corbelled brick pilasters.

Cabinet Shop.—The 62x580-foot cabinet and upholstering shop has a transverse fire wall in the center which divides it into a one-story and a two-story portion. The two-story portion is used for hardwood storage on the lower floor and for upholstering on the upper floor, and is built with two lines of steel columns and longitudinal girders supporting the second floor, as shown in the general cross-section. The transverse beams of the second floor and the columns and girders for the roof are all of wood and correspond exactly to those for the roof in the first story part of the building. A 15-foot standard monitor extends from end to end of the building, on the center line of the roof, and the walls are pierced with windows about 8½ feet wide, 12 feet high and 3 feet apart in the lower story, and 10 feet high in the upper story. The steel columns have closed rectangular sections made with two channels and two cover-plates, and have web-connections and reinforced bracket seats for the 20-inch I-beam girders. The wall ends of the transverse floorbeams are carried on 8-inch I-beams seated on pilasters built into the brick walls. The building is served by a single longitudinal track running through it from end to end.

Truck Shop.—The 82x434-foot truck shop is served by three longitudinal tracks running through it and by the Midway yard crane across one end. The eastern portion is divided into four 20-foot aisles by three longitudinal rows of wooden columns which support the transverse wooden roof girders 24 feet apart. The western portion is divided into three aisles by two rows of steel columns supporting steel beams. There is a 10x20-foot transverse monitor in the center of each roof panel and the side walls have 8½x12-foot windows 3 feet apart. Trenches 18 inches wide and 15 inches deep are provided in the floor alongside the track rails for the convenience of workmen fitting the trucks. They are lined with planks. On one side of the building there are two 16x24-foot fan houses and on the opposite side there are two 12x18½-foot lavatory and toilet rooms.

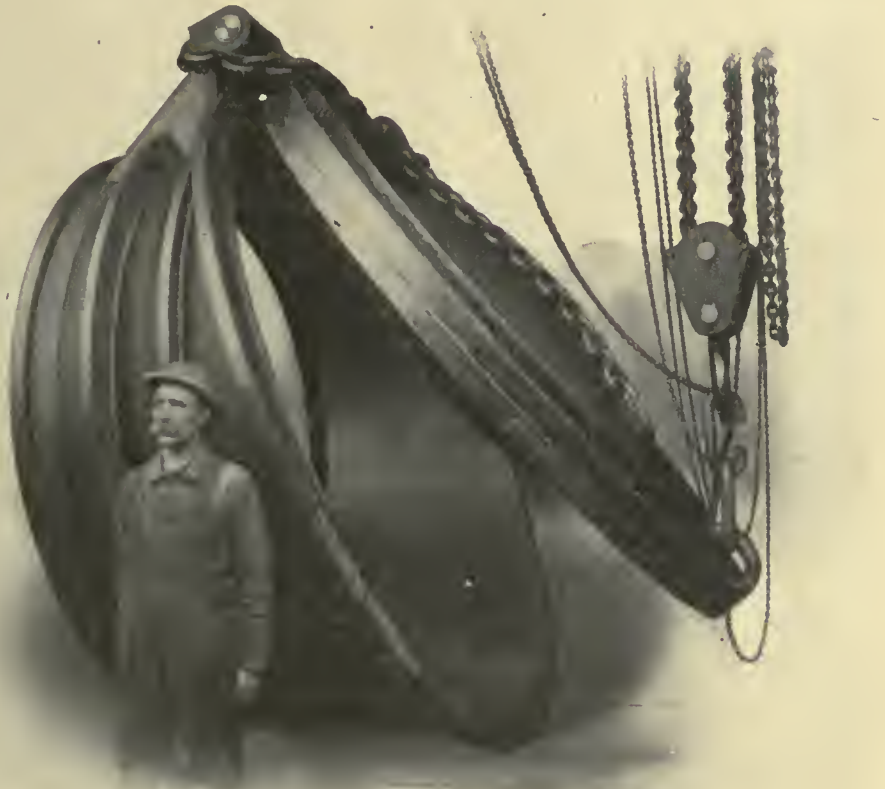
Storehouse.—The 85x594-foot storehouse has wooden roof girders supported by three longitudinal rows of wooden columns, which also carry a center gallery supported on cantilever girders kneebraced to the columns. The column and wall foundations are on piles. The bottoms of the windows are 13½ feet above the floor line to allow for storage racks and shelves on the walls below them. The gallery is lighted by a 12-foot standard monitor extending from end to end of the building.

Office.—The 56x80-foot office building has three full stories besides the basement and attic, and its wooden floors are carried by the exterior and partition walls. The combination roof trusses span the full width of the building and are framed into hip rafters at the ends. A 12x16-foot fireproof vault extends from basement to attic near the center of the building adjacent to the stair-well. The basement is used for a testing room, lavatory, heating apparatus, storage and time-keeper's office. The ground floor is used for clerks, store-keeper, stenographers, telephone and reception rooms; the first floor for general officers, superintendent of rolling stock and car builder; the second floor for drafting room and blueprint room. There are lavatories in every story except at the ground level.

Dry Kilns.—The dry kiln for soft wood has four 19x85-foot compartments. The one for hard wood has one 19x85-foot and one 21x85-foot compartment. Both are equipped with Morton's patent apparatus installed by the A. H. Andrews Company, of Chicago. The kilns are built of wood with a gravel roof. There are no end walls, but the openings there are covered by canvas doors operated by an overhead roll, like a theatre drop curtain.

A Nine-Foot Diameter Flap Valve.

The great growth of the cities of the country has necessitated a corresponding increase in the magnitude of public works of all kinds. This development has extended to the various details of the public service systems, such as pumping engines, pipes, valves and meters, calling for new designs and expedients and exercising the ingenuity of engineers and manufacturers. This tendency has been especially noteworthy in the design and construction of hydraulic machinery and kindred appliances. The new sewerage system of the city of Chicago includes several examples of this, one of which is described in the following paragraphs:



A Nine-Foot Diameter Check Valve.

The photograph reproduced on this page illustrates one of several massive check or flap valves with inlet ports 9 feet in diameter. These valves were placed on the delivery ends of centrifugal pumps and automatically close if the pumps for any reason are shut down. The use of such valves in this case was imperative, as the centrifugal pumps deliver water under several feet head, and no sliding gate could be closed quickly enough to prevent flooding or damage to the pump.

The body of each gate is of gray iron and is partially embedded in the concrete wall. A large gray iron flap of such huge dimensions made strong enough to withstand the sudden strains would, however, have proved far too heavy, and, furthermore, would have greatly impeded the delivery of water through the pump. This obstacle was overcome by devising a partially buoyant float valve composed of a cast-steel rim reinforced by a concentric rib, to which were securely riveted two sheet steel dished plates. The concave sides of these plates were riveted together and joints calked, these in turn being riveted to the ring. Each float was hydraulically tested under pressure to expose leaks.

Both valves and frames were provided with bronze rings dovetailed into the metal and then faced to a watertight surface. Each valve was pivoted on a steel axle hung within bronze bearings. These gates were designed by the engineers of Coffin Valve Company and the Allis Chalmers Company, through whom the valves were furnished. The construction was carried out by the Coffin Valve Company, of Boston, Mass., from whom the illustration was obtained.

Thawing Frozen Ground for street railway construction in Waltham, Mass., is reported, in the "Journal," of the New England Water Works Association, to have been accomplished by the use of lime. There is said to have been nearly 2 feet of frost in the ground. It was a macadamized street. Several barrels of lime were scattered over the part to be dug up; the lime was then covered with manure and wet. The next day the ground was in perfect condition for digging. Lime has also been successfully employed for thawing water service pipes.

Discharging Capacity of Culverts.

By Washington Parker Ireland.

It is a well-established fact that the shape and condition of the entrance or inlet to pipes and conduits affects their discharging capacity. If the end of the pipe projects into the water, the discharge will be less than when the end is flush with the end of the reservoir. Pipes provided with bell-shaped or conical mouthpieces will give a greater discharge than flush-end or inward projecting pipes. It is likewise true that the loss of head at entrance, for a pipe discharging a certain amount, varies with the shape of the entrance to the pipe. These principles were established by hydraulicians who made experiments to determine the effect of different conditions and shapes of approaches on the discharge from cylindrical pipes. An examination of these experiments reveals the fact that they were all made with pipes of small diameter, varying in most cases from ½ to 2 inches. The results of these experiments may not be applicable to pipes of large diameter such as are used to conduct water through railroad embankments and under highways.

Pipes through embankments are usually provided with approaches consisting of timber or masonry walls, the form and position of which, it is supposed, affect the discharge. Since the results of the experiments with pipes of small diameter may not be applicable to pipes of large diameter, it was believed that an investigation of the flow through larger pipes would be a contribution to hydraulic knowledge, and would also bring to light the best method of constructing railroad and highway culverts.

Before entering into this investigation it will be well to briefly review the theoretical explanation of the flow of water through pipes.

The total head which causes flow of water through pipes may be represented by the equation $h = (v^2 \div 2g) + m(v^2 \div 2g) + f(lv^2 \div 2dg)$, in which h is the total head, $v^2/2g$ is the amount of h used to impart velocity to the water, $m\,v^2/2g$ is the amount of h taken by contraction, resistance of the inner edge of the pipe at entrance, and expansion to the full size of the pipe, together called entrance head, and $flv^2 \div 2dg$ is that part of h used in overcoming friction. The term v is the average velocity of the issuing stream in feet per second. The average velocity is used because the actual velocity varies in different parts of the section considered. For a short horizontal pipe, the velocity in the lower part is greater than that in the upper part, since it is under a higher head. Near the side of the pipe the velocity is less than near the center, the smaller value being due to friction. Th term g is the acceleration of gravity, m is the coefficient for entrance head, f is the coefficient of friction, l is the length in feet of the pipe flowing full, and d is the diameter of the pipe in feet.

The loss due to friction, $flv^2 \div 2dg.$, is small in short tubes, as is seen by the following demonstration: In an experiment made by the writer with a 12-inch pipe three diameters in length, a head of 1 foot gave an actual velocity of 5.6 feet per second. The velocity head corresponding to this is 0.71. The water, after contraction, fills the pipe at a distance of two diameters from the entrance. Hence l, the length of that part of the pipe flowing full, is 1 foot. The friction factor, f = 0.02 (see Merriman's "Treatise on Hydraulics," page 168). Substituting these values, $flv^2 \div 2dg = 0.02 \times 1 \times 0.71 = 0.014$. The loss due to friction is therefore about 1.4 per cent. in this case. The term $flv^2 \div 2dg$ will therefore be dropped for pipes of three diameters length, and the friction loss will be included in the term for entrance head $mv^2/2g$. We shall use the formula $h = v^2(1 + m) \div 2g$. The coefficient of entrance head m is obtained from $m = (1 - C^2) - 1$ (see Merriman's "Treatise on Hydraulics," page 165, Art. 73) in which c is the coefficient of discharge, determined by dividing the actual discharge of a short tube by the theoretical discharge.

The real problem is to determine the loss of head at entrance, $m\,v^2/2g$, with different shaped approaches and under different conditions. To make this determination experiments were made with a wrought iron cylindrical pipe, 12 inches in diameter and three diameters in length. The pipe was provided with straight wall and wing wall entrances built of dressed and matched flooring. The straight wall was so constructed that the distance from the edge of the pipe to the bottom and sides of the wall was two diameters. The wing walls were built so that they could be swung on hinges to any desired angle with the axis of the pipe.

The pipe was placed in a horizontal position in a large weir channel, with one end protruding through a hole in a water-tight bulkhead built across the weir opening, and the other end, supporting one of the above described wall entrances, resting on an A support. The water entered the channel at the upper end and was discharged through the pipe. The head on the center of the pipe was measured by means of a graduated rod which was read to hundredths of a foot. After discharging from the pipe the water passed over a 3-foot suppressed weir. The actual discharge was measured by means of this weir, the head on the weir being obtained with a hook gauge.

A set of experiments was made with the wing-walls making angles of 0, 15, 30 and 45 degrees with the axis of the pipe; each set comprising experiments made with the pipe under three different heads, varying from 0.5 to 1.3 ft. Another set was made with the straight wall entrance perpendicular to the axis of the pipe, the end of the pipe being flush with the wall. The actual discharge in each experiment was divided by the theoretical discharge calculated from the equation $Q = A \times \sqrt{2gh}$, in which Q = the discharge in cubic feet per second, and a = area of pipe in square feet, g = acceleration of gravity, and h = head on center of pipe in feet. The value thus obtained is the coefficient of discharge and substituting it in $m = (1/c^2 - 1)$, the coefficient of entrance loss, m, is obtained.

Having obtained values of m in the above described manner for each shape and condition of entrance, the relation between m and H, the head on center of pipe, was found by plotting the results on cross-section paper on which were also plotted the results of similar experiments with a 6-inch pipe provided with diverging conical mouthpieces, as well as straight wall and inward projecting. It is shown by these diagrams that the experiments with 12-inch pipe verify those made with the 6-inch.

By plotting the results in this manner it was clear that there is not much difference between the values of m for the inward projecting pipe and the pipe flush with wall of reservoir (straight wall). Generally, then, for culverts flowing full at the discharge and the values of m may, without great error, be taken to be 0.52 for flush end, and 0.62 for entrance end projecting into stream. For low heads or slow velocities it may be somewhat larger.

The values of m for diverging mouthpieces do not differ much from each other. For angles of divergence of from 10 to 30 degrees m may be taken to be 0.20, and from 30 to 60 degrees it may be 0.25, the culvert flowing full at the discharge end.

Pipes provided with diverging mouthpieces have much smaller values of m than inward projecting pipes, or flush ends.

The discharge from culverts not flowing full is materially less than that usually calculated, due to the dropping of the water, or contraction at entrance, and to the error in the velocity assumed. The value of m, using v as the velocity calculated from full pipe section in the formula $h = (1 + m)\,v^2/2g$, will be from three to six times the value found for conditions for the pipe actually running full. If the actual average velocity in the part-full pipe was used the resulting value of m would not be far from the amounts given above. In order that a culvert may flow full and discharge the amount calculated by the usual formula, the head on the center of the pipe must be at least one diameter.

Model of Straight-Wall Entrance.

Model of Wing-Wall Entrance.

Having obtained the coefficient of entrance loss, m, for pipes of three diameters length the discharging capacity of pipes or culverts of any length may be calculated by means of the formula

$$v = \sqrt{\frac{2gh}{1 + m + f\frac{l - 3d}{d}}}\ .$$

(see Merriman's "Treatise on Hydraulics," page 180). Using the above values of m, 0.52 for straight wall and 0.62 for inward projecting formulas for discharge through culverts with the discharge end flowing full are as follows:

Straight Wall Entrance—
For $l = 3d$, $q = 0.81a\ \sqrt{2gh}$.
" $l = 12d$, $q = 0.77a\ \sqrt{2gh}$.
" $l = 24d$, $q = 0.72a\ \sqrt{2gh}$.
Fifteen Degree Wing Wall Entrance—
For $l = 3d$, $q = 0.79a\ \sqrt{2gh}$.
" $l = 12d$, $q = 0.75a\ \sqrt{2gh}$.
" $l = 24d$, $q = 0.71a\ \sqrt{2gh}$.

(The 15 degrees is the angle of divergence of each wall from the axis of the pipe.)

Pipe Projecting Into Stream—
For $l = 3d$, $v = 0.78a\ \sqrt{2gh}$.
" $l = 12d$, $v = 0.74a\ \sqrt{2gh}$.
" $l = 24d$, $v = 0.70a\ \sqrt{2gh}$.

There is little difference between the discharge for the different ends. When the discharge end does not flow full, m ranges from

1.5 to 3.0. The values of c corresponding to these values of m are 0.63 and 0.50 respectively. We therefore have the equation $q = 0.50$ to $0.63\, a\sqrt{2gh}$, by which the discharge may be calculated. Thus we see that the discharge from culverts not flowing full at the discharge end is only two-thirds to three-quarters that from culverts flowing full. Using the above equation the following values of q were obtained:

Straight Wall—
For $l = 3d$, $q = 0.63a \sqrt{2gh}$.
" $l = 12d$, $q = 0.61a \sqrt{2gh}$.
" $l = 24d$, $q = 0.58a \sqrt{2gh}$.
Fifteen-Degree Wing Wall—
For $l = 3d$, $v = 0.54a \sqrt{2gh}$.
" $l = 12d$, $v = 0.52a \sqrt{2gh}$.
" $l = 24d$, $q = 0.51a \sqrt{2gh}$.
Inward Projecting—
For $l = 3d$, $q = 0.52a \sqrt{2gh}$.
" $l = 12d$, $q = 0.51a \sqrt{2gh}$.
" $l = 24d$, $q = 0.49a \sqrt{2gh}$.

The above equations were derived considering no velocity in the water at entrance to culvert. Assuming a velocity of approach of half the velocity in the culvert the following equations were derived from

$$v = \sqrt{\frac{2gh}{\frac{3}{4} + m + f\,\frac{l-3d}{d}}}$$

for the pipe flowing full and partially full.

Pipe Full at Discharge End.

Straight Wall—
For $l = 3d$, $q = 0.89a \sqrt{2gh}$.
" $l = 12d$, $q = 0.83a \sqrt{2gh}$.
" $l = 24d$, $q = 0.77a \sqrt{2gh}$.
Fifteen-Degree Wing Wall—
For $l = 3d$, $q = 0.86a \sqrt{2gh}$.
" $l = 12d$, $q = 0.81a \sqrt{2gh}$.
" $l = 24d$, $q = 0.75a \sqrt{2gh}$.
Inward Projecting—
For $l = 3d$, $q = 0.85a \sqrt{2gh}$.
" $l = 12d$, $q = 0.80a \sqrt{2gh}$.
" $l = 24d$, $q = 0.75a \sqrt{2gh}$.

Pipe Not Full at Discharge End.

Straight Wall—
For $l = 3d$, $q = 0.67a \sqrt{2gh}$.
" $l = 12d$, $q = 0.64a \sqrt{2gh}$.
" $l = 24d$, $q = 0.61a \sqrt{2gh}$.
Fifteen-Degree Wing Wall.
For $l = 3d$, $q = 0.57a \sqrt{2gh}$.
" $l = 12d$, $q = 0.55a \sqrt{2gh}$.
" $l = 24d$, $q = 0.53a \sqrt{2gh}$.
Inward Projecting—
For $l = 3d$, $q = 0.54a \sqrt{2gh}$.
" $l = 12d$, $q = 0.52a \sqrt{2gh}$.
" $l = 24d$, $q = 0.50a \sqrt{2gh}$.

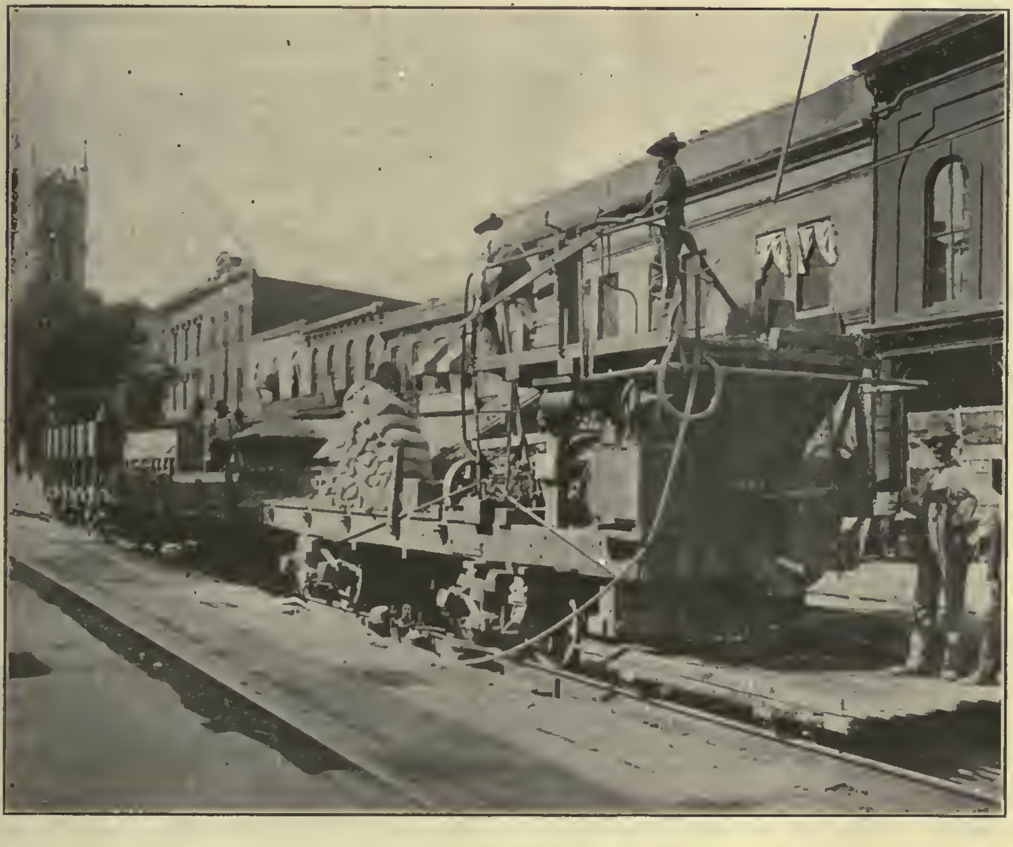
If railroad or highway culverts are constructed with wing-wall entrances there is not much difference in the values of m for different degrees of divergence. With the pipe flowing full m varies from 0.60 to 0.80 with any angle of divergence between 0 and 90 degrees, including straight wall or flush end. So far as shown, then, the discharging capacity is practically independent of the form of entrance. Wing-walls may be advantageous in directing the flow of drift and rubbish through the culvert.

The best culvert construction is that in which a minimum loss of head at entrance and a maximum discharge are obtained. This may be accomplished, as the results of this investigation indicate, by building conical mouthpieces, diverging from the edge of the pipe at an angle of from 10 to 30 degrees with the axis of the pipe. It is only necessary to construct the mouthpiece diverging from sides and top of pipe since the bottom, if constructed, would soon be filled with material deposited by the stream. This is an economical method of construction since the length of the mouthpiece, which is determined by making the area of the outer end twice the area of the pipe, varies from one-third the diameter of the pipe to one diameter, for angles of divergence of from 30 to 10 degrees.

These notes are taken from a thesis submitted last year at the University of Illinois in the course in civil engineering. The writer is indebted to Prof. A. N. Talbot, of the municipal and sanitary engineering department of the University, for valuable suggestions and advice during the investigation of this subject.

The Panama Canal Commission sailed for the Isthmus on Tuesday for a preliminary study of conditions there.

A Concrete Plant for Street Railway Work.



The Kerwin Concrete Train of the Detroit United Railway.

The accompanying illustration shows a plant built somewhat over a year ago from the plans of Mr. John Kerwin, superintendent of tracks of the Detroit United Railway, in the company's shop. In the construction of a modern street railway roadbed a large amount of concrete has to be used, but the conditions of the work make it impracticable to place the material in the track at a low cost if it is mixed in the usual semi-portable plants. The quantity to be laid in any one place is comparatively small in proportion to the whole amount, and the highest economy is only possible when a portable plant is employed. Mr. Kerwin employs a train of three cars, that at the head carrying the mixer, the middle one the sand, and the third, broken stone. A narrow-gauge track runs down the middle of each car, and the sections of the track are connected over the couplings by fish plates. On the mixer car the track ends in an incline leading to the platform over the mixer. When the material cars are empty two more with fresh supplies are attached. The little hopper car shown on the track in the middle of the train is hauled along by a cable running to a winding drum at the head, which is controlled by the operator of the mixer. All the machinery is operated electrically.

When the plant is in use, the hopper car has half a yard of sand spread over its bottom and then half a barrel or two bags of cement is put on the sand. The little car is then run back to the last or stone car, which has high sides in order to hold the broken stone on a platform above the track on which the charging car runs. A cubic yard of crushed stone is discharged over the cement through an opening in the platform, and the batch of raw materials is then hauled to the hopper of the mixer.

The mixer is a drum 8 feet in diameter and 4 feet long, revolved by an electric motor. The boy standing on the platform adds the water to the batch, the amount being measured by means of the tank or cask shown behind him on the staging. The mixed concrete is discharged through the chute to the low car on which the men are shown standing, and this car is dragged by a horse to the place where the concrete is to be used. The car has a pole bottom, like a contractor's cart, to facilitate the dumping of the concrete.

This plant avoids any storage of materials on the street, keeps the mixer close to the work, and furnishes a batch of concrete every 5 minutes if it is desired. A crew of nine men are required to operate the train, which is estimated by Mr. Kerwin to save about $20 a day when concrete construction is in full swing.

The Association of Portland Cement Manufacturers is erecting on the exposition grounds at St. Louis, a concrete building, in the Mission style of architecture, which, with its contents, will constitute the collective exhibit of the cement industries. The building consists of three halls, with two 25-foot courts between, connected by a loggia, and will form the gateway to the "outside mining exhibit." The center hall will contain exhibits of cement in all stages of manufacture, together with drawings and photographs of cement plants and quarries, and cement and concrete work. One hall will be a complete testing laboratory in charge of an engineer. The third hall will be a meeting place for engineers, architects, contractors and others interested in cement, and will be supplied with the leading trade journals. Among the most interesting structural features of the building will be the beams supporting the roof. They have a span of 30 feet and are to be cast on the ground and then erected in place.

The Fallacy of the Tests Ordinarily Applied to Portland Cement.

Read at the November meeting of the Lehigh Valley Section of the American Chemical Society, by Richard K. Meade.

The qualities which are requisite for a good Portland cement are those which insure that concrete made from it shall be of sufficient strength to withstand any and all strains, stresses and shocks to which it may be submitted, not only when first made and allowed to harden, but after the lapse of many years. The tests now applied to cement all aim to search out these qualities, or show their absence, and may be classed under two general heads, i. e., those designed to show the strength of concrete made from the cement, and those designed to show its endurance. Under the first head come the tests for tensile strength, compressive strength, fineness to which the cement is ground, as this influences its sand-carrying capacity and hence its strength, and time or rate of setting, as quick-setting cement may not give sufficient time for proper manipulation of the concrete and slow-setting cement may take too long to get its strength. Under tests for endurance come the various so-called soundness tests, and possibly chemical analysis as the quantities of magnesia and of sulphur trioxide present are supposed to have an influence upon endurance.

It is the writer's intention in this paper to discuss some of the false conclusions that may be drawn from a too rigid interpretation of the results of these tests even when they are properly manipulated. Improper manipulation or the varying results due to the personal equation of the operator or the different percentages of water used in gauging the mortar, or the sundry modes of making briquettes and pats, trowelling, ramming, shaping, etc., enter no part into it, and for the sake of simplicity it is supposed that the results of different operators agree. It is well to say, also, at the outset that it is not the writer's intention to advocate any new system of cement testing nor to suggest that the present one be done away, but merely to point out certain weaknesses which limit its general application to every case, and to recommend a stronger leaning towards those tests which show the strength and endurance of sand mortar rather than neat cement.

Soundness.—The tests ordinarily applied to Portland cement are those for soundness, tensile strength, fineness and rate of set. These are placed in the order of relative importance as considered by most inquirers. Unquestionably the most important test of cement is that of its endurance, or the test for soundness, and this test has certainly the right to be the one most widely discussed. It is unfortunate that the test which seems to be accepted by the majority as a standard is the long-time cold-water pat, a test requiring such length of time for its completion as to practically forbid its use. The conditions of the case demand a rapid test in order that the consumer may not be required to store the cement for a long period of time while he awaits the results of his cold-water pats. Quite a number of these rapid tests have been proposed, chief of which are the boiling test first devised by Prof. Tetmajer of Zurich, and the steam test recommended in its preliminary report by the last committee of the American Society of Civil Engineers on cement testing. A milder test much used in England is the warm water test of Faija in which the pats are allowed to harden over water kept at 120 degrees Fahr. for six hours and then immersed in the latter for eighteen hours. Very little cement which fails on the boiling test will pass a five-hour steam test, but a great deal of that failing on the boiling and steam tests will pass the Faija test satisfactorily.

To the manufacturer the boiling test is an exceedingly useful one, for if a cement will pass this test it will pass any test to which it may be subjected. He can not hold his cement in his stock house for months while he ascertains if it will pass the cold-water pat test and so he applies an accelerated test to tell him if this cement will pass the tests to which it is likely to be put. To my mind there is a strong comparison between the boiling test and the color test for carbon, so much used in the steel works laboratories. While this latter test is very useful to the manufacturer still no engineer would condemn steel on the result of such a test, for though it may give correct results in nine out of ten cases he does not care to take the risk of this being the tenth case and of throwing out a good steel, and so working great hardship to the manufacturer.

Unquestionably much good concrete has been made from so-called unsound cement, and this is the key to the whole objection to the boiling test. It is probable that much of the first American Portland cement would not have passed the boiling test, yet it is upon the merits of the work done with this cement that engineers are now using American instead of imported cement. Butler gives a strong plea for the Faija test and states that in the twenty years this test has been in use, no cases of failure in work by cement passing this test have come under his observation. If the Faija test is severe enough to exclude all bad cements, then the boiling test is needlessly severe as it rejects many cements which pass Faija's test.

All cement probably contains some free lime. From the nature of the case this must be so, since cement raw materials are not ground to a degree of fineness nor carried to a state of fusion which would permit of every molecule of lime coming in contact with a molecule of silica or of alumina. Now there are limits beyond which if the uncombined or free lime goes certain results will take place. Let us suppose that with a very small percentage present the cement will fail on the boiling test but pass satisfactorily five hours in steam, and if a still larger percentage is present it will fail in the steam but pass the Faija test. Now, again, let us suppose that a neat mixture with a certain small percentage of free lime is sound, with a larger percentage a 3:1 sand mixture is sound, with a still larger percentage a 1:3:8 concrete is sound. (It is well understood that the tendency of cement to disintegrate is greater in a neat paste than in a sand mixture, and anyone with experience in cement testing knows of cases where neat briquettes were disintegrated in time and yet the sand ones were sound and strong.) Now how do we know that the limit of lime which may be present in good cement (that is cement which will make enduring concrete) is coincident with that maximum which may be present for a sound boiling test?

Nearly all advocates of the boiling test have tried to prove these two limits coincident by comparing the boiling test with the results of neat pats and neat briquettes. Usually the coincidence of a failure on the boiling test with either a warping or cracking of the neat pats or a loss of strength in the neat briquettes on long time tests is considered competent evidence in favor of the boiling test. In reality cement is seldom used neat. A cement which fails on the boiling test, whose neat briquettes fall off in strength after 7 or 28 days, yet whose sand briquettes increase in strength as they grow older, has certainly given evidence that it will make good concrete. In weighing evidence for the boiling test it must be remembered that we do not make this test to see if neat briquettes will fail in strength as they age or if neat pats will warp and decay but whether sidewalks, piers, abutments, foundations, walls, floors and buildings of concrete, not neat cement, will be permanent, and the thing therefore to compare the boiling test with is concrete. Not until we can compare our laboratory records with many examples of both failures and successes in actual work shall we have reliable data for forming our conclusions as to the reliability of the various tests for soundness.

At the last meeting of the American Society for Testing Materials Mr. W. P. Taylor, of the Philadelphia Testing Laboratory, read a very carefully prepared paper upon the boiling test [printed in The Engineering Record of August 15, 1903] in which he compared the results of neat briquettes and neat pats with the results of the boiling test. As is usual he considered a falling off of the strength of neat briquettes on long time tests and a cracking and warping of the neat cold water pat as being positive evidence of the presence of injurious constituents in the cement. He gives these figures: "Of all the samples failing to pass the boiling test 34 per cent. of them developed checking or curvature in the normal pats or a loss of strength in less than 28 days. Of those samples that failed in the boiling test but remained sound for 28 days, 3 per cent. of the normal pats showed checking or abnormal curvature in 2 months, 7 per cent. in 3 months, 10 per cent. in 4 months, 26 per cent. in 6 months, and 48 per cent. in one year; and of these same samples 37 per cent. showed a falling off in tensile strength in 2 months, 39 per cent. in 3 months, 52 per cent. in 4 months, 63 per cent. in 6 months, and 71 per cent. in one year. Or taking all these together, of all the samples that failed in the boiling test 86 per cent. of them gave evidence in less than a year's time of possessing some injurious quality.

"On the other hand, of those cements passing the boiling test but one-half of 1 per cent. gave signs of failure in the normal pat tests and but 13 per cent. showed a falling off in strength in a year's time."

Mr. Taylor after making these comparisons acknowledges their fallacy by one of the closing paragraphs of his paper.

"Now finally we come to what is after all the most vital question of all, and this is the relation of the results of the boiling test to the conditions found in actual work and there every tester of cement runs up against a stumbling block, for while almost every one connected with testing can cite instances of failures in the boiling being corroborated by failure in the work, it nevertheless cannot be denied that in the vast majority of cases work done with cement determined in the laboratory to be unsound will give most excellent results in practice and show not the remotest sign of any sort of failure."

Experiments made by a committee of the Society of German Portland Cement Manufacturers in connection with the Royal Testing Laboratory at Charlottenburg forced them to report in 1900 and again in 1903 that none of the so-called accelerated tests for constancy of volume was adapted to furnish a reliable and quick judgment in all cases concerning the applicability of a cement. The experiments which they made consisted in putting the cement into actual work and observing it during a period of four years. The committtee recommended the 28-day cold water pat as a standard test. If this test is taken as a standard the boiling test will reject two good cements for every bad one according to Mr. Taylor's figures, as he states only 34 per cent. of the failures on the boiling test were corroborated by failures in the 28-day normal pats.

Tensile Strength.—Perhaps the results of no test are given so prominent a place in the manufacturers' advertisements as the neat strength of briquettes made of his brand. We hear the question constantly propounded by the prospective purchaser of "How much does your cement pull?" and a thousand-pound neat 7-day break is considered compensation for all the deleterious qualities a cement may have. In reality, the neat break is not of so much value as we are apt to suppose, and taken by itself is little criterion of the quality of cement. Unsound cements often give notoriously high results and the addition of plaster or gypsum will also increase the neat strength. In both of these instances there is apt to be on long time breaks a falling off in strength, permanent in the former case and usually only temporary in the latter case.

A fact that is generally known is that up to a certain point coarse grinding of the cement will give higher neat results than fine grinding. A cement 75 per cent. of which passed a 200-mesh sieve gave after 7 days a neat strength of 912 pounds and a sand strength of 256 pounds. The finer portion of this cement, that passing a 200-mesh sieve, gave for the same period a neat strength of 715 pounds and a sand strength of 463 pounds. A sample of float (i. e., the fine cement dust which collects on the beams, etc., in a cement mill and which is nearly all of it an impalpable powder) gave for 7 days a neat strength of 679 pounds and a sand strength of 558 pounds. This dust mixed with 25 per cent. of coarse cement, i. e., that passing a 100-mesh screen but retained on a 200-mesh, gave 919 pounds neat but only 252 pounds sand strength in 7 days. Certainly in both these cases neat strength would have given us a poor comparison of the value of the two products. As cement is always used with sand, the sand strength is the important thing.

Another point which has often been brought against cement, and American cements in particular, is that of a permanent drop in tensile strength after the 28-day test. In fairly quick setting cements with their usual low lime content and to which the normal amount of gypsum or plaster has been added, this drop is rarely met with and is probably then due to improper manipulation of the test. In cements high in lime, without being necessarily unsound, or in cements to which a large addition of plaster or gypsum has been made, this drop is often met with. In unsound cements it is usually met with, often after the 7-day test.

While it is true that any drop in strength indicates a disrupting action, still cement is never used neat and in the vast majority of cases when a cement shows a slight falling off in neat strength, the sand strength increases with age. Humphreys states that the compressive strength of neat cement does not experience this drop when the cement is sound even if the tensile strength does fall off somewhat after the 28-day test; an important fact, if true, as cement is seldom if ever used in tension. This brings us to the question if it is not a fallacy to subject a material to a tensile stress to see if it will stand a compressive one.

Coarse grinding of the cement has some influence on the increase in strength with age. A very fine cement increases neat very little after 7 days, while a coarser one keeps on increasing. This is no doubt due to the fact that the coarse particles are acted on much slower than the fine ones, and solution and crystalization of these go on after the finer ones are all hydrated. The following experiment was made with the same cement. Cement A is just as it comes from the mills. Cement B is cement A with the coarse particles (residue on a No. 200 sieve, removed:

Age.	7 days.	28 days.	3 mos.	6 mos.	9 mos.
Cement A, lbs.....	618	695	675	725	750
Cement B, lbs.....	518	546	535	510	549

Fineness.—The most rigid fineness specification could be filled by a cement which would be many degrees too coarse. Some of the older specifications could be easily filled by a product which would show almost no setting qualities and no sand-carrying capacity. If a sample of clinker is crushed in an iron mortar by a pestle and sieved as fast as it is ground through a 100-mesh screen a product will be obtained 100 per cent. of which will pass a 100-mesh screen. Many of the older specifications call for only 90 per cent. If a pat is made of this cement it will just about cohere. If, however, the fine particles are sieved through a 200-mesh screen and the flour washed off the coarse particles by benzine and the latter driven off by heat, the product will still all pass a 100-mesh sieve and yet will have no setting properties. If another sample is ground in a mortar and sieved after every few strokes of the pestle through a 200-mesh screen it will nevertheless be almost worthless as a cement. When washed free from its flour with benzine it will just about hold together. In the writer's laboratory there is a Braun's gyratory miller for grinding samples, in which the grinding is done by an enclosed round pestle revolving in a semi-hemispherical mortar. In the bottom of the mortar is a hole which can be stopped by a plug. The grinding may be done in two ways, one by feeding the sample into the hopper in the cover and allowing it to work its way out at the bottom, then sieving out the fine material from the coarse, and returning the latter through the grinder, and so on until all has passed the sieve. The other, by placing the plug in the bottom of the mortar and allowing the pestle to work upon the material until the latter has reached the desired fineness. Two samples of cement were prepared from the same lot of clinker by these methods. One sample, the one made by passing the clinker through the miller and sieving out the 200-mesh particles after each grind, would of course all pass a 200-mesh sieve. The other sample, the one made by grinding the whole sample to the desired fineness without screening, tested 96 per cent. through a 100-mesh sieve and 76.5 per cent. through a 200-mesh sieve. Sand briquettes were made of these two lots of cement with the following results.

Samples made by	7 days.	28 days.	3 mos.	6 mos.
Grinding and screening to fineness (all 200 mesh) lbs.........	Broke in clips	Broke in clips	Broke in clips	28
Grinding to fineness without screening...	215	295	325	318

The cementing value of Portland cement depends upon the percentage of those infinitesimal particles which we call flour. No sieve is fine enough to tell the quantity of these present. At the same mill it is probable that the sieve test is relative but to the engineer who is called upon to examine the product of many mills using different systems of grinding the sieve test is hardly to be expected to give the relative percentage of flour in each. The product of the Griffin mill and of the ball and tube mill probably differ much in the percentage of flour present, even when testing the same degree of fineness on the 200-mesh sieve. Even with the ball and tube mill system one ball mill and two tube mills would probably give a product with a higher percentage of flour than one tube mill and two ball mills, even when the cement was ground to the same sieve test. The size screen on the ball mills probably also influences the percentage of flour in a product of a certain fineness.

Rate of Set.—The test for setting time is of course influenced by many laboratory conditions, such as temperature and manipulation. This test, however, is seldom used as a basis of comparison but merely to see if the cement is sufficiently slow in its setting action to be properly manipulated or whether it hardens rapidly enough to satisfy the requirements of the work on which it is to be used. The fallacy in the case of this test lies in the terms initial and final set. These terms are meaningless as "set" is a chemical reaction which begins with the addition of the water and goes on indefinitely, or merges into possibly another chemical reaction, if you wish to consider "set" and "hardening" as different phenomena. To fix two points in this reaction by means of loaded wires and call them the beginning and the end of the reaction is a misnomer. It would be better to use the terms heavy and light Gillmore wire or some similar term if other apparatus for determining the set is used.

An Excavating Tunnel Shield.

A steel cylindrical shield invented by a Mr. Price for tunnel excavation in soft material is illustrated in a recent issue of London "Engineering." The dimensions are not given, but it seems to be of comparatively small diameter for a single-track tunnel and is interesting on account of the excavating apparatus which is fixed in it between the tail-piece and the cutting edge. A horizontal shaft in the axis of the cylinder is supported by transverse girders and carries a cutter head with six radial arms in a transverse plane apparently just in advance of the cutting edge. Horizontal knives are bolted to the equi-distant arms and have projecting tools which cut concentric grooves about 6 inches apart in the face of the heading and loosen it previous to excavation. The cutter head acts somewhat like a large milling tool. Its feed is controlled by the hydraulic rams which are used to advance the shield. It makes an annular excavation of the full diameter of the shield and the center core is removed by an eccentric fluted knife.

Attached to the extremities of the arms are steel buckets somewhat resembling a common coal scuttle. They are set with their wide faces in transverse vertical planes and have sharp edges on the front side and on the curved outer face. As they revolve, they fill with spoil, which, at each revolution, is automatically dumped into a chute in the upper part of the shield. The chute delivers to a motor-driven conveyer belt which is long enough to fill the cars necessary to remove all the material excavated at one setting of the shield.

The excavating apparatus is driven by a 50 horse-power British Thomson-Houston tramway motor. Fourteen of the machines are now in operation and several of them are used on the Great Northern, Piccadilly & Brompton Railway.

Coal Consumption where superheated steam is employed was referred to in a paper recently read before the Rugby, England, Engineering Society, by Mr. G. D. Seaton. In the case of one compound engine, 1.31 pounds of coal were burned per indicated horse-power, the boiler pressure being 140 pounds, the steam temperature at superheater 498 degrees Fahr., and the indicated horse-power, 1,273. In two other compound engines, the coal consumption was 1.46 and 1.6 pounds, the boiler pressures being 155 and 135 pounds, respectively; the steam temperatures, 491 and 488 degrees and the indicated horse-power, 980 and 236. In the case of a triple expansion engine, the coal consumption was 1.3 pounds, with a boiler pressure of 180 pounds, a steam temperature of 600 degrees and an indicated horse-power of 457.

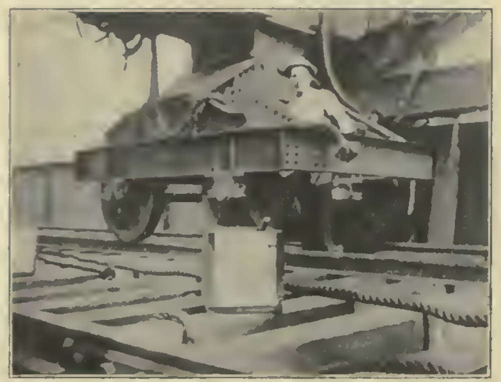
The Erection of the Monongahela River Bridge, Pittsburg.

Part II.—Scheme of Erection and Main Travelers.

Both anchor arms and both cantilever arms were erected simultaneously by duplicate travelers starting at the anchorages and working symmetrically until they met at the center of the main span, and the following description of one traveler and its operation is therefore applicable for both. As soon as the falsework was completed, the floor system was assembled from the anchorage to the river side of the main pier, and two additional lines of stringers, borrowed from the cantilever arms, were temporarily assembled to the floorbeams as close as possible to the trusses to serve as blocking stringers and increase the stability of the traveler. Some materials were delivered to the traveler on push cars on the standard-gauge material tracks on the falsework outside the trusses. More were hoisted out of barges by a steel derrick on the river pier. The wooden travelers used for erecting the falsework assembled the floor system. The chords, weighing from 11 to 36 tons per section, were set by the steel travelers. All the members were hoisted to the top of the falsework by the 30-ton steel derrick on River pier, described on page 277.

Movement of Traveler.—The steel traveler was erected near the anchor pier and commenced the erection of the trusses at pin 5-L. All the members were assembled on 5-L and on 4-M from this position of the traveler; it moved back part of a panel and assembled the members of pin 3-L and then moved one full panel farther back and completed the erection from 4-L to 1-L. The inclined end post 1-L 3-U, about 85 feet long, weighs 35 tons and was shipped in two pieces, which were hoisted separately to the top of the falsework, splice-riveted and erected as one piece. The traveler then moved successively, without retrograding, from 2-L to 5-L, 7-L, 8-L, 9-L, 10-L, 11-L and 12-L, entirely completing the erection behind it as it advanced. These operations were performed in accordance with eighteen diagrams numbered and lettered so as to show the sequence of all steps and having notes directing the blocking, wedging and any special provisions to be made at different joints. The normal position of the traveler was 2 feet back of the panel point, and it was not anchored between 1-L and 12-L. The traveler was rigged with two tackles for each member handled, and, as many pieces had to be supported simultaneously until both ends were connected, about sixty tackles were provided. For heavy loads the tackles were suspended near the panel points of the traveler and were always so arranged that all members were handled without fleeting, except to transfer them from the material tracks to the planes of the trusses. In every position of the traveler it was wedged up to bearing on a transversely extended base, the loads suspended from opposite sides were kept approximately balanced, the lateral and sway braces were always connected immediately, all splices were filled with bolts or drift pins and all panel points were jacked up as high as possible and blocked there until the suspended span was swung.

When the traveler arrived at the main pier, it erected the lower six panels of the tower and made all connections on pins 11-L and 12-L, which engage the cast-steel pedestals set in posation checked for average temperature. The upper ends of 11-L 10-M and 12-L 13-M were supported temporarily by bars borrowed from 16-L 15-M and connected to short suspension links from the top of the tower sections. All members were assembled on pin 10-M in their final positions before the temporary bars were put on the projecting ends of the pin. After the temporary bars were removed, the ends of the pin were cut off close to the permanent bars. Temporary timber falsework on top of the traveler supported the tackles with clearance for assembling the upper two panels of the tower. In order to drive pins 11-U and 12-U, the top of the tower was tilted back towards the anchorage by removing the blocking under panel points 9-L and 10-L; afterwards the tower was plumbed by the weight of the cantilever arm. Beyond the main pier the traveler accomplished the remainder of the erection of the main span without retrograde movement, assembling the members from its overhanging up to 1½ panels in advance of its wheel-base on the completed structure and then moving forward one panel at a time to the end of each successively finished panel. To provide for the center panel connection adjustments temporary toggle bars 19-M 19-U, wedges at 18-L and screws at 19-M were inserted when the members were assembled at those points. Care was taken to set these appliances so that after allowing for the computed deflection, elastic deformation and temperature elongations and compressions, the positions of the center panel points would require that they should be slacked off. The movements of the heavy and rigid masses were thus effected by gravity and friction, and inertia only had to be overcome in operating the devices which were so proportioned that they could have lifted as well as lowered the trusses if necessary.


Forward Truck of Traveler.

Design of Traveler.—The Z-shaped traveler was about 150 feet long and 109 feet high over all, with a 63-foot overhang and an 18-foot 4-inch x 84-foot wheel-base. It was supported on four four-wheel standard-gauge trucks of special construction, two of them on each of the permanent tracks of the bridge. It was built entirely of steel and weighed with complete equipment and rigging, about 288 tons. The heaviest single pieces lifted by it weighed 36 tons, but it was required to support several pieces at once and was thus subjected to maximum loads of 120 tons. Its four vertical posts had rectangular cross-sections built of 12-inch channels with their flanges turned in and latticed. They were made in sections from 20 to 45 feet long with milled ends and web and flange cover splice plates. Jaw plates were shop-riveted to their webs and flanges to receive the field connections of the transverse struts and diagonals. At the feet of the forward posts their channel webs were bolted to diaphragms connecting the double webs of the transverse box-girder FG, and projected below them to connect with the ends of the lower chords of the bottom trusses.

The horizontal struts between the tower posts were made with pairs of channels latticed, the longitudinal diagonals were pairs of ¾-inch wire ropes and the transverse diagonals were pairs of 1⅜-inch or 1½-inch square rods. All other diagonals were single rods from ¾ inch to 1½ inches square, and all had pin connections and sleeve-nut adjustments. All the members of the top and bottom trusses, except two or three secondary ones which were built of angles, were made with pairs of 10-inch to 15-inch channels, latticed, having bolted and riveted connections to the channel webs and to jaw plates shop-riveted to the chord channel webs.

The lower chords of the bottom trusses were connected at panel points by horizontal transverse struts with I-shaped cross-sections made of pairs of angles back to back, latticed and connected to the vertical posts 30 inches above the chord centers, so as to give clearance underneath for material cars. The rear strut was made with a pair of 15-inch channels having reinforced webs and connected to short vertical posts or pedestals kneebraced to the chords. It served as a girder with pin bearings on the pedestals of the two rear trucks. The upper chords of the lower trusses were braced together with transverse struts similar to those of the lower chords.

The front legs of the travelers carried all the live and a large portion of the dead loads, and were supported, as previously mentioned, by box-girder FG composed of a pair of 27-foot transverse plate girders, with 6x6-inch flange angles and 42-inch webs 2 feet 8 inches apart, connected by nine vertical transverse diaphragms. One diaphragm was in the center, and one pair 6 feet 10 inches each side of it carried a pedestal under the girders, which had a 5-inch pin bearing on the truck; another pair of diaphragms 11 feet each side of the center received the feet of the tower posts. Transverse pedestals were riveted to the extremities of the girders and provision was made between their double webs for the spring bearings on the blocking stringers. Wedge bearings were made under their flanges.

The forward trucks each had a 9x6½-foot horizontal framework of 12-inch I-beams and channels, connected by vertical transverse diaphragms, supporting a pair of transverse distributing girders built of heavy plates and angles and connected by longitudinal diaphragms. They received the tower loads through a 5-inch pin about 3 feet long, which engaged at the center the loop end of a vertical anchor-rod 2 inches square and about 12½ feet long. The lower end of the rod had a nut and washer bearing against the under side of a transverse reaction beam AB, composed of two 12-inch channels 8 feet long bolted together 3¼ inches apart back to back and engaging the bottom flanges of the track stringers. The rear trucks were much smaller and lighter than the front ones and resembled tall bridge shoes seated on pairs of 12-inch longitudinal I-beams. They were braced to the bottom chords of the lower trusses, and were anchored to the stringers in the same manner as the forward trucks. The calculated dead load reaction on each of the forward trucks of the traveler was 180,000 pounds, the live load reaction 140,000 pounds. The dead load reaction on each rear truck was 80,000 pounds upwards, live load 60,000 pounds. The center to center distance of the trucks and their height allowed sufficient clearance for a material car to be pushed between them and underneath the cross girders. This method of furnishing steel to the traveler was, however, much less used than that of hoisting it directly into place from barges in the river.

The upper trusses were connected together by six transverse girders 6 feet deep with kneebraces and web connections to the vertical posts like the connections of floorbeams in railroad deck bridges. The three girders at the rear end of the trusses had solid web plates; the others were open trusses with vertical and diagonal members made with pairs of angles. All of them had solid web cantilever bracket extensions about 12 feet long at each end. The girders and cantilevers carried three fixed lines of longitudinal steel jigger beams and several movable lines of wooden jigger beams, from which the tackles were suspended. Each line consisted of a pair of 18-inch I-beams 12 inches apart, web-connected to the girders. Longitudinal lattice-girder struts 3 feet deep connected the ends of transverse girder brackets so that they formed alternate braced and unbraced panels.

A transverse box-girder BG, 39½ feet long, was made to be suspended from the overhang and carry the forward ends of the material track stringers and erection platform stringers. It had two 42-inch webs, 30 inches apart, connected by five vertical transverse diaphragms. The end diaphragms were stiffened by horizontal channels riveted to their upper edges, back to back, and had bent pin plates for the connections with pairs of long divergent 1⅝-inch suspension ropes. Four pedestals were riveted across the top of the girder, and had seats for the bottom flanges of the stringers and guide flanges parallel to the longitudinal axis of the bridge to retain them without bolting, the length of the seat being sufficient to insure safe bearing with a considerable variation in the position of the girder. This arrangement would have supplied a working platform and obviated fleeting the truss members beyond the traveler front trucks, when material was delivered through the traveler. As it happened that all heavy truss members were delivered in the barges, the suspended box-girder was not used.

Special Features of Design.—The peculiar outlines and dimensions of the main travelers were very carefully adapted to the conditions of erection. Had it been possible to use it, a simple traveler running on the top chords would have been the ideal construction, but this was impracticable both on account of the curve of the chords and because the sub-vertical posts would have required much reinforcement to support the weight of the traveler and its loads. The tower of the traveler was designed to be entirely enclosed within one 40-foot panel of the main trusses and to clear the transverse bracing at panel points. The lower truss was made shallow so that its highest point would clear the lowest transverse struts in the permanent sway-bracing. Diagonal members being omitted between the top of the tower and the top chord of the bottom trusses, allowed the tower to stand close to the last panel of permanent cross-bracing and permitted the latter always to be completed within one panel of the end of the cantilever arm.

The traveler was supported on trucks running on parallel tracks which were spaced as far apart as possible, so that their outer rails were in the planes of the permanent stringers, but the base thus provided was deemed inadequate for so high a traveler and an ingenious construction was adopted to extend the effective base of the traveler to nearly the full clear width between the trusses.

The dead load of the traveler, carried in the front posts, is taken into the girder FG with pin bearing on the front wheel trucks. The girder cantilevers beyond the trucks and is fitted at each end with a pedestal which terminates in a roller held in a vertical slot. The vertical movement of the rollers in the slot is adjusted by heavy springs held inside the pedestals. When the dead load only of the traveler was carried, as in moving, the pedestal rollers rested upon the top flanges of extra lines of

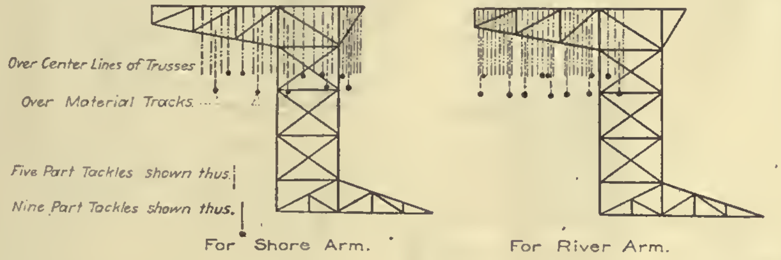
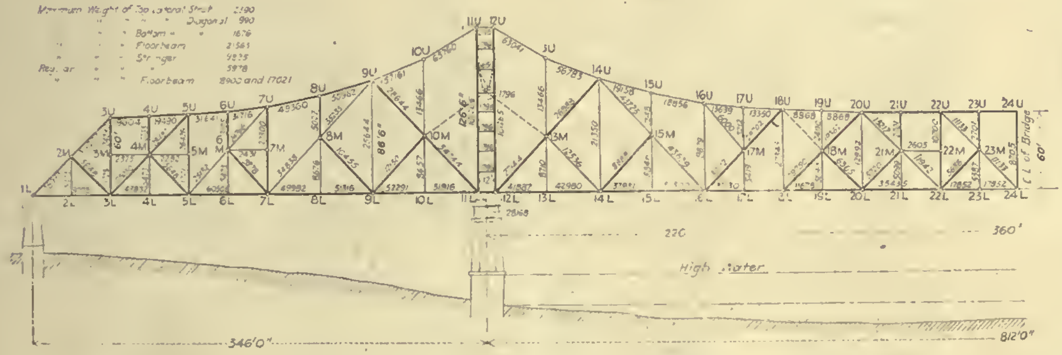
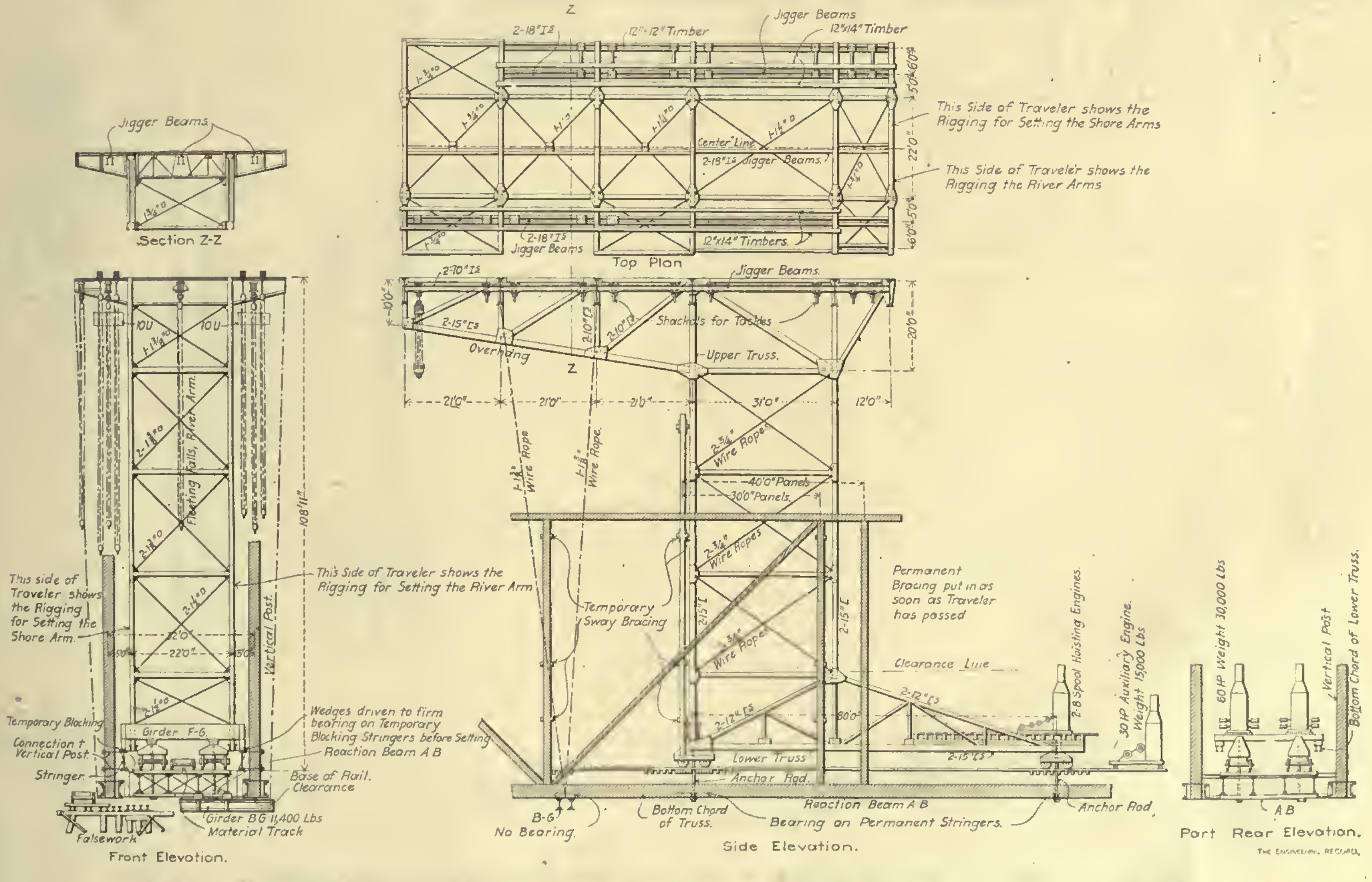

Over Center Lines of Trusses
Over Material Tracks
Five Part Tackles shown thus
Nine Part Tackles shown thus
For Shore Arm.
For River Arm.

Diagram showing Approximate Distribution of Falls. THE ENGINEERING RECORD.



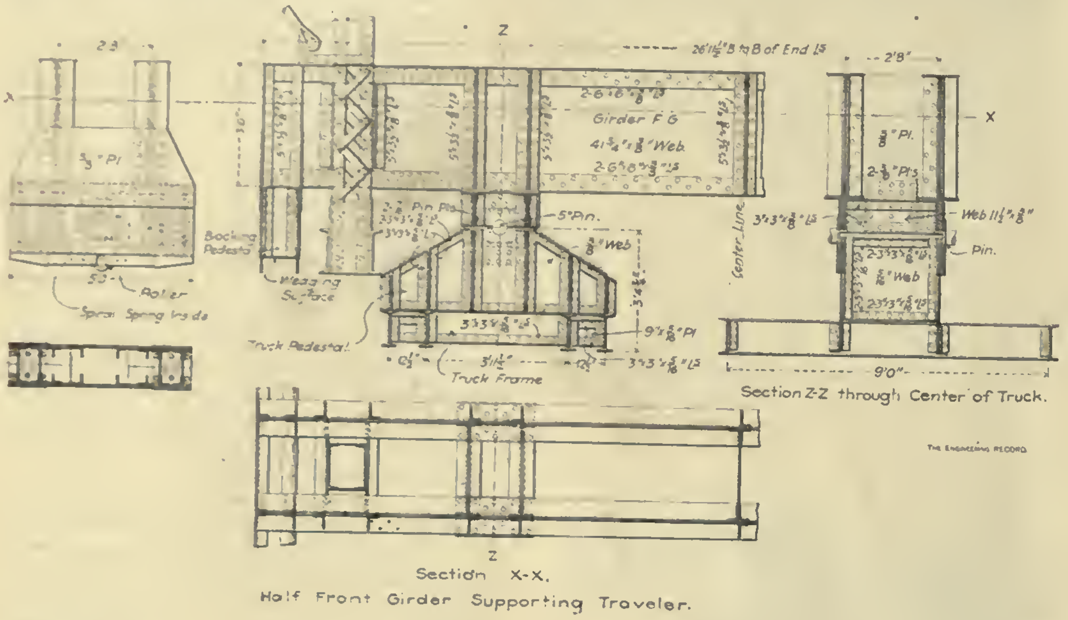
Weights and Dimensions of Main Span



STEEL TRAVELER AND PORTION OF CANTILEVER TRUSS, MONONGAHELA RIVER BRIDGE, PITTSBURG.

outside blocking stringers, bolted temporarily to the floorbeams of the anchor arms and to the posts of the cantilever arms. The springing rollers then afforded sufficient support to avoid any serious tendency to tipping. When lifting heavy loads, the traveler was blocked on the bridge stringers by driving steel wedges between the flanges of the stringers and the pedestals on both sides of the rollers. As the center-to-center distance of the cross-girder pedestals was 25 feet 10¼ inches, while the center-to-center distance of the trucks was but 13 feet 8 inches, the stability of the traveler was greatly increased whenever it was erecting heavy bridge material. The traveler endured, without the slightest difficulty, many heavy winds, some of them strong enough to blow the long suspended tackles with heavy bottom blocks into nearly horizontal positions.

Temporary Wind Bracing.—Special pains were taken to preserve at all times the integrity of the complete sway-bracing between the cantilever trusses as far as the extremities of the successively completed panels. As soon as the vertical posts were set in front of the traveler tower, they were braced together by pairs of wooden horizontal transverse struts and loop-eye sleeve-nut wire guys pin-connected to the vertical plates to which the struts were bolted. These sway-braces form complete and independent sets on both front and rear faces of the posts. When the traveler was moved, the set of braces on the rear face was removed and the traveler advanced until its forward posts came in contact with the sway-braces on the front side of the vertical post. The sway-bracing on the rear face of the vertical post was then replaced, temporarily enclosing the traveler posts between the two sets of bracing. The bracing on the front faces of the posts was then removed and the traveler post released and advanced and the bracing replaced, thus always securing the thorough bracing of the vertical posts of the trusses until the traveler had passed that panel and the permanent bracing

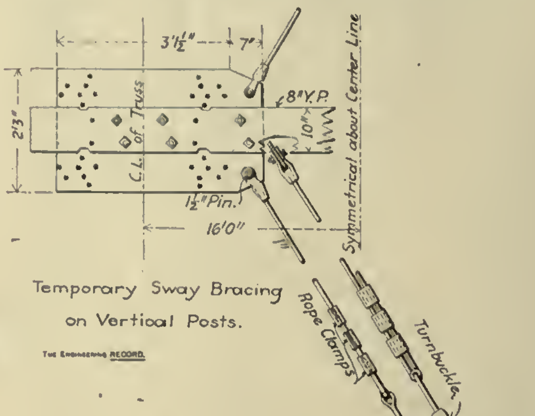


Section Z-Z through Center of Truck.

Section X-X.

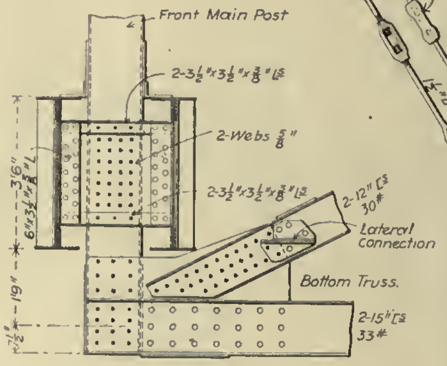
Half Front Girder Supporting Traveler.

The Engineering Record.



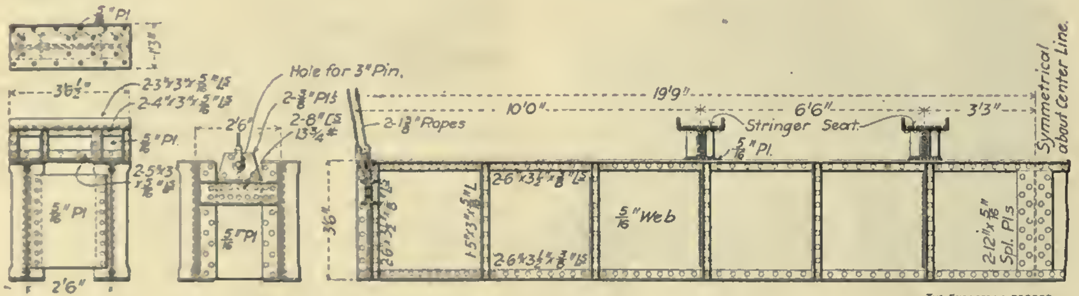
Temporary Sway Bracing on Vertical Posts.

The Engineering Record.



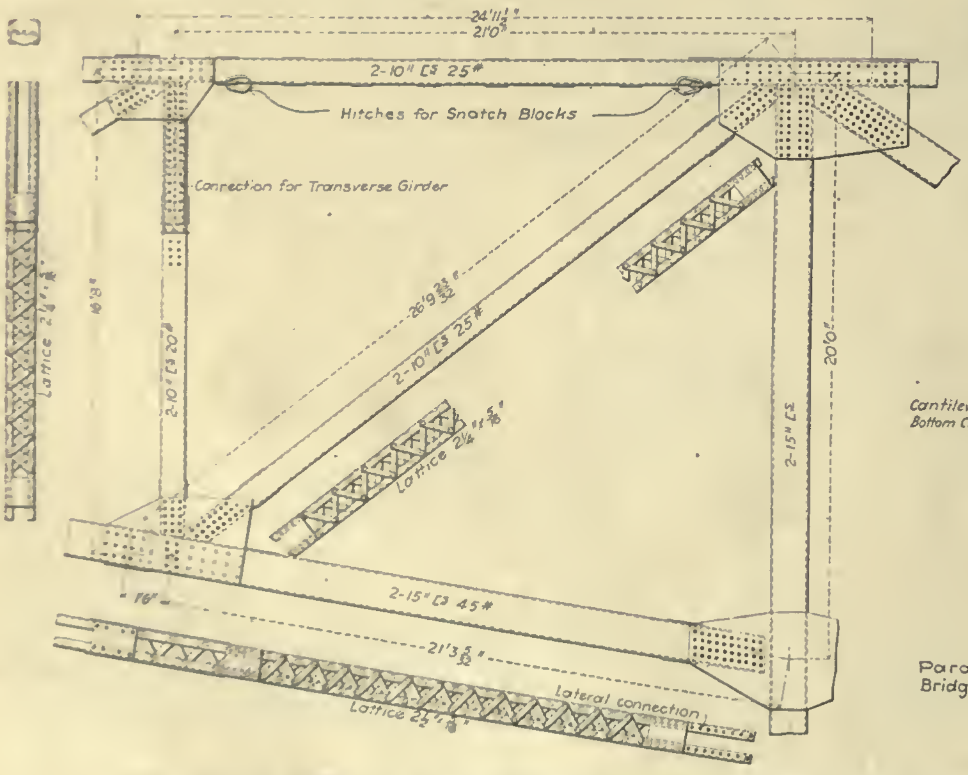
Connection of Vertical Post to Transverse Girder and Bottom Truss

The Engineering Record



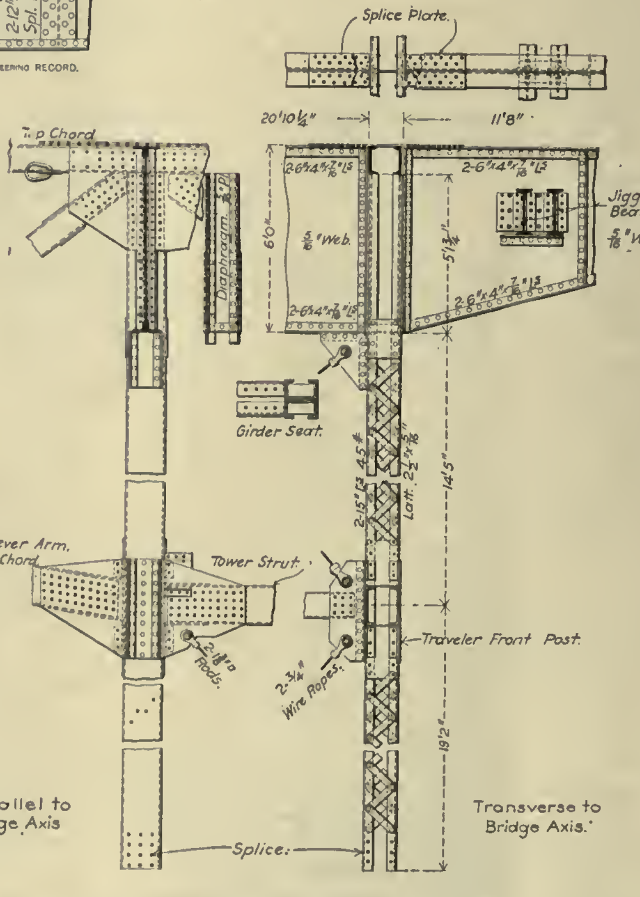
Suspended Box Girder, B-G, to Support Ends of Stringers.

The Engineering Record.



Section of Cantilever Truss in Top of Traveler.

The Engineering Record



Upper Part of Front Post of Traveler.

The Engineering Record.

PRINCIPAL MEMBERS AND CONNECTIONS OF STEEL TRAVELER, MONONGAHELA RIVER BRIDGE, PITTSBURG.

was assembled there. The towers over the main piers were braced in four vertical panels. At the other panel points there were from one to three vertical panels of sway-bracing. As the traveler track conformed to the grade of the bridge, the traveler was always anchored by anchor rods attached to its trucks and to reaction beams under the permanent stringers. After each movement of the traveler, the front wheels were blocked directly over the floorbeams and the trucks were anchored to the permanent stringers.

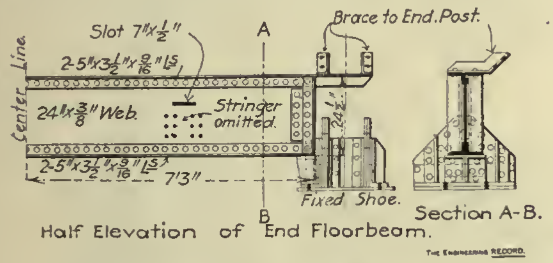
Equipment.—The traveler was rigged with a large number of five and nine-part tackles reeved with 1¾-inch manila rope and having capacities of 12 and 18 tons each, respectively. The nine-part tackles were suspended from the pairs of I-beam "jiggers" by shackles engaging vertical U-bars which passed between the pairs of beams and had nuts engaging bearing plates on their top flanges. The five-part tackles were suspended with slings from either the steel "jiggers" or from single 12x16-inch wooden "jiggers" placed wherever convenient. The lines from all tackles were led through snatch-blocks down the vertical posts of the traveler so as to clear the sway-bracing. Each traveler was equipped with sixty 16-inch snatch blocks, one hundred and eighty 16-inch single blocks, eighty 16-inch double blocks, forty 16-inch quadruple blocks, twenty 1,200-foot coils and forty 800-foot coils of 1¾-inch manila line, thus providing for sixty sets of tackle. There were two eight-spool 60-horse-power engines seated on the traveler and two two-drum four-spool 30-horse-power auxiliary engines behind each traveler. There were also ten 100-ton hydraulic jacks used on the bridge. About 50 men were required to operate one traveler and assemble and connect the steel. Under favorable conditions they erected 300 tons of steel in one 8-hour day. They were closely followed by several gangs driving field rivets with pneumatic hammers and by hand.

(To be continued.)

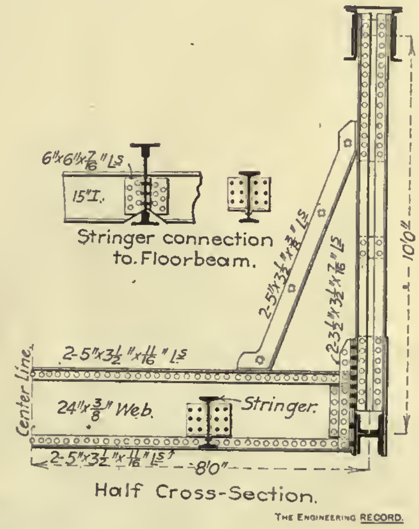
Shale Screenings were used for surfacing one of the drives in Central Park, New York, some years ago, but was found to be unsatisfactory, being very slippery in dry weather and sticky when moist. Last year the material was removed, and gravel substituted, and a marked improvement has been shown.

A One Hundred-Foot Pony-Truss Single-Track Through Span with Shallow Floor.

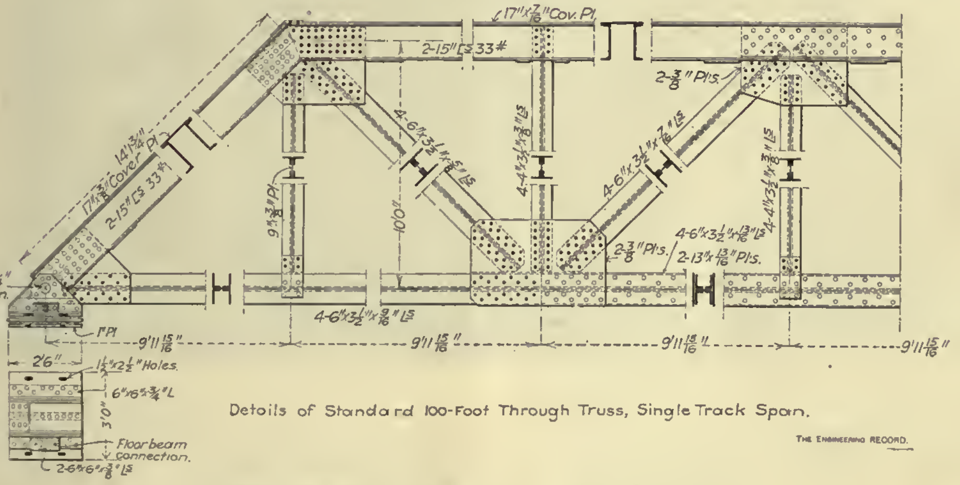
The design of a riveted through-truss 100-foot span to be used, where a very shallow floor is required, in locations similar to those where plate girder spans are often adopted, has been very carefully developed by Messrs. Boller & Hodge, New York, who have specified it in many cases with satisfactory results. They consider it superior to an equal span through plate girder on account of the lighter weight and corresponding economy, for the more desirable arrangement and efficient disposition of the metal, for the more satisfactory provision for tension and compression stresses in the chords, for the shorter field rivets and for the division into separate members which can be shipped in small space and do not involve difficulties of transportation, handling, or erection which are encountered with very long and heavy girders.



Half Elevation of End Floorbeam.



Half Cross-Section.



Details of Standard 100-Foot Through Truss, Single Track Span.

Pony Truss Bridge Designed by Boller & Hodge.

The top chords are of standard trough-shaped latticed cross-section, well balanced and having large vertical gusset plates shop-riveted to the insides of their webs to form jaws for the field-riveted connections of the web members. The bottom chords have H-shaped cross-sections with abundant stiffness besides their tensile strength and well adapted for any required sectional area without materially varying the extreme dimensions or involving long rivets. All web members have I-shaped cross-sections made with four angles and tie plates, and engage the jaw plates on the top chords and similar ones shop-riveted to the outsides of the flanges of the bottom chords. The top chords are made in two sections and the bottom chords in three sections, all of them, and the end posts being connected together by the web member connection plates. All connections are riveted, and there are independent pins through the feet of the end posts to take bearing on the riveted shoes. The webs of the shoes have outside vertical stiffener angles and are connected by inclined transverse diaphragms in the plane of the end post cover plate, forming a continuation of it.

The webs of all floorbeams are made in single lengths and no notches or irregularities are required for their connections with the trusses. They have no intermediate web stiffener angles, but the end vertical stiffener angles project a little above the top of the floorbeam, and directly engage the lower chord jaw-plates, to which they are connected by accessible short field rivets. The intermediate floorbeams are kneebraced to the vertical posts with pairs of angles, back to back, having their ends bent tangent to the flanges of the posts and beams. The end floorbeams are seated on reinforced horizontal shelf angles riveted to the shoe webs. Their top flange angles project beyond the ends of the webs as far as the outer edges of the end-post cover plates, to which they are braced by short bent angles shop-riveted to the floorbeams and field-riveted to the end posts. The stringers are 15-inch I-beams about 9 feet 11 inches long, flush with the bottom flanges of the floorbeams. Their webs and lower flanges are beveled at their ends to clear the floorbeam flanges and the end stringers are connected to short lengths of I-beams on the opposite sides of the floorbeam webs which form brackets carrying the ties over the piers. These brackets are spliced to the stringers with top and bottom flange plates, the former passing through slots in the floorbeam-webs and the latter being riveted to beam flange angles. The bottom laterals are single X-brace angles field-riveted to horizontal connection plates across the ends of the floorbeam bottom flanges. In each panel one angle is continuous and the other is cut to clear and spliced with a horizontal connection plate shop-riveted to the continuous angle. The vertical flanges of both angles are placed up. Both angles are cut to clear the stringers and are spliced across them by horizontal plates field-riveted to the stringer flanges.

This bridge has a computed weight of 131,500 pounds, is built entirely of medium steel and is proportioned for a train load of 4,000 pounds per linear foot preceded by two locomotives and tenders each weighing 284,000 pounds on a 48-foot wheel base. This load includes four 40,000-pound driver axle loads 5 feet apart. The complete shop drawings and bill of floor timber are contained on a single 25x35-inch tracing, from which many spans have been ordered and built without any additional drawings.

A Large Pumping Engine, installed at the Waihi mines in New Zealand, is described in a recent issue of "Engineering." It is of the Cornish cycle type, with compound cylinders, and a beam transmitting power from connecting rods to pump rod. Its high pressure cylinder is 60 inches in diameter with 6 feet stroke and its low-pressure cylinder 110 inches in diameter with 12 feet stroke. The ratio of cylinders is thus 6.7 to 1. The stroke of the pump plungers is 12 feet and the pump plungers are 23 inches in diameter. The first plunger set is placed at a depth of 700 feet from the surface. The engine is designed to raise 1,500 gallons per minute from a total depth of 1,550 feet. To raise this quantity the engine works at 7 strokes per minute, developing 730 horse-power. The rocking beam, built of steel plates and angles, is 48 feet long, 8 feet deep at the center and weighs 50 tons. The two bearings of the center shaft are each 22 inches in diameter and 24 inches long. The engines were constructed from the designs of Mr. Henry Davey, M. Inst. C. E., of London.

Railway Location in the Florida Everglades.—I.

By William J. Krome.

That portion of the State of Florida lying south of latitude 25 degrees, 30 minutes has, up to very recent times, remained as completely unexplored as the interior of Thibet. It embraces the southern end of the Biscayne pine reef, the lower part of the Everglades, Whitewater Bay and the Great Mangrove Swamp.

A few squatters have for some years raised vegetables for the Key West market on the prairies in the vicinity of Cape Sable, but their knowledge of the country to the north of them has been very limited. The few existing maps were entirely unreliable and the reports as to the character of the country by the occasional trapper or inquisitive naturalist who had penetrated for some distance into the region, were far from encouraging.

Therefore when the officials of the Florida East Coast Railway decided upon an exploratory survey through this territory, with the object of determining its possibilities from a commercial view point, various problems rather out of the ordinary were presented to the engineering department. To obtain the information desired it was necessary to cover a belt of too great width to confine the work to a single center line, so a series of closed meanders, linked together into a continuous chain, was adopted as the trunk of the survey. From this, laterals and tie lines could be run as required. The fact that one end of the work was at a known elevation of about 12 feet above mean low tide in Biscayne Bay, the other at Cape Sable on the Gulf of Mexico, with a great probability that at no place between would the elevation of the country vary more than a few feet from a regular grade line connecting these two points, made a line of levels unnecessary.

Camp on Long Key in the Florida Everglades.

The question of obtaining supplies being one of the most difficult to solve, as small a field party as possible was organized, and the stadia adopted as the method of measurement.

There is never any trouble in finding plenty of applicants for every position open on a piece of exploratory work of this character, but the selection of men who will go the whole route and who can be brought to understand, beforehand, that it is hard work, under trying circumstances, and not a pleasure trip that they are going into, is one of the serious problems for the chief of party. For this expedition, men of previous experience on similar work and of known staying ability were of course given the preference and green material cut out to as great an extent as possible. The choice of good men for the places of axemen and packers was particularly difficult, for upon them depended much of the work and colored labor had been decided upon for these positions. The writer has found the Central Georgia negro about the most reliable of his race for rough work and seven of the eight colored men selected were from that section. The following half year, in which these men worked on the average 28 days a month, without a single desertion or complaint, justified this belief.

The party when complete numbered sixteen men. Of these, eight were in the field crew, including chief of party, transitman, recorder, two rodmen, two axemen and a colored cook. To keep them supplied with food and necessaries required a pack party of six men in the charge of a white chief packer. A steward looked after the permanent supply-camp and was required to keep track of the stock on hand, closely reporting weekly to the chief of party. Owing to the irregularity of communication with the nearest source of supplies at Miami, it was necessary to get in orders a considerable time before the goods were actually needed.

Each member of the field party was furnished with a stout canvas knapsack and the limit on personal outfit was the weight the individual felt able to carry. This amount was reduced in most cases very shortly after the first long pack, but probably averaged forty pounds per man during most of the trip.

Various materials were tried for field clothing with more or less success. Pantasote sheeting was found too warm for the climate and gave poor service. Canvas wore well and dried quickly after being wet, but is too stiff and uncomfortable to make a desirable working garment. A good grade of khaki, well made, was found to give the best satisfaction of any fabric tried and has been used with success on subsequent work. It wears well, dries quickly and is soft and easy fitting. Foot-gear caused much trouble. Rubber is a poor material for the purpose under any conditions and in a warm climate, for regular wear, will not do at all. The best of leather when soaked in water for hours and then pounded over coral reef, indescribably rough and sharp, soon shows signs of grief. Ordinary shoes do well to last a single week. A half-boot, lacing to the top through large eyelets (hooks are a nuisance), Blucher cut with bellows tongue, a heavy sole and stiff counter came nearer meeting the requirements than any other type. The soles were kept thickly studded with hob-nails and the uppers were pierced, well down, to let the water out. To keep it out when wading waist deep was an impossibility.

The mosquito plague being one of the most serious obstacles that was encountered, each man was provided with a bar and the proper stretching of these became quite an art. About the best bar for this purpose is made of cheesecloth with a canvas roof. The canvas top should be seven feet long by three feet wide, with loops or grommets at the corners. The cheesecloth should have a depth of about five feet and be sewed to the under side of the roof, leaving two inches of the canvas projecting all around. If this projection is stiffened with buckram or by doubling, and the roof of the bar stretched flat when pitched, it will shed a light rain quite well and the water will not run down the sides. These nets may be stretched from a stake at each corner, or by putting in a spreader across the ends, two stakes will answer.

Head nets are uncomfortable affairs at best, but their use on this work was at times imperative. Cheesecloth and bobbinet are too hot and are very hard to see through. The net that was most satisfactory was that worn by the Cape Sable squatters. It is built for use over a stiff rimmed hat and consists of a band of 10-ounce canvas, fitting closely around the crown of the hat and extending out to the edge of the rim. To this is firmly sewed a strip of close mesh copper wire netting extending down about 3 inches in the back and curving over the shoulders to the level of the wearer's chin. Cheesecloth is taped on around the bottom of the copper gauze of sufficient width to tuck well inside the coat which is buttoned over it. The wire netting is kept out from the face by the stiff brim of the hat, allows the air to pass through freely and can be seen through with ease, it being possible to run an instrument quite well from inside one of these gilded cages. When not in use it can be completely removed from the hat and there are no strings to become knotted or broken loose. It is, however, somewhat troublesome to carry.

A wagon trail was broken out from the claim of the last homesteader, through the rock reef forming the Biscayne pineland, to a point near its southern extremity and there a base of supplies was located. To this point goods could be hauled in light loads by wagon, but beyond it everything was advanced to the field party by the packers, until the Whitewater Bay region was entered when connection was made with a relief schooner.

To as great an extent as possible, all provisions were put up in duck bags waterproofed with paraffine. These bags were of two sizes, holding about five and ten pounds apiece of such provisions as rice, beans or meal. They, in turn, were placed in specially waterproofed canvas pack-sacks and their contents seldom showed signs of dampness even after long exposure to the weather. Regular leather pack harness was used in handling the loads. The weight that could be carried by a packer varied of course with the length of the journey and with the character of the country to be traversed. Under favorable circumstances packs as heavy as ninety pounds were brought in over a trail five miles long; at other times, through pot-holes and deep muck, twenty-five pounds was a wearying load. A 14x16 foot wall tent, without fly, makes about as heavy a pack as should be put on a man under the best of circumstances.

Boats were a necessity in transporting supplies, although the water in the southern portion of the Everglades is usually very shallow during the dry season of the year, during which the work was carried on. The dug-out of the Seminole Indian is too heavy for carrying, and canvas or Canadian canoes are too frail to stand dragging when loaded. So 14-foot steel duck boats were used and served the purpose admirably. They were light enough to be readily carried by two men across portages, and three men could drag one loaded, where only a few inches of water covered the muck. By using a couple of these boats as sleds, with two men harnessed in front and one pushing with a pole from behind, the six packers could bring in twelve full-size packs through muck and water where 40 pounds would have been a killing back load.

The Obstruction to Surveying Offered by the Mangrove.

A Camp Kitchen.

The food was confined mainly to such articles as could be sacked. Under this head come rice, grits, several varieties of beans, oatmeal, coffee, sugar, salt, flour, meal, tapioca and evaporated fruits. Tinned meats, evaporated cream, baking powder and other canned goods were used to some extent but they make an awkward pack and were dispensed with as far as possible. Pilot bread saved the use of an oven and was our staff of life. Fresh meat in the form of venison was easily obtained during the major portion of the trip but fresh vegetables were unknown on the menu.

An emergency supply of condensed foods was carried and on several occasions was drawn on heavily. This class of goods is largely imported from Germany and can be obtained in considerable variety. Soups of a dozen kinds, all tasting alike, are put up in vest pocket packages, vegetables, of as many sorts, evaporated and compressed until they resemble a good grade of plug tobacco, sliced potatoes as hard as bone, porridge, sausages and evaporated eggs were all given a trial. The potatoes, after being well soaked, are an excellent substitute for the fresh article and the soups, properly prepared, are nourishing and palatable, but it requires a hungry man to relish the vegetables or eggs.

(To be continued.)

Cleaning the Bottom of Reservoirs.

In Central Park, New York, there are a number of reservoirs or basins forming features of the landscape architecture of the property. A couple of years ago their condition became so unsatisfactory as to receive the condemnation of the Board of Health, particularly as breeding places for the mosquito. They were choked in places with vegetation which prevented a free circulation of the water and collected refuse. The Park Board has accordingly been cleaning these basins in a manner which will doubtless interest all water-works superintendents.

As no appropriate tools were on hand, the Department was compelled to design and manufacture them, and in a few days they were put in successful operation. The first of these implements to be constructed were large rakes with long handles, which were placed on the bottom of the stream and fastened to the stern of a boat by means of a rope and crotch. The boat and rake were then hauled by horse power and a system of pulleys, the whole making a very powerful machine and bringing to shore a great quantity of pond weed at every draw. By a system of stakes set in the water at the starting point, the lake bottom was successfully raked from two to four times, bringing up the plant by its roots. In many places it grew to a length of 9 feet or over and so thickly that it was impossible to row a boat through it.

At one place the Egyptian lotus had taken complete possession, and in and among these large plants nearly three feet of debris had collected. To remove the lotus roots a special machine, consisting of eight steel chisel-shaped knives, was constructed upon a frame of great strength, the knives fashioned so as to penetrate into the mud 14 inches. This also worked with pulleys and horse power, and the section was dredged several times and the roots and coarse material brought to the shore and removed.

The cat-tail flag also covered large areas and was so thick that boats could not penetrate, and every year it was extending and collecting drifting material. This was pulled up by hand and the steel-knife dredge was used to clean out the roots and the material collected about them.

Two other important implements were constructed, a mowing machine at work on the bottom of the lakes cutting off the pond weed and lotus in swaths, and large drifting rakes which were used to collect the material as it came to the top of the water. The south end of the leading basin was filled with sunken brush, tree limbs and lumber, and many of the shrubs on the edge were filled with a decaying mass of leaves, and harbored colonies of rats that burrowed into the banks where the water collected and made suitable breeding places for the malaria mosquito.

The Water-Power Plant at Hauterive, Switzerland, has a maximum output of 9,000 horsepower at 200 feet head. The water is conducted partly through a tunnel in which the velocity is about 10 feet per second.

Concrete Construction in Yellowstone National Park.

A considerable use of concrete has been made in the recent government improvements in the roads, bridges and other structures of the Yellowstone National Park. The old Golden Gate viaduct for example, was a timber trestle structure against the face of a high cliff which has been replaced by one of concrete on account of the difficulty, delay and expense of securing steel, the possibility of building concrete without the precise surveys necessary for steel work and because it was considered that the concrete masonry springing from the face of the cliff would harmonize better with the natural scenery. The new viaduct has eleven arches which carry an 18-foot roadway built to a 10 degree curve and an 8 per cent. grade. It is 200 feet long on the center line and the outer parapet has a radius of 573 feet. The piers are seated on horizontal surfaces stepped into the solid rock and are 3 feet wide and 18 feet apart on centers at the outer faces. Their sides are in radial vertical planes which converge 6½ inches in 18 feet. They carry solid concrete arches which have a rise of 24 inches and are 18 inches thick at the skewbacks and 12 inches thick at the crown.

The pier and arch concrete have respective proportions of 1:2:4 and 1:2:3 made with Atlas Portland cement, unwashed sand and gravel containing a small percentage of loam, the use of which was considered to be justified by the result of experiments made by Professor C. E. Sherman, of the Ohio State University, U. S. Assistant Engineer in charge of the viaduct. Briquettes were made with one part cement and three parts sand containing different percentages of clay or loam. Crushed quartz sand of the American Society of Civil Engineers standard and two other kinds were used and briquettes were broken when 7 days and 1, 2, 3, 6, 9 and 12 months old. The net results indicated, strange to say, that clay or loam, without hydraulic properties, when used in quantities up to 15 per cent., considerably increased the strength of the mortar. The work was done in 1900 and there have not yet appeared any evidences of weakness due to the presence of loam and clay in the sand.

The crown of each arch is reinforced by a 7x15-foot piece of netting made with No. 8 wire and 2½x5-inch mesh, the long dimension of the mesh and the short dimension of the netting being parallel with the bridge axis. The connection between each arch and parapet wall was reinforced by four 4-foot pieces of rail. Work was commenced at the high end of the bridge and after the completion of the piers the arches were built alternately with joints between them and between the parapet walls on the center radial lines of the piers. The latter were made with a vertical 2x6-inch tongue and groove to allow for temperature expansions. The 545 yards of concrete were laid by 91 men in 122 hours during 19 days, the work being done in haste under great disadvantages due to the difficulty of storing material and the very severe winds prevailing which interfered with work in the middle of the day.

The old viaduct was obstructed by a 25-ton rock 15 feet high which stood 8 feet from the face of the cliff. This was broken from its base at a horizontal seam and was raised with jack screws and moved on rollers to a new position on a concrete foundation at the roadside where it remains as a natural monument.

Some trouble has been occasioned by seepage through the concrete which caused a white deposit on the faces of the piers. This was remedied by a cement wash and partially successful measures were taken to close the parapet joints with lead. In view of this experience it is recommended that in future work of a similar kind the upper surfaces of the arches should be waterproofed with an alum lye like that used on the Government fortifications and that the parapet expansion joints be made watertight by bent strips of sheet lead built into both sides.

In order to admit visitors to the right bank of the Grand Canyon of the Yellowstone a steel-concrete bridge has been built half a mile above the upper fall between two volcanic rocks that jut out from the opposite banks. It is 160 feet long and 18½ feet wide over all and carries a 14½ foot roadway 43 feet above low water. It has a single Melan arch of 120 feet span and 15 feet rise, with ten lattice girder reinforcing ribs 22½ inches deep at the ends and 12 inches deep at the center. The flanges are made with pairs of 3x2½-inch angles back to back connected by zigzag web members and the ribs are united by transverse braces bolted to the flanges 12 feet apart. The center lines of the ribs coincide approximately with that of the concrete which is 48 inches thick at the skewbacks and 24 inches thick at the crown.

The arch ring and spandrel facing were made of 1:2:4 concrete, using Atlas cement, broken stone and washed sand. The haunches were filled with concrete to the camber line which was a circular arc with a versed sine of 30 inches. The filling was 1:4:9 Lehigh cement concrete, made with unwashed gravel and contained about 200 cubic yards of boulders. The arch ring and filling made a single continuous mass and contained a total of about 900 cubic yards of concrete. It was built monolithic, without any provision for temperature movements, and to resist the expansion strains longitudinal steel rods reaching from each abutment nearly to the center of the bridge were bedded in the concrete about 2 feet below the roadway surface. There is a narrow sidewalk with a steel guard rail on each side of the bridge and the concrete hand rails are reinforced by horizontal steel channels and vertical steel bars. At each end of the arch there is an approach about 21 feet long with curved concrete side walls and solid concrete filling.

For the construction of the bridge a temporary center pier was built on a timber crib sunk on and around a submerged ledge which anchored it against the strong current at the head of the rapids. Vertical posts were set in the crib, bearing on the rock bottom and the crib was filled with stone. Timber shore piers were built and, with the center pier, supported two spans of falsework, each having five combination queen-post trusses. On these trusses the falsework and forms were built and contained a total amount of about 80,000 feet of timber of all kinds much of which was available for use after the completion of the bridge.

Concrete was mixed by hand on a slightly inclined board about 25 feet long. The materials were dumped in batches of 18 cubic feet at the upper end of the board. Two men turned them dry and a third applied water after every shovelful. The succeeding mixers, eight in all, on each side of the board, turned it over with shovels and passed it along, more water being added by a second man. The concrete was made very wet and was shoveled into carts from the foot of the board. The work was continued day and night to make continuous concreting built from both abutments towards the crown. Three eight-hour shifts completed it in 74 consecutive hours at a rate of about 10 yards an hour. The cost of putting in the concrete was about $1.50 per cubic yard and the drawings were made and most of the work was supervised by Mr. Robert Walker, United States overseer.

A low concrete dam was built for the water supply reservoir at Mammoth Hot Springs. Excavations were made to good clay soil and in them a longitudinal row of sheet piles to prevent leakage underneath were driven and cut off 6 inches above sub-grade. The dam was built in separate sections about 12 feet long, with expansion joints between them. A 3½x⅛-inch vertical strip of sheet lead was set on the end wall of the form for each section of the dam, and one side of it was bent at right angles to make a 1½-inch projection parallel to the dam axis and built into the concrete. When the bulkhead was removed and the adjacent section was concreted the transverse part of the lead strip was bent 90 degrees to form a second 1½-inch projection which was built into the concrete and thus bonded the successive parts together with a flexible connection Z-shaped in horizontal cross section. The mortar was well packed around the lead and formed a satisfactory joint which proved watertight under the 6-foot head to which it was subjected. The concrete was mixed very wet and the upstream side of the dam was faced with mortar put on when the concrete was laid and showed very few evidences of permeability.

A long aqueduct and flume for the water power of the electric light plant was made with a rectangular concrete trough supported on square concrete columns with extended caps and bases and on lower rectangular concrete piers, all 12 feet apart on centers. The aqueduct sections were made with expansion joints over the piers, with lead plate connections like those described for the dam.

Water for the irrigation of a 30-acre plateau at Mammoth Hot Springs was taken from a domestic supply main 100 feet above the reservoir level. In order to reduce the velocity of discharge the horizontal lower end of the 6-inch outlet pipe discharged tangentially into the bottom of a circular concrete basin, 20 feet in diameter and 4 feet deep. This produced a circular motion of the water which discharged over a vertical 6x¼-inch steel weir plate around the edge of the basin and flowed into the flume which conducted it to the irrigation grounds. The basin has proved to be somewhat too large so that the water does not overflow in a full sheet around the entire circumference, but is sucked down over the top of the discharge pipe and crowns up on the opposite side.

The above work is described and illustrated in a report of Capt. H. M. Chittenden, Corps of Engineers, U. S. A., published in the annual report of Chief of Engineers, U. S. A., for last year.

A Textile Mill Power Plant is described briefly in the current issue of the "Journal" of the Worcester Polytechnic Institute in an article by Mr. Eugene B. Whipple. On a test of 5.3 hours' duration, the engine, which is a vertical cross-compound condensing unit provided with a reheating receiver, indicated 778.9 horse-power on 13.02 pounds of water per indicated horse-power-hour, with a steam pressure of 115 pounds, a vacuum of 28.83 inches, a superheat at the throttle of 15 degrees and a superheat in the reheater of 24.65 degrees. The reheating receiver and the cylinder heads are jacketed, and the jackets used 1.2 pounds of water per indicated horse-power-hour, included in the given water rate. The cylinders are 26 and 52 inches in diameter and the common stroke, 48 inches; the speed was 79.3 revolutions per minute. Steam for the condenser pump is passed through the reheating coils and the pump exhaust is put into the receiver and then passed through the low-pressure side of the engine. The test load was 70 or 75 per cent. of the rated power of the engine. The steam was supplied from four Manning boilers, each having 2,888 square feet of heating surface.

The Construction of the Scherzer Lift Bridge at Newark Bay.

The Central Railroad of New Jersey crosses Newark Bay with two tracks, which, until recently, have been carried on a pile trestle bridge with a steel-truss center-pier swing span, which is being replaced by double-track Sherzer rolling-lift bridges. One of these spans has been erected and was described in The Engineering Record of February 27. During construction one of the tracks was closed to facilitate the work, but service was constantly maintained on the other track.

The new piers are built entirely of concrete on timber platforms supported by piles cut off at a depth of about 32 feet below low water. Operations were commenced by diverting the traffic from one of the tracks and removing the piles of the old trestle on one side of the center line of the bridge for about 40 feet each side of the axis of the pier. This area was then dredged about 15 feet to a depth of 34 feet below low water, and piles about 2½ feet apart on centers were driven in it to a penetration of about 20 feet through mud and sand to a bearing on rock. The piles were cut off in a horizontal plane 32 feet below low water with an accuracy of about ¼ inch by means of an apparatus which had been successfully used by the contractors for cutting off piles to a depth of 48 feet below the surface of the water. It resembles the machines used for the same purpose by the Department of Docks of the city of New York, but differs from it in some of the details and in that it is operated by an individual engine.

A 12x12-inch vertical timber 60 feet long is bolted to the cross-heads traveling in the guides of an ordinary floating pile driver. On the face of this timber there are bearings for a 3-inch shaft 50 feet long in which a seat is cut from end to end engaging a key in the driving pulley. At the lower end of the shaft there is a horizontal circular saw 48 inches in diameter, which is secured to it by a collar and countersunk bolts on the upper side, leaving the lower side a plane surface without projections. A scale of feet is marked on the vertical timber and the latter is carefully adjusted to required height by a leveling instrument. A target is set on it giving the exact distance below the level it is required to cut the piles. The shaft moves up or down through the driving pulley; the latter remains stationary at a convenient height above the deck of the pile-driver scow and is driven with a twisted belt from a 10x12-inch steam engine seated on deck under the pile-driver tower and supplied with steam from the pile-driver engine. The advantage of this arrangement is that the pile-driver engine is always left free.

To the upper part of the vertical timbers, or leaders, a light horizontal steel yoke is attached which is large enough to allow a pile to be lifted through it and is seated at the top of the leads. To the extremity of this yoke a tackle is attached, which is also made fast to the top of the pile next in advance of the one being cut. The lead line from this tackle is operated by a hand windlass on the pile-driver scow and serves to steady the machine at work. The scow is anchored in four directions by lines to capstan heads on its deck and is easily moved back and forth to feed the saw. The regular pile tackle of the pile-driver is attached to the top of the pile, and while the latter is being cut, it is held on opposite sides by men with pike poles. The cutting is very easily and quickly accomplished after the saw is brought into position and the pile is then immediately lifted up and removed and the saw is advanced to the next pile and so on. As many as 100 piles have been cut by this machine in 10 hours.

After the pile foundation had thus been completed for one end of the pier, one track was shifted to a position over the completed foundation and the other track was abandoned and the piles removed over the remainder of the pier site and the operations above described were repeated. The timber platform supporting the pier on the piles was composed of four solid cross layers of 12x12-inch timbers which formed the bottom of a caisson with vertical sides of 3-inch horizontal planks. These sides were from 26 to 28 feet high and the planks were spiked to 8x10-inch vertical timbers 2 feet 6 inches apart. The tops of the verticals were mortised into a horizontal 12x12-inch cap and the verticals at the corners were made double and secured together with bolts having their solid heads on the inside piece and their nuts countersunk in the outer piece under the planking. The lower edges of the planks were carefully fitted flush to the upper surface of the timber platform and the four sides were fastened together by the bolts through the double corner pieces. Between the vertical timbers eye-bolts 3 feet long were screwed 18 inches into the platform timbers. The eyes engaged hooks on the bottoms of thirty 1¼-inch vertical rods which passed up through the horizontal caps of the vertical timbers and took bearing on them with nuts and washers. In this manner the lower connection was made about 1 foot above the surface of the platform and enabled the upper end of the rod to be easily entered in the hole through the cap timber before the hook on the lower end engaged the eye.

In similar caissons the weak point is often found in the connection of the vertical timbers to the upper cap where excessive strain comes on the mortised joints. In these caissons difficulty from this source was avoided by providing special rangers to receive the bearing of the transverse struts and resist the outside pressure. Horizontal bracket planks were nailed to the vertical timbers just below the upper ends and projected on the inside far enough to carry horizontal timbers which were not framed or bolted to them. These timbers took bearing against the vertical inner faces of the posts and received on their opposite sides the ends of the interior struts. Corresponding lines of inside rangers were set in the same manner as required to brace the lower parts of the caisson, and, as the concrete was built up, the through struts were removed and braces were inserted between the rangers and the hardened concrete.

The joints in the plank sides and between them and the deck were thoroughly calked, and the caisson was floated to a position near the pier site and there moored. A form was built in it corresponding to the required dimensions of the pier and was partly filled with concrete mixed by a steam-driven Smith machine on a barge alongside. Concrete was deposited in the mould until the bottom of the caisson was sunk nearly to the top of the pile foundation. It was then moved under the railroad track and carefully lined into position over the piles and was sunk to rest on them by admitting a little water through the top of the coffer-dam. After it was finally seated, the remainder of the concrete was built up to low-water mark and above that point the upper part of the pier was constructed with absolute accuracy, an allowance of 2 inches each way having been made in building the submerged portion.

The original walls of the caisson were kept as low as possible to avoid lifting the concrete to an unnecessary height, but above low-water mark they were extended a few feet by spiking to them courses of 8x12-inch timbers laid edgewise with calking cotton between them. After the completion of the pier, the caisson walls were separated by unscrewing from the inside the horizontal bolts through the double corner vertical pieces. The nuts on the top of the thirty vertical rods were unscrewed and the rods were forced down and unhooked from the eye-bolts, allowing the four sides to be separately detached and removed ready for use on the next pier. The Sanford & Harris Company, Hoboken, was the contractor for the substructure.

The superstructure now under construction consists of six spans supported on seven piers, and is symmetrical about the center pier as shown in the general elevation, page 254 in the issue of February 27. The piers are numbered 1 to 7 and are respectively about 120, 36 and 42 feet apart in the clear from each end to the center. The 120-foot opening, 1-2, is spanned by the riveted through trusses of the rolling lift. They are about 25 feet deep at the shore end and are about 150 feet long over all so as to project towards the center pier and overhang the 36-foot span, 2-3, with a quadrant-shaped lower chord of about 25 feet radius on which they revolve as the truss rises to the vertical position. The 36-foot spans, 2-3, are heavy, deep, through plate girders, which serve as tracks for the rolling trusses. The 42-foot spans 3-4, are deck plate girders and carry, over the center pier, a steel tower, about 30 feet wide and 60 feet high above the track, which supports the operating house and machinery 22 feet clear of the tracks and has on each side a guyed cantilever girder arm about 28 feet long above the tracks, extending nearly to the end of the rolling span.

The bridge has been built from pier 1 to pier 5 inclusive, and the superstructure work was commenced by driving piles both sides of the bridge between piers 3 and 4 and erecting on them the 40x84-foot wooden traveler 115 feet high. This tower looked like falsework, and was called a traveler, but it really served only for the support of tackles for assembling the steelwork, and did not support the trusses during erection nor move back and forth from panel to panel like ordinary travelers, being stationary during the erection of each pair of trusses or girders and moving only from span to span. It was built in two sections, the lower one having vertical posts 36 feet apart transversely with outside batter posts increasing the width 24 feet on each side. The vertical and inclined posts were well braced by horizontals and diagonals in transverse and longitudinal planes and provided a clearance 65 feet high over both tracks and the operating tower and house. The lower section thus resembled an ordinary striding traveler with the sway bracing inverted, and was surmounted by a 36x40-foot tower 50 feet high on top of which were seated two 10-ton 55-foot-boom stiff-leg derricks operated from one hoisting engine on a platform at track level alongside. Two 1¼-inch steel guy cables were attached to the tower 65 feet above the track and were anchored to the trestle or to the pier on opposite sides, and with the batter posts, gave sufficient stability for the traveler under ordinary conditions.

The track girders between piers 3 and 4 were delivered and placed on the old trestle work alongside the tracks. The two 36-foot 30-ton track girders were set in position on piers 2 and 3 by steam lighters, after which traffic was abandoned one Sunday and the track girders between piers 3 and 4 were placed in position by the traveler, the old floor system was removed and the new floor system was completed at the west end from piers 1 to 4. The framework was erected for the center permanent tower and operating house and the installation of machinery was commenced there so that it would be ready to operate when the rolling lift span was completed. The two 28-ton rocker girders were then placed in position at the east end of the track girders and the construction of the truss was assembled and completed in vertical position, counterweights being added as the erection progressed to insure abundant stability. All connections were made with gusset plates and the holes were filled with drifts and bolts and riveted as fast as eight gangs of pneumatic riveters could follow. In this way the superstructure for one of the double track lifts has been erected without much interference to either traffic or navigation, although trains passed over the bridge under headway often not exceeding four minutes. Navigation was accommodated by the old swing span which was retained in service during the construction of the first half of the rolling lifts.

The air plant consisted of one standard 22-horse-power gasoline compressor which had a capacity of 120 cubic feet of compressed air per minute, sufficient to run eight hammers. The time of erection of the spans was equivalent to about 75 working days with a force of about 60 men. The subsequent erection and adjustment of machinery was tedious work. The total weight of one 120-foot lift-span with its girders is about 1,000 tons, including 250 tons of cast-iron sectional counterweight. After the machinery was installed and tested, traffic was abandoned one Sunday, all of the old trestle between piers 1 and 2 was removed and the span lowered into position. The necessity of maintaining clearance through the lower part of the span for traffic during erection made it necessary to omit the transverse bracing between the rocker girders. This was put in the same day that traffic was abandoned to permit the span to be revolved into its horizontal position. Previously the girder had been sufficiently secured by the falsework and temporary wooden bracing.

The vital point in the erection was the preservation of absolute accuracy in the position of the first panel point above the rocker girder. This developed a tendency to move laterally and required constant attention and adjustment with hydraulic jacks and shoring. This, of course, resulted from the necessary temporary omission of the lateral bracing. Otherwise the span was self-supporting and imposed practically no weight on the traveler.

It is worthy of note that in the erection of this class of bridges exact alignment of the trusses is seldom attained, but in this case the truss revolved from vertical to horizontal position with perfect accuracy both in alignment, length and level, so that the ends of truss centered perfectly on the abutment shoes. The absence of the twist which is customary in this sort of work whether it be erected horizontally or vertically was considered very gratifying by the contractors.

August 26, 1903, soon after the 42-foot center span and the track girders had been placed and before the erection of the rocker span was commenced, a very severe squall was experienced which wrecked many buildings and caused large damage to the shipping in that vicinity. It struck the traveler with such violence as to blow it transversely entirely off from the piles and into the river where it collapsed, but was not capsized, causing the death of three men. The traveler was so well braced and so strong that it held together until blown entirely off from the supports, when, of course, the fall into the water caused its destruction. This involved considerable loss and a delay of two months. At other times the traveler experienced very strong winds without any injury.

The bridge is owned by the Central Railroad Company of New Jersey, Mr. W. G. Besler, vice-president and general manager, and Mr. Joseph O. Osgood, chief engineer, and is used by it and by the Philadelphia & Reading and the Baltimore & Ohio Railroads. The substructure plans were made by Mr. Austin Lord Bowman, bridge engineer. The superstructure and machinery were furnished by the Scherzer Rolling Lift Bridge Company. The Bethlehem Steel Company was the contractor for the machinery and the superstructure was furnished and erected by the Pennsylvania Steel Company, Mr. J. V. W. Reynders, superintendent, Mr. Frederick W. Cohen, engineer of erection and Mr. L. N. Gross, superintendent of erection.

Notes on the Baltimore Fire.

From a report by S. Ashford, Inspector of Buildings, District of Columbia.

After a general survey of the ruins I would say that the combustible buildings are entirely wrecked and are but a heap of brick. This condition would seem, therefore, to divert attention to the "fireproof" structures as the only visible examples for study. But the very thoroughness of the destruction of the combustible buildings gives reason for careful consideration on the part of architects, inspectors, insurance agents and owners. So before passing to the sky-scrapers, I desire to dwell on the more general subject of fire protection in combustible buildings, and to invite attention to a government publication in the form of Consular Reports on Building Regulations of Foreign Countries, of 1892.

These reports first impress you with the small number of conflagrations, which are, in fact, almost unknown; due, as the consuls infer, to the "solidity of the buildings" and the thickness of the dividing walls between buildings and parts of the same building. There may be different opinions concerning the efficacy of the rival materials, but all agree that there is nothing to compare with brick walls for resisting fire, and the means of safe construction for limiting fire in combustible buildings lies in the erection of thick enclosing walls of brick, with as many partitions or crosswalls as the subdivision or interior arrangement will allow. The bracing effect of these cross walls was shown in the Baltimore fire by the standing angles or corners of buildings when everything else was down, and the scarcity of cross-walls was evidently accountable for the complete demolition of buildings. These walls and cross-walls should be carried through the roof at least a foot. It is evident that we use too many stud-partitions and not enough interior walls to brace the side walls when roofs and floors burn away.

Many buildings in Baltimore were provided with sprinkler tanks which are undoubtedly efficacious for interior fires in their early stages, but in many cases in Baltimore, where the supports were burned away, these tanks completed the destruction. The regulations adopted last summer in the District of Columbia seem essential for the safe installation and maintenance of such appliances, which might become a menace to building occupants and firemen in case of the failure of supports through slow combustion, by decay, or rapid failure in fire.

Generally speaking, the buildings externally are in fair condition except where the face bricks have left the backing. In many cases where hollow or cellular terra cotta was used in decorations, lintels or architraves of windows or belt courses, the outer web has burst or broken off, leaving the cells resembling the front of an open file case, and in some cases large consoles and brackets in the cornices nearly two hundred feet above ground have split open. It should be remembered that this terra cotta was subjected to heat but not water, which probably accounts for its fair condition. Of course, the window frames are entirely gone. I found about half a dozen wall-beams exposed and, strange to say, always on the leeward side of the building. I noticed some brackets under beam-ends, but no columns were seen from outside, and the steel frames in all cases but one seem to have escaped injury. Our regulation requiring 9 inches of brickwork outside of columns seems to afford proper protection. I should say that the outside walls suffered about 10 per cent. loss on the brick and terra cotta buildings and from 10 to 30 per cent. when brick and stone.

I do not believe the architect or engineer ever contemplated a severer trial for fireproofing. The steel frame, when protected by brick, was decidedly satisfactory. The interior of these buildings suffered considerably. Every particle of woodwork, including the sleepers imbedded in concrete filler, was completely obliterated and the hollow tiles forming the floor arches badly damaged, especially in the halls and corridors, where they seemed to get the intensified heat due to the blowpipe effect of the through draft from hundreds of open windows and doors. The lower webs of these tiles are split off and the fracture extends from one-third to one-half up the partition. This failure released the slabs or tiles protecting the lower flange of the floor-beams which, in many cases, are now exposed. The damage to the floors is worse in front of the windows, where the hot blast emerged from the building. Terra cotta partitions are standing, except a few that were evidently blown over on the floor, with the blocks still in good condition. Judging from some samples of brass and copper the fused condition of some typewriting machines, and melting of some iron mullions in the windows, I would say that the temperature was above 2,000 degrees F. in some parts of these buildings, but in some rooms with scagliola decorations and calcined plaster or gypsum products, such as plaster of paris, on walls and ceilings, the decorations and structural features are almost perfect. The same resistance of plaster of paris was noticed in the grounds or benches for the marble wainscoting. The marble is gone but the plaster is firm and uninjured.

It is my opinion that all the terra cotta floors have suffered to the extent of 50 per cent. in area, and that by the loss of the lower web they are in a dangerous condition, with no means of determining their actual condition while in place. It seems necessary to increase the thickness of the lower web and change the form of the block to avoid the sharp angular junctions at web and partition where the fracture begins. A rounded or convex surface of the under web would seem to improve conditions and form a better key for plaster, which might protect the terra cotta from sudden changes in temperature when sprayed by cold water during a fire.

High-Speed Electric Traction will shortly be tested on a 12-mile stretch of the Swiss State Railway near Seebach, using a 400-horse-power electric locomotive designed by the Maschinenfabrik Oerlikon near Zurich. It will employ a 15,000-volt single-phase current transformed on the car to direct current, and has already shown in preliminary tests a capacity for hauling a 500-ton train for an indefinite time at 25 miles an hour. The trolley wire is attached directly to the top of the insulators on the pole line and the current is taken off by a new form of collector designed for this special service. The trolley wire is thus kept at the side of the track and not overhead, an arrangement that will appeal strongly to the managers of railways now in operation as steam roads.

John R. Freeman.

A few years ago, when the Comptroller of the City of New York retained Mr. John R. Freeman to investigate the water supply of that place, considerable surprise was expressed that such a problem was intrusted to an engineer whose work had, for some time, largely been along the lines of insurance engineering. At that time The Engineering Record was able to point out privately to a number of enquirers the exceptional fitness of the appointment, and as Mr. Freeman has again been retained to investigate the New York water supply, and his second report, as a member of a committee with Messrs. William H. Burr and Rudolph Hering, will shortly appear, it is a fitting time to print a brief outline of his professional career.

He was born on July 27, 1855, in the little community of West Bridgeton, Me. His early days were spent on the farm and his education was begun in the district school of that place. This was supplemented by terms in the public schools at Portland, Me., and Lawrence, Mass., and then the full course in civil engineering at the Massachusetts Institute of Technology, where he was graduated in 1876. Mathematical and scientific subjects had always been of much interest to him, and while attending the Lawrence high school he took all of these subjects regularly covered in a three-year course during his first two years, while his vacations were spent as a rodman in the employ of the Water Power Company. During his studies at the Massachusetts Institute his summers were spent with the same company as computer, draftsman and assistant. After graduation he joined the staff of the company regularly and soon rose to the position of principal assistant engineer to Mr. Hiram F. Mills, chief engineer.

At that time Mr. Mills was engaged in making many experiments on the flow of water, capillarity, friction, etc., and his assistant developed much fondness and aptitude for investigations of this nature. It is probable that the experiments conducted by Mr. Mills at this time are among the most important hydraulic studies made in this country, although so little has been published concerning them that they are comparatively unknown even to this day. Mr. Mills also acted as consulting engineer to various manufacturing companies in Lawrence and other New England manufacturing centers, and the details of much of this work fell to Mr. Freeman's care during the ten years he held the Lawrence position. He was engaged on many surveys and designs in this way for water-power improvements at Sewall's Falls, N. H., and Bellows Falls, Vt., as well as nearer home, and undertook occasional engineering design on his own responsibility. During this time he had charge of the daily measurements of the water power used by the Lawrence factories and of water power measurements for the factories of Manchester, N. H., and in this way secured the intimate knowledge of stream-flow and of gauging which proved of much value later on.

After ten years of this experience he decided to open an office in Boston for general practice in hydraulic engineering and mill work. While this step was under consideration, he received the offer of a position as inspector and hydraulic engineer for the Factory Mutual Fire Insurance Companies, which he accepted for a year only in the belief that the acquaintance to be gained in this way with mill men and mill architecture would be a valuable asset later on when he undertook consulting practice. In this manner he entered the insurance field in which he has since remained, although not to the exclusion of other business and engineering enterprises. He found a comparatively new specialty in fire protection engineering, which not even now receives the recognition it should. In the course of this work he has been called upon to make tests of the efficiency of many public water works as well as to investigate the new appliances for fire protection which are all the time coming out. His experiments on the discharge of fire nozzles and the hydraulics of fire streams are among the standard investigations of engineering and too well known to need more than mention. In a short time he was called on to reorganize the inspection service of these companies, of which he was placed in charge with the title of chief inspector and chief engineer. In this work he appreciated from the outset that it afforded good openings for the best engineering talent, and accordingly recruited his staff of draftsmen, experimenters, inspectors and engineers from the graduates of engineering schools so far as possible. To show what a field exists in this line of work it is only necessary to state that more than two thousand large mills valued at over a thousand million dollars unite for fire protection purposes in the Factory Mutuals. Mr. Freeman has particularly sought to perfect standard methods and appliances for fire protection, and to unite manufacturers of fire appliances on certain standards of quality while preserving to each his individuality of detail. The specifications almost universally adopted for underwriter fire pumps, underwriter nozzles, fire hose, and the like, were drawn up by him after much experimental work, and even since his advance in the companies to a position of larger responsibility, he keeps in close touch with all engineering work as chairman of the committee over the inspection department. It was in 1896 that he became president and treasurer of the Manufacturers', Rhode Island and Mechanics Mutual Fire Insurance Companies, which was virtually a consolidation of the oldest two organizations of this character. Under his charge their business has increased about three-fold, while these results were so successful that a year ago, on the death of Col. Thomas J. Borden, Mr. Freeman was called upon to become president and treasurer of three more companies of this nature, the State, Enterprise and American. At the present time he is accordingly in charge of the fire-protection and insurance interests of property valued at more than $300,000,000, making his office the largest of its kind. Fondness for engineering work has caused him to steadfastly decline to devote his time exclusively to business interests.

John R. Freeman.

From 1894 to 1896, Mr. Freeman was the active member of the Water Board of Winchester, Mass., doing much to reorganize its work and raise its efficiency. In the latter year he was appointed one of the original members of the Massachusetts Metropolitan Water Board, charged with building new water supply works for Boston and neighboring towns, receiving the appointment on account of his position in the engineering world as well as his executive ability. He had much to do with the successful organization of that great work, but his change of residence in 1896 from Boston to Providence made it necessary for him to resign. During his stay in Massachusetts he was twice appointed by the Supreme Court to be one of three commissioners to appraise the value of private water works. In addition he has acted as consulting engineer to a number of manufacturing corporations on matters of construction and water-power development.

In 1899 he was selected by Comptroller Coler of New York as an engineer familiar with large water supplies and unbiased by local prejudices to investigate the water supply of that city. At this time Mr. Coler was making a strong fight against a proposed contract with the Ramapo Water Company for an additional supply for the city, and Mr. Freeman was selected as a wholly disinterested engineer to report on five subjects, namely: First, the capacity and adequacy of the present sources of supply compared with the consumption at present and in the near future. Second, the amount of waste and the extent to which it is practicable to prevent it. Third, the sufficiency of pressure and volume of present water supply for fire protection. Fourth, the best means of adding to the present water resources when occasion requires. Fifth, the advantages and disadvantages of the additional supply offered by the Ramapo Company. These investigations had to be made in a very short time and yet with a complete grasp of all but the minor details of every feature involved. Field parties were organized, investigations started on the existing works and at the hydraulic laboratory of Cornell University, and a designing office opened where the data were checked, computations made and plans for new works prepared. The request to submit such a report was received by Mr. Freeman on August 24, 1899, and it was handed to Mr. Coler seven months later. In its printed form it is a book about 600 pages, profusely illustrated with maps, diagrams and designs, and is generally acknowledged to be the most elaborate water-works report ever prepared by one engineer, a fact that is all the more striking when the short time permitted for securing the data and writing the document is considered.

Hardly less interesting as a piece of engineering literature is the report submitted by Mr. Freeman as chief engineer of the committee appointed in 1901 to consider the advisability of constructing a dam across the tidal estuary of the Charles River between Boston and Cambridge for forming a large water-park. This problem has been before the people of the two cities for the last forty years. Mr. Freeman made many new investigations on the sanitary and hydraulic features involved, which added much new information on the subject and so far removed the apprehensions of the public that the execution of the works has been authorized and placed in charge of a special commission. The report of these studies is a book of about 600 pages invaluable to all who desire to investigate the subject of such works for improving the condition of tidal inlets. This document probably contains more new information than the report on the New York water supply, although it is hardly such an important engineering achievement, for the interests involved were not so large nor was the time for its preparation so limited. Among the special topics treated in it may be mentioned the studies showing that salt water is less valuable for filling a basin like this, which receives some pollution, than is fresh water. The tidal scour question was another interesting subject of discussion, which was handled in a manner contrary to the accepted theories of harbor improvement engineers.

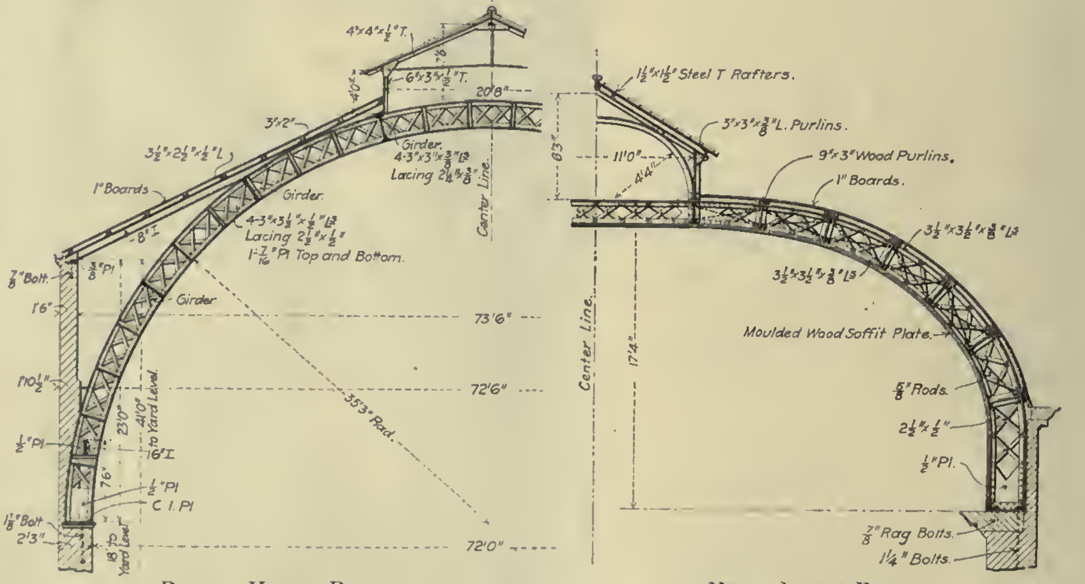
The joint investigation of Messrs. Burr, Hering and Freeman on an additional water supply for New York is too recent to need more than a brief mention, particularly as the full report will shortly be issued. In that report it will be found that there is full recognition of those features of public water supply for which Mr. Freeman's special knowledge of fire-protection engineering leads him to contend always. The supply will come by gravity and be delivered in the city under a high head, with a big terminal reservoir to tide over interruptions in the supply through the aqueduct. The great amount of ground water under Long Island is to be developed, so that the people of Brooklyn and Queens will not be wholly dependent on submerged mains from Manhattan for their additional supply. In addition the commission has selected the softest and purest natural supply available for the purpose.

Although these are the most important investigations made by Mr. Freeman, he has conducted many of considerable interest since his removal from Boston to Providence. He was the consulting engineer for the Nashua, N. H., water-works, and was called in to advise the citizens' committee on similar works at Winchendon, Mass., while more recently he acted as consulting engineer for the water-works improvements at Asheville, and for the great water power development on the St. Lawrence, at Massena, N. Y. He was connected with the suits along the Blackstone River in both Massachusetts and Rhode Island, growing out of the condemnation of the waters of Kettle Brook for the supply of Worcester. In some respects this is one of the most interesting instances of interstate water-rights litigation that has yet arisen. At the present time Mr. Freeman is retained by the Massachusetts Metropolitan Park Commission on the tidal regulation of the Mystic estuary and sanitation of the Cambridge Fresh Pond Marshes.

He was elected a member of the American Society of Civil Engineers in 1889, although he was connected with it for about seven years previously as a junior. He was a director from 1896 to 1898 and a vice-president in 1902 and 1903. He was twice the recipient of the Norman Medal of the Society, once for a paper on experiments relating to the hydraulics of fire streams and the other time for a paper on the nozzle as an accurate water meter. He has also contributed to that organization a paper on the hoisting apparatus of the canal headgates at Sewall's Falls. He was president of the Boston Society of Civil Engineers in 1893, and is at present a vice-president of the American Society of Mechanical Engineers, and has contributed some important papers and discussions to its publications. At the present time he is a director of the National Bank of Commerce and of the People's Savings Bank, of Providence, a trustee of Butler Hospital, and a member of the corporation of the Massachusetts Institute of Technology.

Light Steel Gas Plant Roofs in England.

The retort house for the Hastings Gas Works at Glyne Gap, England, is about 73½ feet wide and 233½ feet long with brick piers and walls and a steel roof. The roof weighs about 160 tons and is divided into 11 panels by 10 main trusses which are seated on cast-iron base plates in the main walls. Each truss is a full-centered hingeless lattice-girder arch 27 inches deep and 9 inches wide. The lower flange is curved to a radius of 35¼ feet and the top flange is concentric with it. The lower ends of the trusses are cut square so as to take bearing on horizontal cast-iron ribbed base plates grouted and anchored to the brick work with long bolts. The flanges are made with pairs of 3x3½-inch angles riveted back to back and reinforced by 9x7/16-inch cover plates. The trusses are divided into 4-foot panels by radial members made with pairs of 2½x2½-inch angles with their ends fitted to bearing on the flanges. Each panel is latticed by two sets of 2½x½-inch X-bracing. They are trussed at the haunches by zigzag ⅝-inch rods which are apparently secured by single small rivets, and are either superfluous or inadequate for efficiently strengthening the truss which should have sufficient stiffness from its web and flanges. The trusses are connected by six lines of longitudinal lattice girders in radial planes, with the same depths as the trusses, and web-connected to them at the intersections. They have 3x3-inch flange angles, 7x⅜-inch reinforcement plates and 3¼x⅜-inch latticing. The trusses and longitudinal girders support the upper ends of 8-inch I-beam rafters, the feet of which have shoes anchored to the tops of the side walls. They are 10½ feet apart and carry 3½x2½-inch angle-iron purlins 3¾ feet apart, which are sheathed with 1-inch boards nailed to wooden strips bolted against their upper sides.



Retort House Roof. Meter House Roof.

Hastings, England, Gas Plant Roofs.

On the center line of the roof there is a monitor about 21 feet wide and 7½ feet high which has an angle iron framework and light truss rods connecting the lower ends of the rafters.

The meter house is 46 feet wide and 128 feet long with a curved roof having a cross-section which resembles a semi-ellipse and is groined at the ends. The main roof trusses each consist of three sections, the end ones being curved through 90 degrees of approximately elliptical lines for the top and bottom flanges. These sections are 2 feet deep radially at the base and 16 inches at the opposite end. The lower flange has a rise of 16 feet and the top flange has a rise of 17 feet 4 inches. Both are made with pairs of 3½x3½-inch angles and 2½x½-inch lattice bars. The upper ends are connected by a horizontal lattice girder 16 inches deep and 11 feet long which is surmounted by a monitor made with an angle iron frame having a curved portal angle and bent rafters continuous from eave to eave.

The end sections of the trusses are divided into 7 panels each by radial double T-bars about 3½ feet apart. They have base plates 2 feet square which are connected to the ends of the girder webs by pairs of 5x5-inch angles bent to a U-shape with their horizontal flanges riveted to the plates so that their vertical flanges form pockets receiving the girder flanges. The 9x3-inch wooden purlins are laid flat over the tops of the radial members in the girders and are covered with 1-inch boards parallel to the trusses. The ventilator has angle-iron purlins carrying a full width skylight. The roof sheathing is slated. At the ends of the curved roof there are flat deck roofs with purlins 18½ feet long made of 6x4-inch T-bars trussed with ¾-inch rods.

These buildings are described by the designing engineer, Mr. W. R. Herring, M. Inst. C. E., in the Journal of Gas Lighting, London.

Electric Thawing of water pipes has been extensively adopted this past winter on account of the frequent periods of severe cold. The system was first widely used in the winter of 1898-99, and full directions for carrying on the work were published in this journal then. Of late years the winters have been so mild that this use of electricity dropped from notice.

Book Notes.

It is gratifying to learn that enough engineers are interested in really sound standpipe and water-tower construction to make it necessary to print a second edition of Mr. J. N. Hazlehurst's "Towers and Tanks for Water-Works." This comprehensive and painstaking work on a subject of such limited interest was a rather risky venture for author and publisher, for the number of men who are called upon to design such structures are few in number, and a very large proportion of them formerly were satisfied to leave the actual details of construction in the hands of the contractor. There have been some excellent builders whose work remains in satisfactory condition to this time, but there were also others not in such a responsible class. Mr. Hazlehurst has brought together in this work all the information necessary in preparing plans and specifications for the standpipes and towers, and has stated it clearly, with the assistance of some good illustrations. In the new edition he gives a discussion of the stresses in a steel water tower, a chapter on specifications and an outline of the aesthetic possibilities of these structures, which were not included in the first edition. A number of minor corrections and changes have been made. (New York, John Wiley & Sons; cloth, 6x9 ins., 335 pages, $2.50.)

The second volume of Mr. Edoardo Webber's handy dictionary of technical terms in four languages has just appeared, the order of arrangement in this case being German, Italian, French and English. The title of the book is "Technisches Woerterbuch in Vier Sprachen, II." In this edition about 2,000 technical terms have been added, bringing the number of pages up to 611. It is well printed and bound, and is published at $1.20 by Ulrico Hoepli, Milan. The same publisher has recently issued a second edition of Mr. G. Belluomini's "Prontuario del Peso dei Metalli," a volume of tables of the weights of shapes and tubes of various metals used by the engineer. It is arranged on the metric system and is sold at 70 cents. Both books are in the famous series of Manuali Hoepli, a collection of duodecimo publications that is probably unexcelled for high character, appearance and low price.

One of the most important of the trade associations in this country is the New England Cotton Manufacturers' Association. The local name in the title of this society is unfortunate because it is not a sectional body nor has it been for some time, but represents the cotton industry of the entire country. The "Transactions," issued twice a year from the office of the secretary, Mr. C. J. H. Woodbury, 45 Milk street, Boston, form the most useful work on the industry in the English language. The last volume, covering the meeting held last September, is a 238-page book containing articles on every feature of cotton manufacture. Mr. Edward Atkinson contributes some interesting reminiscences of the early days of the Association, and there are papers on the development of water powers, the steam turbine, the use of storage battery cars in the yards of cotton mills, various novelties connected with mill machinery, the condition of the cotton market and the details of cotton mill practice. The volume is sold to non-members at five dollars.

The convention of the American Water-Works Association at Detroit in June of last year was the most important in its history, and it is not surprising that the "Proceedings" in which its papers and discussions are recorded form a large volume of 724 pages, illustrated with both text cuts and folding plates. A report of the convention was printed in this journal last summer, but the number and importance of the papers and discussions made it impossible to give more than a general account of the meetings. The official report covers most of the field of water-works design and management more or less completely and will be found indispensable in the office of every water-works superintendent. Copies are sold at one dollar each by the secretary, Mr. J. M. Diven, Elmira, N. Y.

The annual report of the Massachusetts State Board of Health is always a document of the utmost importance to engineers interested in municipal works, and that for 1902, which has just been issued, is particularly worthy of study. It contains the usual tables and suggestions concerning the water supplies and sewage disposal works of the State and also a number of special reports. The information from the Lawrence Experiment Station is particularly valuable because of the conservative character of all the work done there. The scientific basis of intermittent sand filtration of sewage was first thoroughly studied at this place, and the same care is now being paid to studies of more rapid methods of purification, including the preliminary treatment of sewage for application to filters. Contact filters, intermittent continuous filters, coke and coal strainers, and septic tanks are under investigation. The effluents from the coarse filters are found to vary greatly in character with high rates of operation, according to the nature of the material of which the filter is constructed and the manner in which it is operated. The efficiency of various sand filters for water has been kept under investigation and the work of the famous Lawrence filters is watched closely. The volume contains an interesting monograph by Messrs. H. W. Clark and Stephen DeM. Gage on the value of tests for bacteria of specific types as an index of pollution, and a particularly valuable statement of the effect of sewage disposal in the commonwealth as indicated by an examination of the outlets of sewerage systems. The data in this volume will repay careful study, particularly when the earlier reports of the Board are at hand so that the history of some of the experimental work can be continued back several years.

The controversy over the adoption of the metric system in this country has lately been enlivened by the publication of a work entitled "The Metric Fallacy." It consists of two portions, one by Mr. Frederick A. Halsey on the general subject of the title of the book, and one by Mr. Samuel S. Dale on the failure of the metric system in the textile industry. So far as can be learned by enquiry among manufacturers of textile machinery for use in metric countries, the statements of Mr. Dale seem to be correct, that is to say, so much of them as relate to the subject in hand. The portion of the book by Mr. Halsey is somewhat difficult to read with profit, because one page of clean-cut argument may be succeeded by another containing so much evident striving for effect that the result is as convincing as the cart-tail oratory of a political campaign. Moreover some of the statements he brings forward concerning the use of non-metric measures in metric countries are laughable to one who has actually lived abroad in contact with men of all stations. Any one making use of this portion of the book ought to reflect seriously that it is hardly right to say the United States is not wholly given up to the English system of measures, because from one end of the country to the other men may be heard to ask for, say, "a chew of tobacco." Some of the units that are stated to be employed in other countries are just as definite in their actual significance as that mentioned, no matter how many places of decimals may be given in some report to show that they have an accurately determined value. [New York, D. Van Nostrand Co.; cloth, 9x6 ins., 231 pages, $1.00]

Of the various branches of surveying there is none which is so attractive as that carried on by the members of the U. S. Coast and Geodetic Survey. The work is done in all sections of the country and under the most diverse conditions, and its character varies greatly according to whether it is for primary triangulation, a reconnaissance of some bay in the Philippines or some undertaking of a degree of accuracy intermediate between these wide limits. Hence the annual reports of the superintendent always contain papers of interest, and this is unusually true of that for 1902. To this volume Mr. John F. Hayford contributes a valuable report on triangulation in Kansas, Mr. Fremont Morse one on the hypsograph, a circular typographic slide rule designed by him, Messrs. L. A. Bauer and J. A. Fleming one on the magnetic observatories of the Survey, one by Mr. Daniel L. Hazard on the results of magnetic dip and intensity observations made by the Survey from 1897 to 1902 inclusive, one by Mr. W. D. Alexander on Hawaiian geographic names, and, finally, the elaborate bibliography of geodesy by Prof. J. H. Gore, which is issued in a greatly enlarged and improved form in accordance with a vote of the International Geodetic Association in 1900. The report is profusely illustrated.

Letters to the Editor.

The Sales Engineer and His Qualifications.

Sir:—The practical side of applied science rests to-day on a foundation of dollars and cents. Someone has well defined an engineer as a man who can make a dollar go the farthest, and this can be doubted by no one whose experience lies in the world of men, and outside the realms of speculative thought. A great deal has been written about the qualifications necessary to make successful engineers, and much less about the engineer's relations to the business side of his work. The subject is too large to be broadly treated in a single letter, so the writer will contend himself with considering a specialized form of engineer, the man who sells apparatus through his commercial, technical and human knowledge.

For a long time the world has been acquainted with the traveling salesman. Many classes of manufactured articles can best be sold by traveling agents of the organization which produces the goods. When it comes to complex applications of scientific invention in the service of man and on a large scale, however, a very different sort of man is required. He bears much the same relation to the ordinary traveling salesman as does the trained professional engineer to the electrician or surveyor. Such a man is the skilled engineering salesman of to-day, or as he is coming to be called, the "sales engineer."

The primary object of the sales engineer's existence is, of course, to sell the apparatus which his company manufactures. If this were his only function, there would be little occasion to pursue this subject further. The great point is that such a man must do far more than sell machinery and appliances, if he is to approach the highest usefulness to his company, its customers, and the community. He must first of all countenance good engineering; he must not adopt doubtful or dangerous schemes simply for the exploitation of his own apparatus, for such a course is bound in time to react upon his company's good name, quite apart from its moral laxity at the outset. He must bend every energy toward the safe solution of the problems that come his way, working out such questions with the help of his own apparatus only. It is his part to lead the investing community along conservative, sane paths; to point the way to progress by the introduction of the latest appliances which his factory can provide, and to emphasize first, last and always, the superior adaptability of these appliances to the work in hand.

This means competition—keen analysis of defects, weak spots, inefficiency and every kind of fault in the design and operation of his own and his rivals' product. It means a technical training that covers fundamental principles in a way so sound that the sales engineer's knowledge will stand up under the hard knocks of commercial life without going to pieces. It demands an appreciation of manufacturing processes, costs, labor and raw material problems; it calls for integrity and tact. Such a man must keep in touch with the great movements of the world; must see in every changing season and shifting circumstance the chance to keep in the development of civilization—the chance to gain new adherents to his company and retain the confidence of the older customers. For unless a customer is retained, it profits but little in the end, and loss in reputation is far easier than gain.

The successful sales engineer will not be content when the final balance due on his contract is paid. He will constantly keep an eye upon the behavior of his apparatus; will watch the approach of new conditions, and forestall the advance of rivals by doing his utmost to make the purchaser see for himself that the choice of apparatus was the best possible one, and has remained the best, from the day the wheels began to turn. If he criticises his competitors' apparatus, he will base his comments upon known facts, and not upon glittering generalities. He will generally be able to point with pride to installations which his company has made that are models of success, and will have at hand definite results with which to back up his claims. Finally, he will make a specialty of the study of human nature; will be a man among men in the best sense, and be a giant rock of truth in the quicksand regions of deception.

Aa for the training of a sales engineer, he must first of all possess a sound body; then an education in applied science, followed by experience in factory study, office practice, and lastly, in the great world of commerce. Year by year as such a man as this plies his vocation, meets celebrated men, visits many places, helps build new systems and revise the old ones, he grows to feel that in his way he is an agent of progress in hitherto unconquered fields, and that his work may be as noble in the service of humanity as the inventor's itself.

Yours truly, Howard S. Knowlton.
Denver, March 21.

Testing Foundations for Buildings.

Sir:—With reference to the tests of soil at the site of the Worthington Works at Harrison, described in The Engineering Record of February 6, it might well be pointed out that while loading tests are sometimes made, as, I think, in the case of the St. Paul Building in this city, tests on areas as small as 3.8x3.8 inches are probably unique. Without further information, the prudent engineer will not be disposed to place much reliance on such microscopic experiments. By standing on the edge of one heel you can easily exert a pressure of, say, 175 pounds on perhaps 0.1 square inch, and the floor will be none the worse for it; but it does not follow that it will be safe to impose the proportionate load of 126 tons per square foot on the same floor. I do not mean, however, to discredit these tests merely because they were made on a small scale, as they may be sufficiently reliable in determining comparative resistances when themselves checked by "many experiments," as is stated to have been the case in this instance. It would be of great interest to know how these experiments were conducted and just what was proved by them.

The upheaval of the ground just beyond the edges of the post merely indicates a disturbance of the surface soil, but the frequent rising of the posts when the load was partly removed would indicate a spongy substratum that might cause some anxiety, especially if liable to lose its ground water by subsequent drainage. That the foundations were started 5 feet above the "satisfactory" and "hard stratum" found by the tests pits would seem to need some explanation.

Very truly yours, H. W. Brinckerhoff.
New York, March 18.

[This note was submitted to Mr. B. L. Baldwin for comment. Owing to the press of work connected with the construction of the Worthington plant, he was unable to give an account of the experimental work which established the sufficiency of careful small-area tests of soil for all practical purposes. He wished to emphasize his belief, based on many years' experience with such tests, that they are entirely trustworthy when carefully conducted and intelligently interpreted.]

Composition Roofs in the Baltimore Fire.

Sir:—The March 5th issue of your journal contains a letter headed "Tin Roofs in the Baltimore Fire," which, to say the least, is very misleading. Permit us to give the facts of the case as witnessed by any number of people, which would refute the statement that tin roofs are more fire-proof than composition roofs manufactured and applied by up-to-date methods and materials.

Occupying the tenth floor of the Union Trust Building, we had an excellent outlook and for a block ahead, before the fire reached us, saw the large embers continually falling on tin roofs which, being a good conductor of heat, caused the sheathing underneath to light and thus helped spread the fire, while slag roofs resisted and retarded the fire absolutely. To be specific:

The Knabe Building directly under our window was deluged with flying embers, but the roof, covered with Ehret's slag roofing, failed to ignite and only yielded when the sheathing caught from the fire beneath and the entire building was in flames. For comparison of tin and slag roofs, architects and owners may well note the following: The Bank of Commerce Building was covered with tin which literally went to pieces under the intense heat, while the International Trust Building roof of Ehret's slag is intact, and the same can be said of the following buildings which, with those mentioned, are right in the heart of the burned district: Alexander Brown's Bank, the Calvert Bank, the Equitable Building, the Union Trust Building, Continental Trust Building, Central Savings Bank, U. S. Fidelity, the Herald Building, and many of lesser note. That the architects of the stricken city have realized this important factor is proven by their specifying Ehret's slag and actinolite tile roofs for the new buildings.

Yours very truly, Warren-Ehret Company.
Philadelphia, March 29.

The Value of Tables of Bids Received for Public Work.

Sir:—Engineers and contractors have much to gain by the publication from time to time of prices prevailing for works of a similar nature to those in which they are interested, but it should be the aim of both engineers and the engineering publications to give the highest value to these published prices. In the past those relating to sewers and water works especially have been of little worth for the conditions surrounding the work were quite unknown. Each list of bids should be accompanied by a succinct statement of the principal conditions under which the work was awarded, such as the nature of the rock encountered, and the method of paying therefor, an estimate of the percentage of wet trenches, the provisions for the payment of general unforeseen contingencies, such as quicksand, removal and care of existing constructions, pavements, etc. A statement of the quantities at the various depths for each size of pipe should be given, and also the rate of wages paid laborers and bricklayers. The general market price for brick such as the engineer will permit upon his work is essential, for the personal equation of the engineer may make a difference in the price of fully twenty-five per cent. in the cost of this material to the contractor.

To show the utter uselessness of some of these tabulations let us take a recent example. In your issue of the 26th instant, a whole page was devoted to giving in detail the prices received at a certain town in Pennsylvania, which in my judgment were utterly worthless to any one hoping to gain some knowledge of what work is worth, because, among other things, there is no indication whatever either as to the maximum, minimum or average depth of trench on any of the sewers. Nor is it stated how deep were the manholes, flush-tanks, etc., nor was there any statement as to how rock was to be paid for in the trench. Not even by comparing the bids on the various items is there any way to determine an approximate value of the work.

Taking, for instance, the first item in the tabulation under consideration. It consists of 1,410 feet of 6-inch pipe sewer and the prices of the various contractors are 40, 42, 48, 56, 68, 70 cents and $1.05 respectively. Any one would say without hesitation that the highest bidder bid out of all proportion to the value of the work. An examination of the plans reveals the fact, however, that upon one of the three short streets in which 6-inch pipe is to be laid the sewer is 18½ feet deep at its upper end, at another 13½ feet deep at its upper end and a third 9½ feet deep. The plan shows that the average depth of the 8-inch pipe is somewhere in the vicinity of 8½ feet. The low bidder asked 62 cents per foot for this construction, while the highest bidder asked 75 cents therefor. It is self-evident that the 6-inch pipe at the greater depth stated may well be worth fifty per cent. more than the 8-inch pipe at the lesser depth when it is remembered that the difference in cost of the material amounts to but a few cents, yet the highest bidder was the only one who bid more for the more expensive construction. The other bidders assumed that the smaller the pipe the less the cost should be irrespective of depths at which it was to be placed, quite an erroneous assumption.

I trust that in the transmission of tabulations on much of the work now under advertisement, engineers will see that it is to the interest of the profession to give as complete information as to the conditions surrounding the letting of such work as possible.

Yours truly, Alexander Potter.
New York, March 29.

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The Uselessness of Smoke.

In the science conference held at the recent dedication of Palmer Hall at Colorado College Professor Henry Crew quoted in an address on teaching physics Helmholtz's explanation of a scientist's dual purpose: "Action alone gives a man a life worth living, and, therefore, he must aim either at the practical application of his knowledge or at the extension of the limits of science itself." In connection with this quotation, the speaker pointed out the mutual benefits that have followed the growing intimacy between the engineer and the investigator in the domain of pure science. It is also instructive to the engineer to notice that "Science," the weekly organ of general scientific investigation in this country often contains some contributions of a strictly engineering character. The American Association for the Advancement of Science has engineering sections, and their papers indicate the close relations between the scientist and the engineer. In electrical subjects it is impossible to say where engineering ends and pure science begins, so close is the connection. In civil engineering, on the contrary, the accurate judgment that comes from a long and intelligently directed experience is far more often needed than a knowledge of intricate scientific laws. Between these limiting branches there is a great field in which progress in practical achievements is measured in no small degree by the extent to which scientific principles are applied by the engineer.

These thoughts are suggested by a paper in the journal mentioned on the "Science of Smoke Prevention," by Prof. Charles H. Benjamin. The engineer knows to-day very well that smoke can be prevented by a careful avoidance of the conditions causing it. Even with hand firing, a good fireman can reduce the smoke to an inoffensive amount. To do this he has to work hard, continuously and intelligently. Very few people are willing to pay adequately for such service in a boiler plant, and consequently no small percentage of their coal pile is wasted in the air, causing a considerable loss to themselves and an annoyance more or less severe to their neighbors. Nobody has any right to prevent another from wasting his coal, but when such waste is accompanied by a pall of smoke, interfering with the normal conditions of life, the situation is entirely different. As the subject is presented to-day, there is no excuse for the sooty atmosphere of many American cities. There was a time when the anti-smoke agitation was looked upon by most people as a shrewd move of salesmen for steam jets and stokers, but the work done by the man of science along this line is convincing the public that a smoke-laden atmosphere is just as unnecessary and unhealthful as dirty streets and defective sewerage. Moreover, since the scientist has taken the subject up, the owners of boiler plants are rapidly becoming convinced that heavy smoke really means lost fuel, and both hand firing and mechanical stoking are receiving far more atten tion than before.

In this particular subject, the value of scientific study lies in the determination of the reasons for the trouble, and not in discovering methods of overcoming them. As a matter of fact, the same subject was thoroughly investigated years ago on a small scale and quickly and definitely settled. But in that case, it was taken in hand by a great corporation with remarkably farseeing management, while in the present case it is the general public that is directly interested and consequently progress has occurred at snail pace. When the Standard Oil Company found that the market for oil would be increased by improving the character of lamps, it was only a short time before every lamp maker in the country was informed, directly or indirectly, how to make his lamps so that combustion in them would be perfect. It is interesting to notice that a great coal-producing corporation has recently taken up the same idea and is distributing to its customers a valuable treatise by Mr. Bement, the Chicago specialist in furnace management, who points out what must be done to burn coal in the most economical manner. This company recognizes, just as the Standard Oil Company did years ago, that the sale of its output is helped and not retarded by teaching economy in consumption.

The prevention of smoke depends, as Professor Benjamin clearly states, on the observance of three conditions, the supply of enough air, a sustained high temperature and the thorough mixing of the gases. With too little air, the hydrocarbons are not consumed, with too much air the gases are chilled, and with the air improperly supplied the combustion is irregular; each defect results in smoke. It is unnecessary to employ mechanical stokers to avoid these defects, although it generally happens that the stoker is the cheapest remedy. Even when a mechanical feeding system has no advantage in point of economy, its value as a smoke-preventing device still calls for its use in many places. At the present time, when some people take pride in filthy chimneys under the mistaken idea they indicate thriving industries, the smoke-preventing importance of stokers is not appreciated. But the time is rapidly approaching when public sentiment will insist on the abolition of such nuisances on the ground of civic decency and general health. When pure science, engineering, hygiene and municipal pride unite in saying "stop" to a nuisance, something is sure to happen.

The Inspector of Asphalt and Cements of the District of Columbia.

It is with astonishment that the engineering profession has learned of an attempt in the United States Senate to curtail the dignity and standing of one of the technical officers of the District of Columbia. It is certainly strange that the national legislature for the whole United States should focus its attention upon a competent employee of the Engineer Commissioner of the District of Columbia and lay aside matters of national importance to consider the following regulation: "Said Inspector of Asphalt and Cements shall not render expert advice to or perform service for or receive or accept compensation of any kind from any person, firm, corporation or municipality other than the District of Columbia." Why the Inspector of Asphalt and Cements should be singled out in this manner from among the host of scientists and engineers in Government employ is a question that should receive attention. If any reason exists why Mr. Dow or any other gentleman occupying the position should refrain from outside practice, the Engineer Commissioner of the District has full authority to act in the matter. The Congress of the United States is too big a forum for the consideration and settling of such a subject, which is manifestly a detail of administration entirely too small for it to investigate properly.

The facts of the matter are that the Inspector of Asphalt and Cements in the District of Columbia must be a chemical engineer of high standing. The acceptance of a great deal of work depends upon his judgment, and it is imperative that he should be a truly just arbitrator of the respective claims of the District and the contractors for asphalt pavements. The manner in which payments for asphalt construction are made in the District is an unusual one, for this reason the Inspector has to carry exceptionally heavy responsibilities. As a business proposition, it is important for the District to have a man in the office of high technical standing and of absolute business integrity. Such a man has to be paid a considerable sum, equivalent to what he can obtain in other work. As a matter of fact, the District of Columbia is extremely parsimonious in all its dealings with its engineer employees, and it has been a practice for many years to allow these men to accept remuneration for work done for other interests than the District. In this way good men have always been employed in Washington, and their association with undertakings or investigations outside of the strict line of their official duty has broadened and strengthened their technical attainments and enabled them to supplement their meager salaries in an adequate manner. Why Congress should select the Inspector of Asphalt and Cements as the one employee who must not accept outside work passes understanding.

Upon investigation, The Engineering Record learns that this proposed regulation is opposed by the present Engineer Commissioner of the District of Columbia, and is also being vigorously fought by influential men in other cities than Washington, who have come to regard the work done by the Inspector of Asphalt and Cements as the most important independent municipal control of the asphalt paving industry in this country. The technical work that Mr. Dow has been doing, and Mr. Richardson before him, is the source of a very large percentage of the really valuable information concerning the manufacture and laying of asphalt paving materials at the present time. Mr. Dow's work for other municipalities has, it is believed, been extremely limited. It is understood that what little he has done has been of material benefit to the office of the District Commissioners and has been carried on with proper discretion. Congress, if it takes the proposed action, will so diminish the prestige and financial returns of the office of Inspector that the work will fall to men of inexperience, without high standing. At the present time municipal officers all over the country look to Washington for precedents in the construction of asphalt pavements, because it is recognized that the control exercised over the contractors by the District is very thorough and impartial. This fact is so well known that it is astonishing to see any question concerning it raised in the United States Senate. If Senator Allison, who brought this matter up, were not a man of the highest standing, it would even seem to some observers, trained to the methods of profitable politics of some cities, that the proposed resolution was intended to temper the restrictions under which asphalt paving is now carried on in the District of Columbia. This, of course, cannot be true, although it is questionable that the Senator would introduce such a resolution did he thoroughly understand how the work of Mr. Dow as Inspector is regarded by municipal engineers throughout the country.

Data Relating to the Operation of Mechanical Plants in Buildings.

The performance of the mechanical plants in office buildings is a subject about which there are very few reliable data. It is true that these large structures are the product of comparatively recent years, but time enough has elapsed for the experience with them to supply valuable information concerning the cost of power, heating and lighting. The chief reason why this is not the case is to be found largely in the point of view of the building superintendent, whose duties usually include supervision over the plant's operation, and in the shortcomings of some operating engineers. The superintendent naturally hesitates about giving publicity to such figures as he has, which, as a matter of fact, are rarely more than those easily deduced from coal, water, oil, and supply bills, as they are liable to unjust comparison by the building owner or his agent with those of some plant operating at less expense for supplies but under a very different set of conditions. The operating engineer may also be solicitous about a too careful record, lest the exhibits be disastrous to the security of his position through some odious comparison.

It is not an unusual thing to find the departure of the designing engineer from direct connection with a plant signalized by the appearance of a data sheet, but this, through lack of appreciation of the importance of certain figures either in themselves or in their relation to others, soon come to have little value in the eyes of those in charge and gradually fall into disuse. Not very many months ago an attempt was made to collect in a systematic manner the leading figures of plant operation in a large number of office and loft buildings in New York, but the elaborately prepared log sheets met finally the same fate that befell their diversified predecessors, simply from the absence of a well-understood purpose in their preparation or from the fear of an exposition of inefficiency, whether justified or not. On the other hand, the conclusion should not be drawn that there are few regular methods of reporting daily records; as a matter of fact, many of the larger building are carefully watched in this respect.

The value of records of the performance of mechanical plants is at least twofold. The unit cost of operating a plant is of primary interest and such figures are, of course, already in the possession of many engineers and building superintendents. They do not as a rule, however, in the case of a particular set, cover a varied class of machinery, and it is in respect to this phase of the question that data from many sources have a second and hardly less important bearing. It will be agreed that the hours of operation, intermittent service, the load factor, the severity of the heating season and the like have much to do with unit costs, and so has the class of machinery making up the plant, a difference in the make-up of plants not being so wide among plants in the one region as it is between plants in cities widely separated. As affording the opportunity of discussing the advantage of this or that adjunct of the mechanical plant, or of this or that class of machine, the proper collection and study of plant operation data would promise much. It is not the province of this journal to take a specific instance and outline in the concrete a possible line of betterment; that is the field of the consulting engineer. It is, however, the legitimate position of this paper, as an observer, to record the regular or ordinary results of plant operation, together with an account of the conditions obtaining. Multiplication of information of this character indicates the paths along which best results are apparently obtainable. To be of most value the reports must come from widely different sources and they must, in the nature of the case, be held confidential. The Engineering Record feels no diffidence in offering to become a bureau for the filing of confidential mechanical plant reports for such discussion in the aggregate as seems fruitful. Some interesting figures have already been published under these restrictions, on the cost of operating a number of buildings in New York. The record in question appeared in the issue of December 19, 1903, and, it will be admitted, that the figures are of practical interest, notwithstanding the fact that the identity of the buildings was not disclosed. It is believed that the proposition to act as confidential recorder of mechanical plant data should stimulate the production of carefully prepared reports promising the greatest good to the greatest number without fear of a particular plant or its manager falling under any discrimination. Unless some such arrangement is made it is not likely that much data of this character will become widely disseminated and no one should expected much unless he give his share.

Preliminary Specifications for a Competent Electrical Engineer.

It has been known for some time in Chicago that a careful investigation was in progress to determine the actual results of technical education in fitting young men for electrical engineering, and to ascertain the opportunities open in that profession. This work has been done by Mr. George A. Damon, and the results were recently submitted to the Western Society of Engineers. As one of the very few painstaking analyses of the condition of engineering in an important city, the investigation is of unusual interest and value. Mr. Damon sent a letter of inquiry to one hundred of the leading men in Chicago in the various branches of electrical work. Responses were received from all these gentlemen. The inquiries were confined to men between the ages of twenty-seven and forty-five, on the theory that older men are the product of a set of conditions which have passed away, while men below the age of twenty-seven are to be ranked as students. The inquiries show that of the one hundred men questioned five were in receipt of incomes over $10,000 a year, nine received from $5,000 to $10,000, sixty-six from $2,400 to $5,000 and the remaining twenty below $2,400. The income curve starts with about $2,170 at twenty-seven and extends to $4,000 at thirty-eight. The average of the entire one hundred incomes is $3,440. As a class the consulting engineers receive the largest incomes, the average being $6,400. It must be noticed, however, that these engineers had an average age of forty years and were only nine in number. Young men cannot expect to attain eminence in consulting engineering, although it is true that in electrical work there are more young men who are successful in consulting practice than in any other branch of engineering. Patent law is also a profitable branch of work for electrical specialists, ranking, in fact, next to consulting practice. It seems to be a rule, however, that from the point of view of the financial returns those engineers who have business ability are most successful. Thirty-five of the men who sent replies either controlled the business in which they are engaged or have a partnership interest in it. These facts are well worth the attention of young men who believe that technical knowledge alone is the basis on which remuneration should be paid. It should be noticed that a consulting engineer and a patent attorney both depend for their salaries very largely on business ability, so that in one sense they should be ranked with men engaged in strictly commercial work. It is interesting to notice that the men in the employment of large companies are not so well paid as many of the others, although operating managers and superintendents, responsible for the work of many subordinates, receive high remuneration. In connection with the figures of salaries and incomes, it is instructive to notice that twenty men, averaging thirty-six years of age, who are without a college education, have an average income of $3,670 a year; while sixteen of the men who sent replies, who are also thirty-six years of age and are graduates of Cornell University, have an average income of $4,940.

It should be stated that while the financial aspect of this investigation is interesting, it is by no means the only one that Mr. Damon considers. He has taken pains to ascertain those branches of electrical enterprise that seem to offer the greatest chances for success in the future. The letters of inquiry show that electrical railway work is considered the most promising, telephony, power transmission and electrochemistry are regarded as about half as promising, and power application is considered to have just one-third as attractive a future as electric railway work. The other specialties are ranked far below those mentioned. Eighty of the gentlemen believe that a college education is essential to the highest success, seventy are in favor of a shop course in a large manufacturing company for the technical graduate, seventy of them are also in favor of requiring at least a year's practical work before graduation, a little more than half believe that there are greater opportunities for successful work with the small companies.

Practical experience is discussed very thoroughly, for Mr. Damon was apparently led to investigate the subject very largely to ascertain what practical training a young man should secure. The predicament the recent graduate often finds himself in is well stated as follows: "I can't get a job without experience and I can't get experience without a job." This is a situation which must be removed to a considerable extent by the co-operation of the older men who now have responsible positions through which they are able to assist young graduates. It is largely through such assistance that the best of the young men can be trained to carry on the work of the future, and, merely as a business measure, it goes without saying that it pays to give opportunities for such training. Shop courses do not commend themselves unqualifiedly to this investigator any more than they have to many others who have looked into their actual results. It is a flattering thing for a school to be informed that its entire senior class will be given positions in the apprentice department of some big manufacturing corporation. All young men do not realize that for two years they must work for long hours at very small pay and that not more than half of them will be engaged on work for which they really have any natural aptitude. The result of the apprentice course therefore is to enable the company which maintains it to select the best men in a large number for its service, without expense to itself. No young man should take these apprentice courses who does not feel a natural inclination to engage in manufacturing or who fails to appreciate that for two years he must consider himself merely a student working hard to acquire knowledge of a certain class which will prove useful to him in the future. In making these comments The Engineering Record has no desire to reflect in any way upon the excellent apprentice systems of many companies. They are doing a magnificent work for young men and for the development of American industry. It should be borne in mind, however, by the young men who are thinking of such courses that they afford training only in a narrow line, and that unless their inclinations run that way it may be well be advisable for them to secure practical experience in other ways.

Mr. Damon recommends the formation of a commission made up of the broadest men in the profession, some from the large companies and some from outside practice, to investigate this subject in a broad manner so that young men may have some guide in selecting the proper course for them to follow during the years immediately after their departure from school. In a good many respects this suggestion is one of the most important that has been made for some time with respect to technical education. The American Institute of Electrical Engineers, with its admirable systems of committees and committee work, would do a great deal of good to the hundreds of students in technical schools by appointing such a committee. The great objection made to-day to electrical engineering by many people is the preponderating influence of commercial considerations in its development. Anything which will tend to improve the opportunities open to young men for securing practical experience outside of the works of the great manufacturing companies will be welcomed by a large number of electrical engineers who acquired their training in the shops of these same corporations. The time has come when completely independent electrical experts are in demand, and the Institute will be doing good work if it can formulate a method by which this demand can be filled.

All this discussion is merely preparatory to the pith of Mr. Damon's paper. It was written primarily for the young man in technical schools who is desirous of knowing just what he should do to fit himself for the greatest measure of success in his chosen profession. The financial statements in the paper are of interest, the suggestions to the older men concerning methods of assisting the beginners are of value, but to the young man himself the cream of the paper lies in Mr. Damon's "Specifications for Success." It is a long time since The Engineering Record has read anything so interesting on this subject, and it is glad to give space in its editorial columns to the following extracts from this novel specification.

"In General—The purport and intent of this specification is to cover the labor and material required to produce in complete working order a man prepared to attain his own ideal of success in that branch of electrical work which he may elect. It is to be understood that the omission of the mention of small details in this description does not obviate the necessity of their being furnished. What is wanted is a thoroughly trained, well seasoned, broad minded man, complete with an individual character, a strong intellect, and a sincere purpose.

"Plans—He will form his ambition early in life. He will take a natural interest in the history of men of eminence in his chosen work and their achievements will inspire him with a desire to accomplish great things. He will develop his imagination and constantly broaden his conception of his own possibilities. He will seek to learn what the world wants and then will endeavor to train his natural abilities so as to supply that want.

"Foundations—He will as a boy develop a knack of 'doing things' either as a mechanic, as a draughtsman, or in some boyish business enterprise, and a combination of any two or all three proclivities is desirable. He must early learn the advantage of doing some one thing well, but he should not allow praise for his proficiency to encourage him to neglect study along the lines he does not naturally fancy. He will prepare for college and during this period of preparation he will get enough experience in practical work to demonstrate that he has made a wise choice for his lifework. He will not let the attractions of practical work interfere with his intentions to secure the best theoretical and technical training the country affords.

"Dimensions—He will endeavor early to 'earn money' by doing useful work, and will seek employment outside of his study hours. Everything he attempts he will complete to the best of his knowledge and ability. He will put himself on a self-supporting basis as soon as possible, and will earn his own way through college. If he receives financial assistance, he will treat it as borrowed money, to be returned, and he will keep the debt within reasonable limits. He will not allow any false sentiment 'to finish with his class' prevent him from stopping out one or even two years during his college course to add to his store of practical experience among electrical or allied lines. He will determine for himself whether he intends to realize on his possibilities quickly or whether he will lay a broader foundation for a slower but higher development.

"Capacity—Even if the young man possesses only ordinary talents, his capacity for hard, conscientious, intelligent well-directed work will attract attention and win advancement. When the occasion demands he will be able to stand a long run on overload or respond to excessive demands for short periods without permanent injury. He will be able to direct others and will not depend entirely upon his unaided efforts for results.

"Operation—He will work quietly, and will be turning in the right direction every minute in a simple, direct and accurate way. He will join that great army of workers who are actually doing things rather than that smaller class of men who occupy most of their time in telling what they are going to do.

"Shop Tests—If he enters the shop or testing department of a manufacturing company he will make a bargain which will result in his getting an all around experience in exchange for his services, and, while in the shop, will keep on the move in every sense of the word. He will seek to make himself thoroughly practical in all his ideas and methods of work.

"Finish—He will include in his preparations considerable literary work and will seek after a general culture. He will study at least one foreign language. He will regard his college work as only the beginning of his education and will be a student always. He will seek practice in the art of expressing himself, and will occasionally write a paper on some technical subject. He will become interested in some social, educational or reform movement, and will avoid becoming a recluse interested only in his own work."

The Extension and Improvement of a city under the supervision of a regularly appointed body or according to some predetermined plan, the office of which is to direct the expansion along lines conserving the dignity, beauty and utility of the buildings and streets, seems destined to receive wider attention than it does at present. Some of the appointments to the New York City Improvement Commission, announced in the personal notes this week, call the subject to mind. The New York board is constituted with an executive committee, and committees on highways and parks, on water front and on public buildings.

Engineering Reports prepared for professional papers or contributions to technical journals would have their value much enhanced if the statements of the cost of construction were given in terms of days' labor, quantities of materials and the like, rather than in dollars and cents. In comparing the cost of sewer construction in the vicinity of New York with that in the South, for example, it is of little use to give the figures on the basis of dollars per foot length. But if the number of men employed on the work is stated, the hours per day they work and the time required to complete the work, the data are useful at any time, and in connection with a statement of the leading materials employed furnish information of permanent value. The value of such figures has been occasionally pointed out in the meetings of the American Society of Civil Engineers and similar bodies, but for some reason the hint is soon forgotten. Of course it will never be possible to give minute analyses of cost figures in a technical paper, for it would be wearisome reading, but enough information may often be furnished to permit the reader interested in the subject to compare the expenses of the work described with that of undertakings of his own.

The Derwent Valley Water Works System, Derbyshire.

One of the largest water supply projects now in the intial stages of construction is that of the Derwent Valley Water Board for the benefit of the cities of Leicester, Derby, Sheffield and Nottingham. These works are to include five impounding reservoirs, each about two miles long, of a combined capacity of 10,000,000,000 imperial gallons, five large masonry dams, nearly 60 miles of conduits and several acres of filters; they are estimated to cost approximately $35,000,000, and to require twenty years to build, and will supply about 2,000,000 people, supplementing the existing works of the communities participating. The work is to be done by forces of laborers and mechanics under the immediate direction of the Board and its engineers, and not by contract. The history of the undertaking, descriptions of the watershed selected and of the sites for the dams, and an account of the preliminary operations are interesting.

General View of Howden Dam Site and Vicinity Showing Construction Plant and Buildings, Looking Southeast.

Some years ago the city of Leicester found it necessary to seek an additional water supply, and the upper part of the River Derwent was chosen. This source was better than any other within a hundred miles, its watershed being mostly moorland and very sparsely settled. The efforts of the city to secure control of this desirable gathering ground were opposed; Derby and Sheffield also promoted bills in Parliament to obtain rights to construct reservoirs in the Derwent Valley. Extensive surveys were made and parliamentary inquiries were had; Nottingham and its county and Derby County had their claims to the watershed admitted. The fight in Parliament is reputed to have cost a half million dollars. Ultimately the committee of the House of Commons formed a water board of thirteen members to be selected by and to represent Leicester, Derby, Nottingham and Sheffield and the counties of Nottingham and Derby. This body was called the Derwent Valley Water Board, and in 1899 obtained an act of Parliament granting it the necessary rights to purchase land and other properties and to construct works. The scheme drawn up by the House of Commons committee was formed by taking parts of the various works proposed by the contending claimants for the watershed and combining them into a comprehensive and satisfactory system of works.

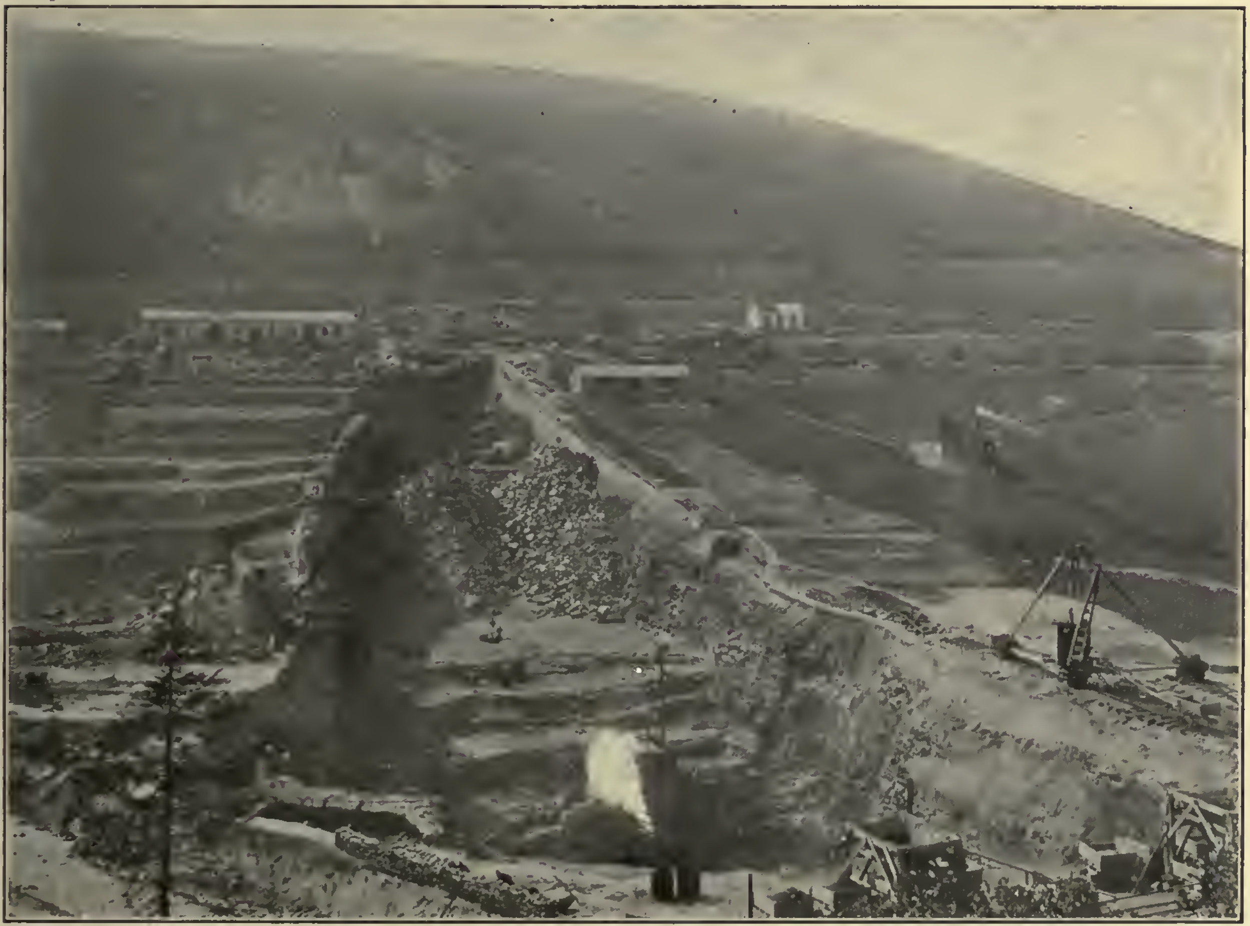
The watershed chosen has an area of about 50 square miles, and is a part of the so-called Peak District of Derbyshire and of the West Riding of Yorkshire. It is a region of hills and valleys, rough pastures and wild moorlands, at the south end of the Pennine Range, with elevations varying from 500 to 2,080 feet above sea level. Geologically this watershed is unusually interesting, being a part of a large anticline which forms the backbone of the North Midlands, and is a portion of the Carboniferous system. The higher ridges are capped with "millstone grits," whilst all the river valleys are cut through Yoredale rocks. Above the former, which comprise several varieties of gritstones, most of them hard rocks in thick compact beds, are the coal measures, cropping out in the coal fields of Yorkshire on the west, Derbyshire on the south and Staffordshire on the southwest. The Yoredale rocks comprise bands of varying thickness of shales and sandstones, the latter being finegrained, but, owing to their lack of siliceous matter, generally of poor weathering qualities. Beneath these strata lies the mountain limestone, which crops out at Castleton and southwards from this town.

Faults, wrinkles and folds traverse the district, and there are numerous instances of both old and recent landslips. The choosing of sites and the designing of the dams have been considerably influenced by these features, it being thought important to avoid overloading the shales and the somewhat broken beds of sandstone under the maxima pressures of the bases of the dams. The lines of the wrinkles and faults are crossed, but in such a way that they cut the lines of the dams approximately at right angles. The folded rocks are much crushed in some places and in other places the folding becomes very abrupt, small faults appearing; but it is considered probable that at certain depths watertight beds will be found. There are no ideal reservoir basins in the region, for the valleys nowhere widen out, the steep hillsides coming down comparatively close to the streams, and there are no narrow gorges throttling the valleys and affording economical locations for dams. Consequently the dams will all be large in proportion to the sizes of their reservoirs.

Of the quantity of water which will be made available by the proposed development of the upper Derwent and its tributary, the Ashop, one-third must, in accordance with statutory requirements, be turned into the Derwent for the benefit of the mill owners who use the stream for water power below the proposed reservoirs. The actual rainfall on the watershed is being determined for a series of years by the observations of a large number of rain gauges which are being maintained at various places in the region. From these records two experts are ultimately to determine what may be regarded as the mean annual rainfall. Meanwhile this is reckoned at 50 inches, and the yield is calculated to be at the rate of 50,000,000 imperial gallons per day. Hence the minimum quantity per day to be discharged into the river is at present taken to be 17,000,000 gallons. Two of the reservoirs, known as the Bamford and the Ashop, are to be built solely for the storing of water for this purpose. As the summer flow of the river falls below the quantity stated, it is evident that the works will benefit the mills. Of the 33,000,000 gallons thus calculated to be available for the daily consumption of the municipalities, Leicester, being in greatest need, is to take 35.72 per cent.; Sheffield, 25 per cent.; Derby, with Derby County, 25 per cent., and Nottingham, with its county, 14.28 per cent.

Howden reservoir is the highest up the valley, on the main stream of the Derwent, and will probably be completed first. Derwent reservoir follows immediately below, and, but for the difference in level, would form a continuous sheet of water with the Howden reservoir, since its water will back up to the Howden dam; it will be the second reservoir completed. The Haglee and Ashop reservoir sites are in the valley of the Ashop, the second immediately below the first. The Ashop River enters the Derwent from the west about three miles below Derwent dam site. Bamford reservoir site is on the main stream just below the confluence. The reservoirs are approximately 37 miles northwest from Nottingham, 44 miles in a similar direction from Leicester, 31 miles west of north from Derby and 9 miles due west from Sheffield, the distances being measured from the nearest reservoir, which is the Bamford. The dams are all to be of masonry founded in the rock. The lengths across the tops at full reservoir level, between the abutments on either hillside, and the maxima heights of the crests of the spillways above the ground surface at the bottoms of the valleys are respectively: Howden dam, 1,080 and 118 feet; Derwent dam, 1,070 and 115 feet; Haglee dam, 980 and 136 feet; Ashop dam, 840 and 103 feet; Bamford dam, 2,500 and 95 feet.

Mr. Edward Sandeman, M. Inst. C. E., has been chosen chief engineer of the Board. He recently completed a large reservoir in Dartmoor for Plymouth corporation. By way of digression an interesting bit of the history of the water works of this place may be permitted here. The Plymouth water supply is one of the oldest in England; Sir Francis Drake was the engineer for the works, and cut a channel about 17 miles long from Dartmoor to the city. The wording of the Act of Parliament which he obtained is curious, for it stipulates that the channel to be cut might be up to 6 feet in width—but the depth was not given. This omission has enabled the town to draw away the whole flow of the river. The act is dated 1585. The reservoir which Mr. Sandeman constructed at Burrator covered Sir Francis Drake's intake, and a pipe line has been substituted for the old open water course.



Howden Dam Excavation, Looking from East End, Showing Cableways, Derricks, and Loading Hoppers for Spoil.

The Peak District being popular for holiday excursions, the Board has had trouble in getting a quarry site, and some of the intended locations have been prohibited, so that it became necessary to go 12 miles south of the Howden reservoir for stone. The Board now owns a site of 50 acres, however, where millstone grit of good quality is being gotten out. Approximately 2,000,000 tons of stone will be required, and will be brought to the works over 5 miles of the Midland Railway Company's line and for the remaining 7 miles on a single-track railway of standard gauge built by the Board. This road has a rising gradient limited to 1 in 40, and runs along the west side of the valley crossing several side valleys on timber trestles. The trestle at Ashopton is 400 feet long and has a truss of 75 feet span over the river. The locomotives in use are of the saddle-tank type, weigh 40 tons and have six coupled driving wheels.

Excavation for the Howden dam was commenced early in the year 1902; that for the Derwent dam was begun soon after. At present these two reservoirs and 8 miles of the aqueduct leading southward are under construction. The two reservoirs in the Ashop valley will follow and the Bamford reservoir will be left to the last.

In each of the trenches for the two dams now under construction the disturbance of the strata is very marked, as is shown by the geological section of the trench at Howden and by some of the views reproduced herewith. This condition of the rock has caused the depths of the trenches to become considerable. In order to obtain a good foundation for the masonry at Howden it has been necessary to go to a depth of 67 feet below the bed of the river, and even at this depth the rock, although unyielding, is open jointed. Consequently a cut-off trench 6 feet wide is being carried down under the heel of the dam to a depth of 20 feet or more below the bottom of the foundation. When watertight strata are reached at any point this trench is stopped; it is to be filled with Portland cement concrete. The cut-off trench is about 15 feet from the upstream edge of the bottom of the dam. The foundation excavation has a maximum width at top of about 200 feet and 160 feet at the bottom, which is the maximum thickness of the dam. The greatest depth of the pit is 84 feet, diminishing as the distances from the crushed parts of the rock are increased.

Through the open joints of the rock foundation water enters the excavation somewhat freely, the quantity pumped per day varying from 750,000 to 1,250,000 gallons. The pumps installed have sufficient capacity to raise 2,000,000 gallons per day; they include one pulsometer, two Tangye's "Special" sinking direct-acting steam pumps and two Evans' Cornish sinking direct-acting steam pumps with condensers. Two locomotive type horizontal and two Cochran boilers supply the steam required. One of the accompanying illustrations shows a part of the pump installation and the sump in the northeast corner of the excavation, also the tilted strata. The thick flat bed on which the man is standing resisted the force which caused the wrinkling. Another view shows the easterly end of the cut-off trench, and indicates in a way the quantity of water encountered. The Ingersoll bar channeler with which the trench is being excavated may also be seen.

At the Howden dam and also at the Derwent two cableways furnished by Messrs. John M. Henderson & Company, of Aberdeen, Scotland, have been installed to handle the excavated materials and then later to transport the materials for the masonry. Each cableway has one fixed tower and one tower traveling on seven curved rails so arranged that at each dam the two cableways together command practically the whole excavation. The span of the cableways at the Howden dam is 1,360 feet, and their capacity is 5 tons. The skips have a capacity of 2½ cubic yards each. The engine houses are so placed, at some distance from the towers, that each engineer can see his cableway, the location being influenced somewhat, also, by the ease of coaling. Besides the cableways there are at each dam a number of locomotive cranes, and several Scotch derricks running on double tracks are also employed. For the rock excavation Ingersoll-Sergeant drills are in use, being operated by steam at present; but a compressed air plant is being installed, and when it is ready for service the drills will be run with air. At Howden a large quantity of the harder sandstone passed through has been selected and stacked in convenient places to be crushed for concrete. The cableway skips dump their loads of spoil into wooden loading hoppers, of which there are two, each mounted in a low wooden tower spanning one of the narrow-gauge railway tracks passing the end of the excavation and extending to the dumps.

The total length of the Howden foundation trench will be about 1,450 feet, but only a part of it is being excavated at first. The trench is not timbered, as is shown by the views. The river has been diverted into a temporary channel for about 200 yards. After the part of the trench first excavated shall have been filled up the river will be turned through a culvert and the excavation completed. The general arrangement of the construction plant, the location of the excavation and the river channels are shown on the accompanying sketch plan and by some of the views, which also indicate the character of the topography of the district. Two miles of railway track have been laid for construction purposes at this dam.

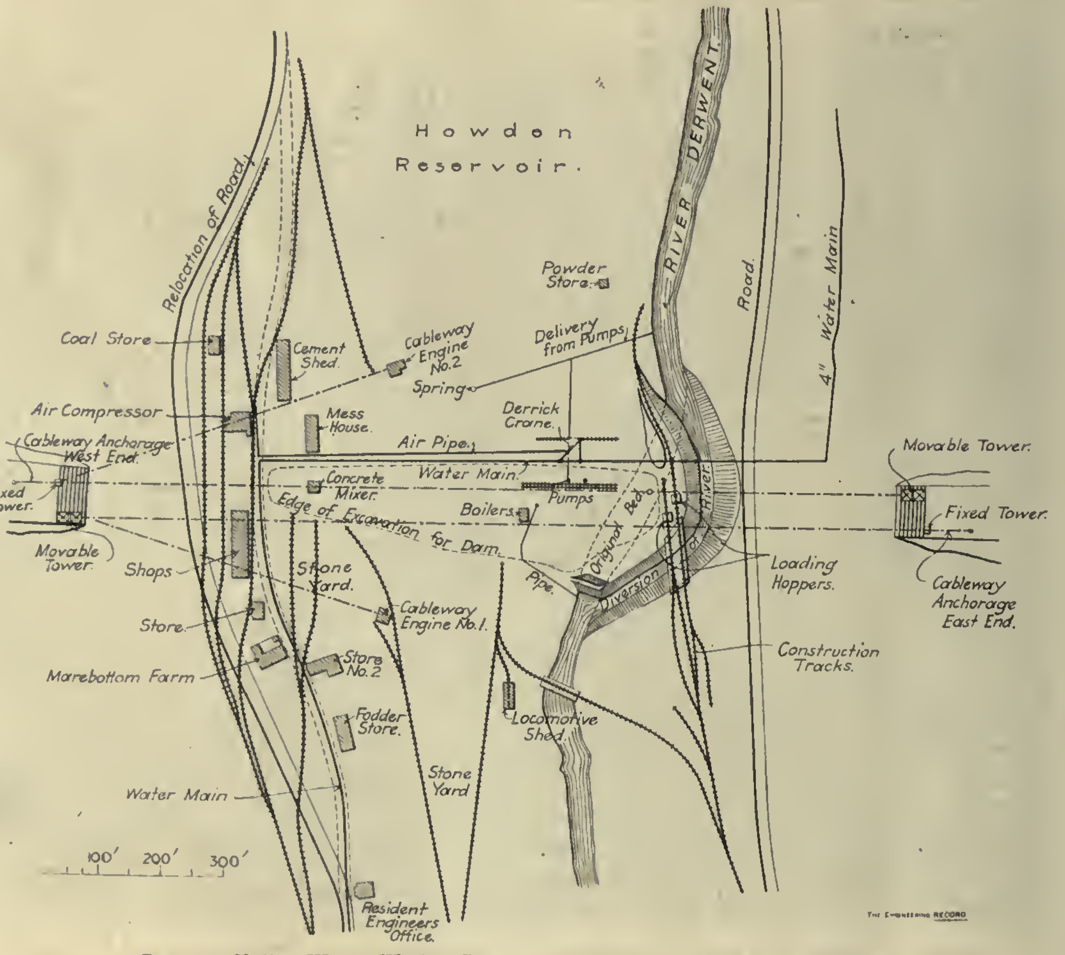
The heart of the Howden dam will be built of Portland cement concrete with large stones embedded in it, and it will be faced with squared blocks of stone from the quarry previously mentioned. Some concrete mixed by hand has already been placed in the cut-off trench, and work on the main part of the masonry of the dam is expected to begin vigorously very soon. A stone-crushing plant has been set up, and this, with the compressor and a machine shop, are run by a 150-horse-power compound condensing engine. Last fall a concrete plant was erected; it will be put into operation this spring. This includes an "Accurate Measurer and Feeder" furnished by Mr. Frank B. Gilbreth, of Boston, Mass., which was installed under the direction of Mr. William H. Larkin, Jr., chief mechanical engineer for Mr. Gilbreth. Portable gravity concrete mixers are used. A water supply under pressure for stone washing and steam making at the Howden dam is piped from a small stream a mile away.

In design the Howden and Derwent dams are alike, each having a long spillway for flood waters in the central part of its crest, flanked by a tower on either side. The towers will contain the machinery for emptying the reservoir and regulating the flow into the aqueduct, and will be connected by a small tunnel formed in the heart of the dam. The tops of the dams will be 9 feet wide. The dams are to be of the so-called gravity type of section and will be straight in plan. The details have not been fully determined, as they are dependent to some extent upon the conditions developed by the excavation. The spillway of the Howden dam will be 500 feet long, and the water passing over it will fall into the Derwent reservoir.

From the Howden dam the aqueduct for conveying the water to the municipalities will extend in a generally southeasterly direction, comprising 3.75 miles of tunnel, 13.75 miles of "cut-and-cover" and 37.75 miles of pipe lines. The tunnel and the "cut-and-cover" will be of brickwork with an internal diameter of 6 feet 3 inches. About 5 miles below the Howden dam the Sheffield supply will be taken off through a tunnel 4.5 miles long, from Ashopton. At Bamford, after the Sheffield supply has been withdrawn, the remainder of the water will be filtered, an acrea of 14 acres having been provided at this place for filter beds. Thirty miles below the Howden dam, on the line of the aqueduct, a service reservoir of 80,000,000 imperial gallons' capacity is to be built. This will be known as the Ambergate reservoir, and from it one line of conduit will branch to Nottingham and another to Derby and Leicester. The Ambergate reservoir will be covered.

Since the works are located in an almost uninhabited valley, it has been necessary for the Board to build a village to house the laborers and mechanics employed. Streets of huts or shanties made of corrugated sheet iron lined with wood and felt have been put up. The larger shanties will accommodate a man with his family, and each has a dormitory for eight men lodgers. The colony is beautifully situated and provides quarters for about 900 persons, mostly men, of course. The streets are macadamized, and a schoolhouse, a police station and a large recreation hall with a stage, billiard tables, etc., have been erected. A fire brigade has been organized, and a water supply, a sewerage system and sewage filter beds provided. A general hospital with twelve beds has been established and an isolation hospital with six beds, and a mile from the village there is the "doss-house," so-called, with thirty beds, where newcomers have hot baths administered while their belongings are disinfected. A stay of one week in the "doss-house" is required before a recruit is admitted to the village. There are a large number of allotment gardens which are rented to the men of the colony on easy terms. Opposite the village, halfway between Howden and Derwent, picturesquely situated and overlooking the valley, is Shire Owlers, the residence of the engineers on these dams.

As previously stated, Mr. Edward Sandeman is the chief engineer of the works. He is a comparatively young man, and has gathered about him a corps composed largely of young engineers. His headquarters are at Bamford. Mr. W. F. H. Creber is the resident engineer at the Howden dam, and Mr. Michael George Weekes, Assoc. M. Inst. C. E., is resident engineer at the Derwent dam. The notes, photographs and maps used in the preparation of this article were furnished to this journal through the courtesy of Mr. Creber and Mr. Larkin.



Derwent Valley Water Works: Plan of Construction Plant at Howden Dam.

Requisite Amount of Water for a Public Supply.

Extracts from a paper by Mr. J. Herbert Shedd, in the "Journal" of the New England Water Works Association.

Mr. Shedd's paper dealt principally with the water supply of Providence, R. I., as he was the designing and constructing engineer for the water works of that city many years ago, and later, as city engineer for seven years, had direct connection with the system. He stated, referring to the necessity for a tight distribution system, that his experience led to the belief that as a rule the bells of water pipes are made too deep. In the city of Providence, where there are now 340 miles of distribution pipes in service, and forming an extremely tight system, the bells are 2 inches deep for the 6-inch pipes and regularly increase in depth to 4 inches for the 36-inch pipes. These straight pipes can be laid on sharper curves without affecting the tightness of the joint than would be possible with the deeper bells. These shallow bells have been in use on the system for about thirty-three years. The ordinary soft lead suitable for calking, is used in the joints. It is laid a little more than ¾ inch in depth, and the gasket makes up an inch or 1¼ inches of the depth of the bell, and that is driven home until it will receive pretty good blows of a hammer without a depression in the gasket. The author has found by a number of observations that it is almost impossible, in the ordinary lead used for making joints in water pipes, to have any apparent effect on the lead by any calking hammer more than ¾ inch below the surface, as the lead seems to remain just as it is run, and is not compacted in any degree below that depth, so far as he could discover, by the calking.

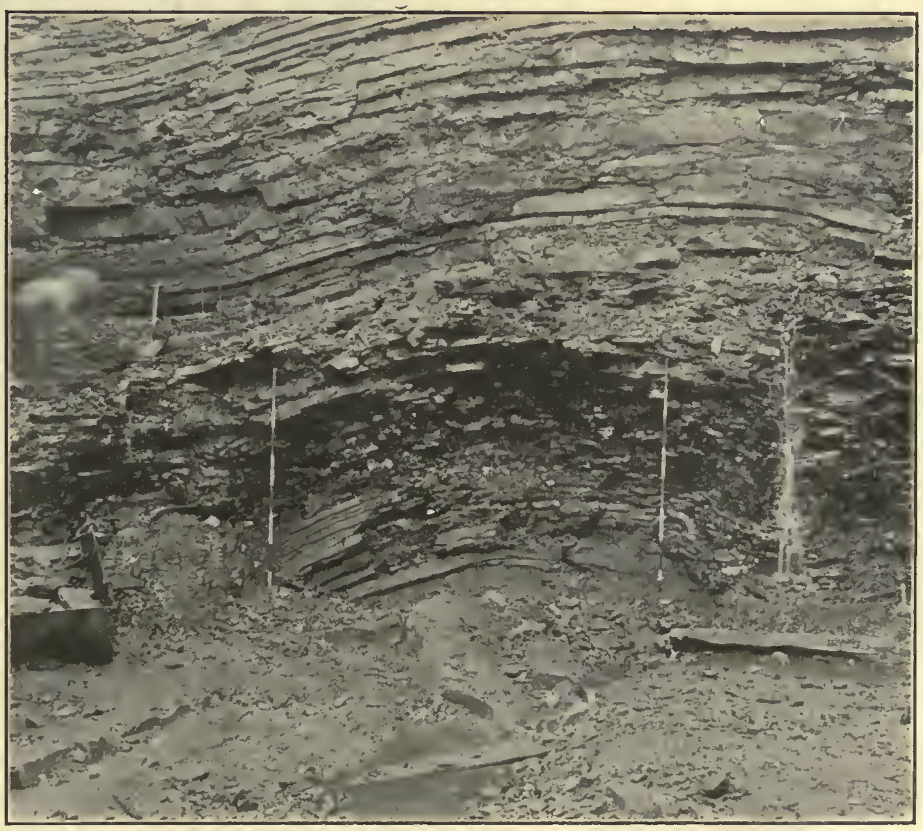
The tightness of the service pipes in Providence is secured by requiring the best materials and the best workmanship. Before the mixture forming the bronze for making the taps and stops was determined upon, a large number of experiments was made upon various bronzes, and a mixture securing toughness, strength, tightness, and ease of working in the shops, so far as these could be combined, was selected. The mixture used is in the proportion of 80 pounds of copper, 6 pounds of tin, 3 pounds of zinc and 2 pounds of lead. The use of lead is for the purpose of securing smooth and easy work in the machine shop. The work upon the tap, service pipe and stop, forming a service, was done by the regular employes in the shop at the pipe yard of the department, and the tap was set in the street main, and the service laid, by the department men.

The system of water rates should be based on the opportunity of each taker to waste water—that is, upon the number and character of the fixtures. The size of the service pipe should be based on the requirement for delivering useful water. A diagram (reproduced in the "Journal") giving the loss of head resulting from delivering certain quantities of water through the taps, service pipes and stops of different sizes and for various lengths of pipe is a valuable aid in fixing the sizes of service pipes to be laid for takers. Such a diagram was made at the beginning of the delivery of water in Providence, and its value has been demonstrated continuously. Cases sometimes occur in which it is appropriate to insert a diaphragm in the tap having a hole of suitable size through it to deliver, without undue loss of head, all the water which can be made useful, but which would serve to throttle an excessive draft.

As a basis for determining the amount to be paid for water by takers, when it was not to be measured by meter, the opportunity to waste water was considered to be of the greatest importance. More water being wasted than used, the means of *wasting* water should govern the rental. This led to a schedule based upon the fixtures connected with the water pipes. Naturally the well-to-do, under this schedule, would pay more than the poor in proportion to the amount of water actually used, but a very important point was gained in the inducement offered to those who had many fixtures, to put in and maintain at their own expense meters for measuring the water taken by them. The water takers thus became the advocate of meters, and nearly all the meters on the works, numbering now nearly twenty thousand, or nearly 85 per cent. of all the services, have been applied at the request of the water takers. The minimum charge of ten dollars per year was fixed for all who took *measured* water. Fifteen years after the delivery of water began, about one-half of all the families supplied by meter were paying the minimum rate, which entitled them to 91.32 gallons of water per family per day, or, upon the basis of five persons per family, to 18.26 gallons per capita. The poorer people were generally supplied by one faucet at six dollars per year.

Tilted Strata in Northeast Corner of Excavation; Cut-off Trench, Showing Pumps.

In 1888, seventeen years after the introduction of water, an analysis made of the accounts of 2,553 families of a good class, taking water through meters and paying the minimum rate, showed that 167 families drew less than 1,500 cubic feet per year, and that the following numbers of families drew respectively more than the preceding and less than the following numbers of cubic feet per annum: 237 families, 2,000 cubic feet; 361 families, 2,500 cubic feet; 445 families, 3,000 cubic feet; 446 families, 3,500 cubic feet; 462 families, 4,000 cubic feet; 435 families, 4,457 cubic feet. On the basis of five persons per family the quantities given as the upper limit for each group correspond respectively to the following numbers of gallons per day: 6.15, 8.20, 10.25, 12.30, 14.35, 16.40 and 18.27. It is probable that the reason why some families use more than others is largely because of outside uses, like watering lawns, use in stables, greenhouses, etc., and because there are more members in the families.



Strata in Side of Excavation, East End of Howden Dam, Derwent Valley.

In 1892 the department noticed what was considered to be an unnecessary per capita use of water, and special inspectors were engaged to examine the supply through services, and the returns of the ordinary inspection were reviewed in the office to discover a reason for such use. About two years were occupied in the examination and in applying remedies. It was found that upon many of the unmetered services there was large waste, and the takers on such services were notified that under the provision in the published rates allowing special assessments to be made for peculiar circumstances they would be subjected to such special assessment, unless they chose to put on meters. A considerable number of such takers had meters set, and the rate of increase in the number of meters showed the influence of this move. The examination and the effort to check waste reached its culmination in 1894. In that year the average daily consumption of water was 9,904,000 gallons and the per capita supply was 65.24 gallons, which was larger than it had been before or has been since, and undoubtedly more than was reasonable. The effect of the special effort to check waste was shown in the following year in two ways that were striking, when observed upon a profile illustrating the conditions. First: The total average daily consumption of water dropped to 8,905,000 gallons and the per capita supply to 56.93, which was still fully up to the requirements for use. Second: The rate of increase in the revenue shot up in a marked way. The full effect of the effort to check waste was not, however, shown until 1897, when the total average daily consumption had dropped to 8,635,000 gallons and the per capita supply to 51.34.

From that time to within about two years, the increase in the total supply has been reasonably consistent with the increase of the population supplied. Lately a new tendency is shown to dispose of a greater per capita supply of water. This seems to be accounted for by the effect of electrolysis, which has a destructive action in several places in the city. On one street several street mains have been taken out in two successive years, being badly decomposed, and one of which had been completely eaten through. The iron bolts of meters have been eaten off and replaced by composition bolts. Lead service pipes have also been badly eaten. The conditions favoring the destructive action of electrolysis are being changed steadily for the better.

The working force in the meter department in Providence consists of three men, who do all the setting and repairing of meters on the system. The total expense of the department is more than returned to the city by the charges against the takers, they being at a fixed rate per meter for the usual operations. The average annual cost per meter for repairs is about 11½ cents. The meters are owned by the water taker, but they are not allowed to be placed except by the city. The city approves of the meters, and sets them, and makes a charge for setting them to those who apply for them. The meter must be one which is approved by the city. There are three or four kinds of meters which are set by the city, and a person is allowed to make his choice from those kinds, but the meters are owned and maintained by the takers, so far as paying the money is concerned. They are managed by the city, put in by the city, repaired by the city, and the cost charged to takers for expenses. Meters are replaced at the expense of the taker, but some have been in use over thirty years, and apparently they are just as good as ever. Very few have failed. A meter is tested as often as there appears to be any need for it.

The consumption of water in Providence is measured by the pumps, and, of course, includes all the waste and the loss by leakage in the distribution system.

In the discussion of Mr. Shedd's paper a number of interesting statements were made by members of the Water Works Association present at the meeting at which the paper was read. Mr. Charles N. Walker, superintendent of the water works of Manchester, N. H., expressed a decided preference for pipe bells from 3½ to 4 inches deep, to run around curves, and Mr. Edwin C. Brooks, of Cambridge, Mass., told of some old Scotch pipes laid in his city in 1857 which had bells 7 inches deep. Several other members also expressed preference for the longer bells. Mr. R. J. Thomas, superintendent of water works, Lowell, Mass., stated that there are about ten corporations in that city that use the city supply as a secondary supply in case of fire. When there are defective check valves they allow mill water to pass into our mains, and we found it necessary for the health of the city to shut the valves on the branches that lead into the corporation premises, fifteen in all. Since shutting these valves the consumption has fallen off from a quarter to half a million gallons a day. Mr. Brooks, speaking of free use of water in public buildings, said: We have a grammar school in our city, not a very large school, which has used a million and a half gallons of water the past year, making a per capita use of water by the school children that is enormous. Nothing that I have ever found has exceeded in crudeness the management of the ordinary sanitary fixtures in schoolhouses. They are given almost no supervision, and the water is allowed to run continuously. Mr. R. C. P. Coggeshall, of New Bedford, said that in some of the schoolhouses ventilating fans had been run by electric motors, but as water was furnished free for city purposes, water motors were installed instead, which use at the rate of about 150,000 gallons a month. It costs the school nothing, and therefore the authorities reason that it costs the city nothing; and the city allows it to go on.

Mr. F. N. Connet, of the Builders' Iron Foundry, Providence, told of a private water company in northeastern New Jersey which had meters on 98 per cent. of its services, but the meters accounted for 28 per cent. less than the plunger displacement of the pumps. He also mentioned the case of a corporation taking water from a city; the consumption was estimated at 50,000 gallons per day, but when an 8-inch Venturi meter was put on the connection the consumption was found to be 280,000 gallons per day.

During a discussion of the slip of pumps, Mr. Shedd stated that a pump well kept up, well cared for, and originally well constructed, should go through a long period with no more than about 2 per cent. of slip, but that he knew of pumps which have up to 4½ per cent. of slip; in Providence the slip had been kept within about 2 per cent., the amount of water discharged as measured over a weir being compared with the plunger displacement. Mr. Dexter Brackett, of the Metropolitan Water Works, Boston, expressed the opinion that conditions giving 2 per cent. slip were the exception rather than the rule. He stated that he had personally measured pumps in which there was 50 per cent. slip; that he had known of others in which the slip was 40 per cent., and that the slip of pumps used on the Metropolitan Water Works had been found to be from 3 to 18 per cent. He said further: With an outside packed plunger pump there is very little slip or leakage past the plunger, but the rubber valves wear with years of use, and as the valves wear there will be an increase in the amount of slip. You seldom get less than 1 per cent. slip with a new pump. Mr. Foster, connected with the Worthington Company for sixteen or seventeen years, said that he thought the slip of a pump ought not to be more than 2 to 5 per cent. He told of the test of a pump which had been in use eighteen years; the valves had been kept in good order and the plungers showed little wear; the slip was found to be 5 per cent.

A Sewage Testing Apparatus has been designed by Mr. W. D. Scott-Moncrieff which is in principle a miniature set of nitrifying trays of the type designed by him and used with much success in various places. The apparatus consists of a box about 7 feet high and 1x3 feet in plan. At the top is a tipping trough which discharges a quantity of sewage over a perforated tray at regular periods capable of a wide variation. The sewage percolates through a series of filters arranged one above the other and finally reaches the free space at the bottom from which it escapes to the drain, the arrangement being in all respects like that used in Mr. Scott-Moncrieff's regular practice. The amount of air passing through the filters is measured by an ingenious syphon device. Cocks are provided at each filter tray so that samples of the effluent from each stage of the apparatus can be taken. It is customary in starting the apparatus to begin with any rate of supply of air and sewage. After running for 24 hours samples are taken from the different cocks, and the highest one at which the desired purification is found shows the depth of filtering material for that particular combination of air and sewage supply. It is found as a rule that the best results are secured when the sewage is discharged every 7½ to 10 minutes and is fully hydrolized by anaerobic bacteria.

Coagulation and Clear-Water Tanks, Cornell University Filters.

Recent Concrete-Steel Water-Works Construction at Ithaca, N. Y.

Filter Plant.—Cornell University is located on a plateau about 500 feet above the surface of Cayuga Lake, on the east side of the city of Ithaca. The campus, containing many large University buildings, laboratories, shops, numerous fraternity houses and residences, has an independent water supply pumped from Fall Creek and distributed by gravity from a reservoir on an adjacent hill. The character of the supply has always been considered satisfactory, but it was recently determined to redouble assurance by providing mechanical filtration for it, and so a special plant was designed by Professor Gardner S. Williams, M. Am. Soc. C. E., in charge of the Cornell hydraulic laboratory. This plant has been constructed under his direction and will be put into service within the next week. The filters receive raw water from the pump mains and discharge the pure effluent by gravity to the reservoir. They have a capacity of 500,000 gallons per diem, and are situated on the top of a hill about 1,000 feet east of the reservoir and 12 feet above it. The plant contains interesting features in design, operation and construction methods. All the tanks are built of reinforced concrete, of unusual form, and have several peculiar details which will be described in this article without discussing the arrangement and connections of the pipe system or analyzing the operation and efficiency of the filtration.

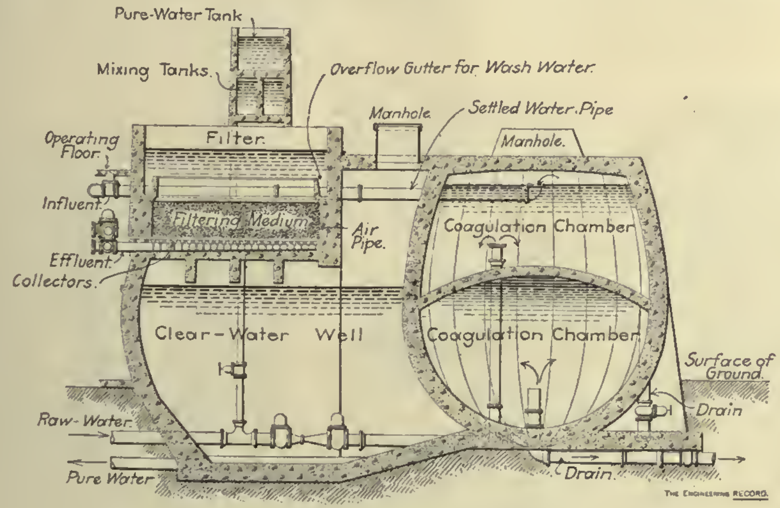
The tanks are two stories in height and occupy a space which has an L-shaped plan and is about 68 feet long, 48 feet wide and 32 feet high in extreme dimensions. They are built entirely of concrete, which is largely monolithic and has comparatively thin cross-sections reinforced with flat and twisted steel bars. They are enclosed by a brick building and are provided with a somewhat elaborate system of pipes and valves, most of which are omitted in the accompanying illustrations so as to avoid complication and emphasize the construction of the concrete work. The structure is divided into three principal sets of tanks—the coagulation tanks, the filter tanks and the pure-water tank. The general arrangement is shown in the plan and is substantially that of two intersecting main tanks with horizontal axes at right angles to each other and with convex bottoms and sides. The coagulation tank is divided into two parts by an arched floor or deck extending from end to end, and a center wall with large apertures in which vertical stop planks can be set to form transverse partitions provides for the further subdivision of each part if desired. The top of the tank is covered by a horizontal floor which is continued over the pure-water tank. The latter is divided by a longitudinal partition wall through two-thirds of its length and is one story, or about 14 feet, high in the clear to the bottom of the twin rectangular 9x13-foot filter tanks, which are 8 feet deep and situated directly above it.

Water is delivered under a pressure of about eight pounds at the floorline through an 8-inch horizontal pipe which passes through the concrete and terminates in a riser with its top about 4 feet above the bottom of the coagulation basin at the east end. The coagulant is mixed in a 3½x14-foot sub-divided tank 3 feet deep, seated across the tops of the filter tanks, from which it is delivered to the inlet pipe, as shown in the cross-section. The water from the lower compartment of the coagulation tank rises at the end opposite the inlet through an orifice in the mid-deck or floor to the upper compartment and filling that portion of the tank overflows into the 8-inch settled-water pipe at the top, 18 feet above the inlet, and is conducted therein to the filter tanks. All of the tanks and their footings were made according to special designs and no part of the work was installed or furnished by any filter company.

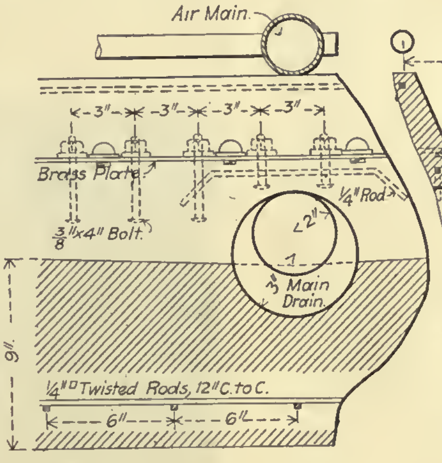
The design is peculiar in that the principal division of the coagulation tank is horizontal rather than vertical, thus enabling the pure water at the top of the lower section to pass upward into the second story, leaving the more turbid portion below, and also provides, if desirable, for a secondary coagulation at the orifice, which with the water at Ithaca seems especially desirable at times. By means of the movable partions in the crosswall, and additional inlets, it is possible to use either the whole, three-quarters, one-half or one-quarter of the basin for coagulation.

The principal structural novelty lies in the form adopted for the shells of the coagulation tank and the pure-water tank, which have cross-sections in the form of a hydrostatic arch designed for the flow line 6 inches below the top of the manholes. In order to utilize all available head, the tanks were built at the greatest possible elevation, and their foundations were carried only to the frost line at a maximum depth of about 5 feet below the original surface of the ground. Here the comparatively narrow bases were built with horizontal footings, and the convex bottom and walls were continued from them above ground with an overhanging construction which produced a curious effect; they were braced by transverse buttresses like chocks or pillow blocks which reduced the strains and gave abundant stability. The walls of the main tanks have a uniform thickness of 15 inches and are reinforced by ¾-inch square twisted steel rods 12 inches apart in transverse vertical planes and by 1x⅛-inch flat untwisted horizontal bars 16 inches apart vertically, woven basket-fashion between the twisted bars. The reinforcement is about 3 inches inside the outer face, and the vertical rods are calculated to provide for all tensile stress, no bending moment being developed.

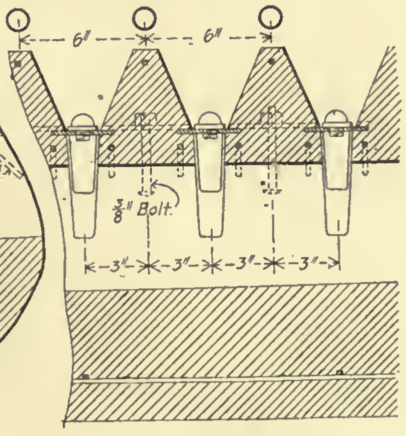
Concrete was laid wet enough to flow and was mixed in the proportion of 1:2:4 with Vulcanite Portland cement, native sand containing 30 per cent. of voids and screened gravel from ¼ inch to 1½ inches in diameter. The footings were not reinforced, and were built



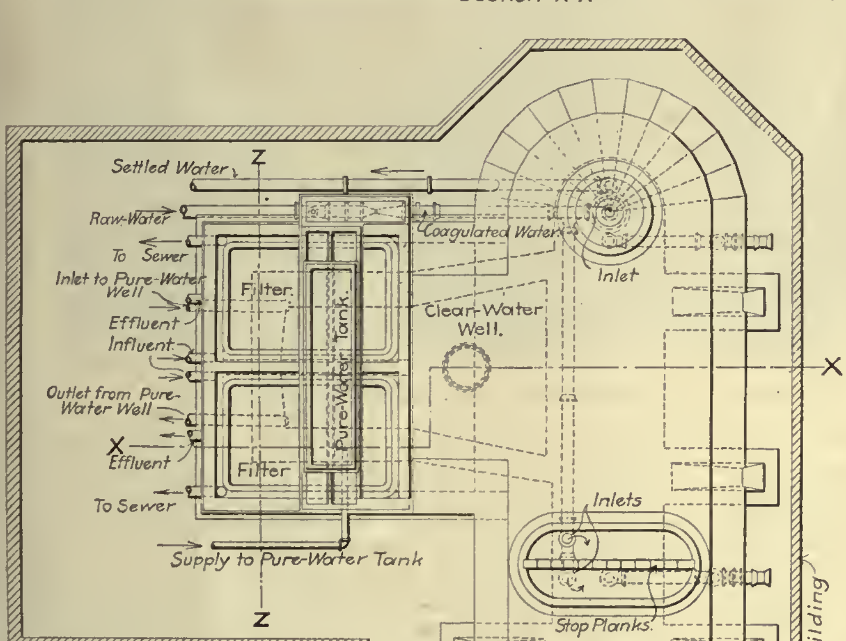
Section X-X



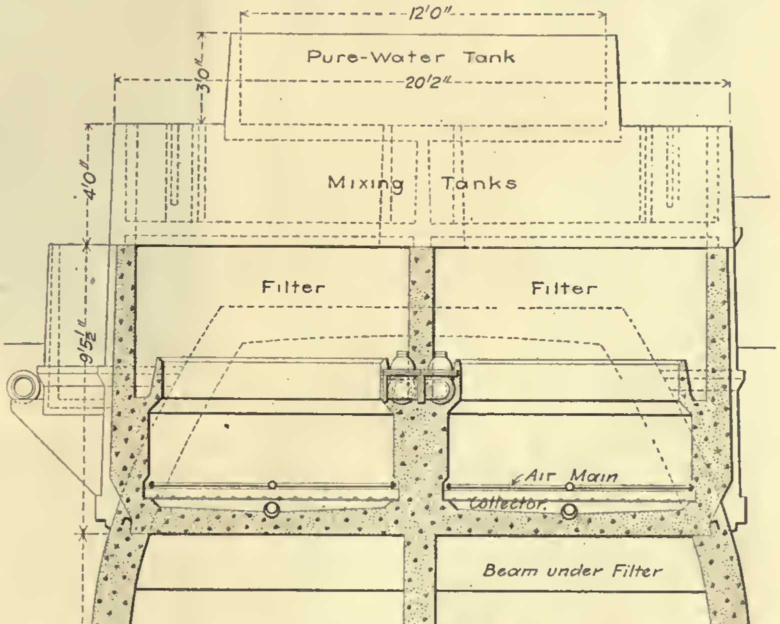
Cross-Section of Filter Floor.



Longitudinal Section of Filter Floor at Center.



Plan at Floor Level



Transverse Section Z-Z.
Most of the Pipes omitted

CONCRETE-STEEL TANKS FOR CORNELL UNIVERSITY FILTER PLANT, AT ITHACA, NEW YORK.

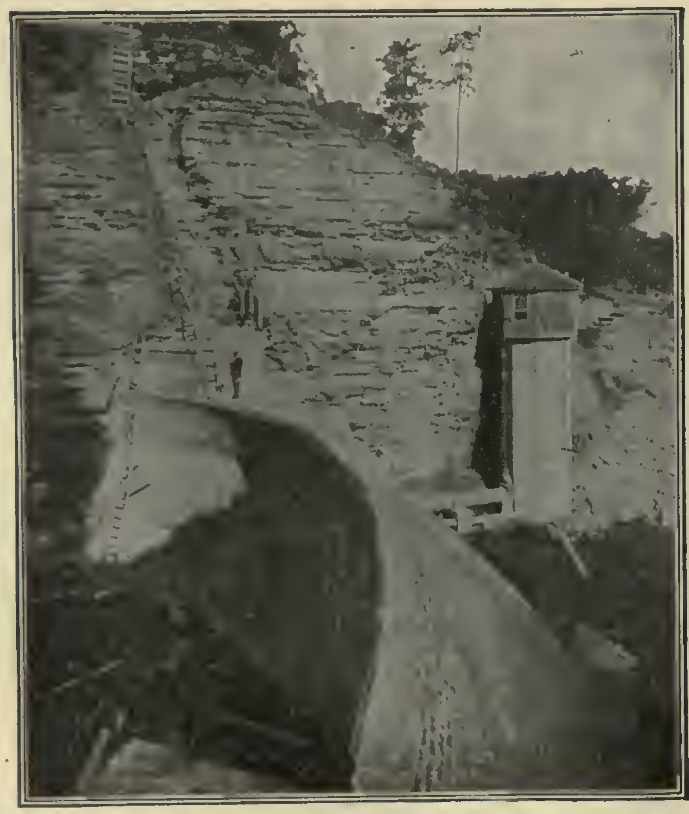
with concrete proportioned 1:3:6. The coagulation tank is 19 feet wide, 68 feet long and 23 feet deep, with a reinforced arched floor 9 inches thick having a rise of 30 inches. The ends of the tank are practically semicircular, being made with eleven sides corresponding to the chords of a semicircular arc. The pure-water well is similar to the coagulation tank, and is about 22 feet wide, 22 feet long and 23 feet high over all, but rectangular in plan with a vertical longitundinal partition through the center as far as the back of the filters, the dividing wall of which is thus supported.

Underneath the filters the tank has an inside height of 14 feet and is spanned with three 8x20-inch transverse concrete beams carrying the bottoms of the filter tanks. These beams are each reinforced with three ¾-inch square horizontal twisted steel rods in the lower side. The floor above them is a solid slab about 12 inches thick reinforced with ¼-inch twisted steel rods 12 inches apart longitudinally and 6 inches transversely. The remainder of the pure-water tank is covered by a roof slab 12 inches thick which reaches from the walls of the tank to the walls of the filter tanks. The end walls of the filter tanks are continuous from one to the other, and at one end are in the plane of the top of the pure-water tank and at the other end cross it transversely and serve as a girder of about 8 feet clear span to carry that portion of the filters. The walls are made 18 inches thick at the base, and at a point about 3 feet above the bottom of the tank are widened out so as to form the gutter around all four sides. The tank is filled with filtering material up to this gutter and when the filter is washed the flow of the water is reversed so as to pass upwards and overflow into it, whence it passes off into a pipe discharging to the sewer. Normally the settled water is received in the upper part of the filter, fills it and percolates downwards through the filtering medium to the bottom where it escapes through special outlets to the underdrains.

The underdrains are grooves in the concrete bottom connecting with the central drain, which is also moulded in the concrete, it being circular in section and tapering from 4 inches diameter at the head to 6 inches at the outlet end. The grooves are covered with brass strips bedded in the floor slab where they were laid with the soft concrete. The edges are secured by transverse iron washer plates 3 inches apart, which are held down by ⅝-inch center bolts moulded into the concrete. On top of the floor there are transverse concrete ribs 4 inches high and triangular in section between each pair of drains. These are made monolithic with the floor and form a corrugated surface with single ¼-inch twisted bars in the top of each corrugation and pairs of ¼-inch bars through the center of the floor slab below each corrugation. The brass plates are perforated throughout their length with small holes to form the strainer. On top of the corrugations is a system of longitudinal perforated brass pipes for air agitation in washing the sand.

The side walls of the filter tanks have vertical inner faces and are battered 1 in 32 on the outer surface. They are reinforced by ¾-inch vertical rods 12 inches apart and 3 inches from the outer faces, also by ¾-inch horizontal rods in the same planes 12 inches apart vertically. The vertical rods are hooked at the bottom around 3x3-inch steel angles built into the outer walls of the pure-water tanks. The coagulant mixing tank on top of the filter tanks is made with an upper and a lower portion, the latter divided into four main chambers and the former consisting of a single chamber to hold pure water for dissolving the coagulant. The walls are vertical on the inner face and battered on the outer face, and are reinforced by ¼-inch square vertical rods 12 inches apart and ¾-inch square horizontal rods 16 inches apart. At the end of the filter tanks there are four reinforced concrete brackets 4½ feet wide to carry the gallery floor and the 8-inch pipe to the filters. These brackets are 6 inches thick and 5 feet deep with three ¼-inch reinforcement rods parallel with the inclined lower edge and two ¾-inch horizontal rods in the upper edge, which are anchored to the main vertical wall.

In constructing the coagulation tank the footings and inverts were first built up to a total height of about 3 feet and the scarfboards or ribs for both walls of the moulds were erected and braced by horizontal and inclined struts, giving the framework very much the appearance of the skeleton of an old-fashioned wooden ship. The inside sheathing was then nailed on and all of the steel reinforcement bars were set in position and wired at intersections. The inner and outer ribs of the moulds were at first wired together, but as it was difficult to make this fastening secure it was later replaced by horizontal strips of band iron 1-32 inch thick, which were nailed to them. The twisted verticals were wired to these strips. The outside sheathing was built up in courses 4 feet high, and the concrete was continuously rammed in around the entire circumference of the tank, work being maintained day and night for about 36 hours until the walls were completed and monolithic construction was secured. Where the walls joined the invert a keyed connection was made, and great care was taken to secure perfect adhesion of the cement there so as to make the junction watertight. The pure-water tank was built in a similar manner, and the filter tanks were made in ordinary forms and were absolutely monolithic.



Ithaca Water Works: Finished Dam Looking Across Gorge.

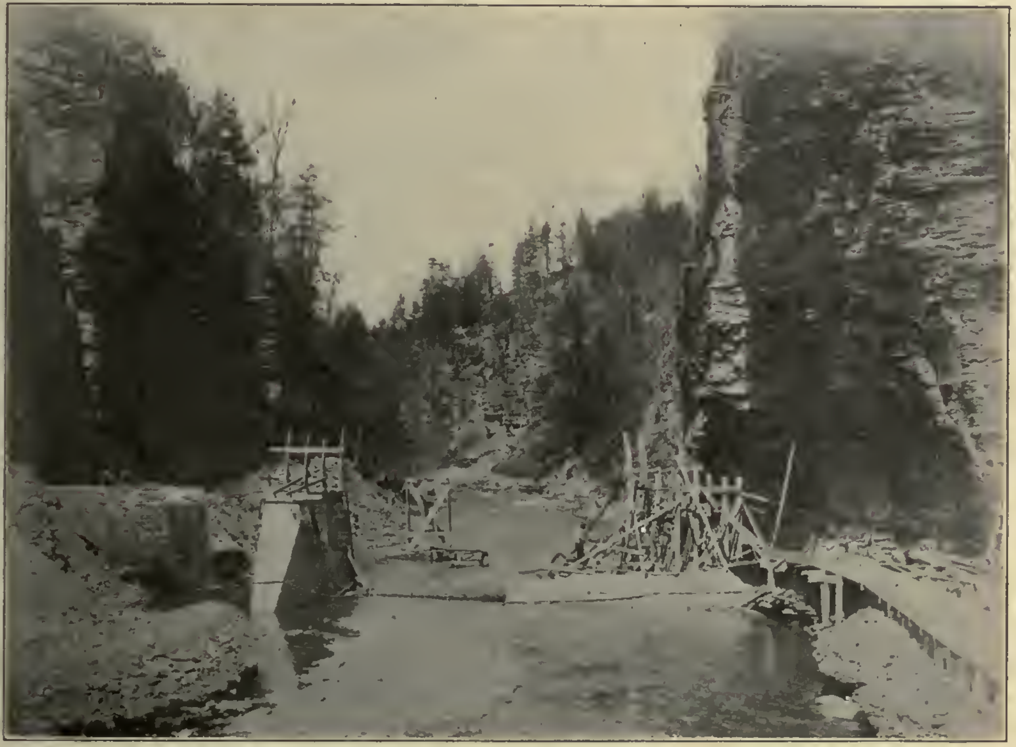
The tanks have been subjected to a pressure head of about 20 feet and have proved watertight. The principal quantities involved in their construction include about 400 cubic yards of excavation, 500 cubic yards of concrete and 26,000 pounds of steel. The contract price for the work was $8,500, including the laying of 3,000 feet of 8-inch pipe and exclusive of the cost of 900 barrels of cement required in the work. The work was done under difficulties incident to its execution through severe winter weather, operations being commenced in September, 1903, and completed March 16. An average force of thirty men was employed, and the concrete work was suspended during January to allow the completion of the filter house. When this was roofed in, fires were built there and the rest of the concrete was mixed with sand and stone warmed in pans over open fires.

Impounding Dam.—The Six-Mile Creek dam to impound the water supply for Ithaca, N. Y., is built in an ideal location about two miles above that city. Six-Mile Creek has a precipitous watershed, is subject to large spring freshets and sudden floods due to summer rainfalls, and flows through deep gorges to Cayuga Valley and Lake. At the dam site the original channel was between almost vertical cliffs of solid rock about 90 feet apart and 500 feet long, but up-stream it widened so as to form a large basin with steep slopes, down which a wagon track was, with difficulty, secured. At the site the geological formation is of shale rock in horizontal strata weathered on the surface, but reasonably hard and sound where protected. On one side the bank is 65 feet and on the opposite side 95 feet high. The dam about 100 feet long over all, is a concrete arch of 90 feet clear span, with the inner and outer faces curved in vertical transverse section so that it resembles a sector of a spherical shell and is remarkable for the peculiar outlines and very small dimensions.

The original design and contract provided for a structure 90 feet high from its crest to the bed of the creek, but after construction was commenced the local opposition was so strong that the plans were modified and it was finally built to a height of 30 feet, as shown in the accompanying cross-section. The radii of the up-stream and down-stream surfaces vary at different elevations and have maximum lengths of 67 feet 9 inches and 57 feet 9 inches, respectively, with a corresponding maximum thickness of 7 feet 9 inches; the thickness at the crest is 12 inches. About 300 feet below the dam there is a parallel dam 6 feet high which retains sufficient water to protect the rock bottom from erosion by the discharge over the main dam. There is also an intake tower above the dam 12 feet in diameter and about 40 feet high. These structures are all built of concrete with brick facing, and are equipped with the necessary waste pipes, valves and operating mechanism. There is no by-pass or waste channel, as it is intended in the time of high water that all excess flow shall be discharged over the crest of the dam. The principal features of the dam were described in The Engineering Record of July 18, 1903, in an account of its excellent resistance to a sudden flood which submerged it before completion.

The location and the character of the design made the construction difficult and special in many respects. It was dangerous and expensive to deliver heavy materials from up-stream, and it was also slow and troublesome to deliver them from below by wagons in the bed of the creek. This increased the cost of coal considerably and made it desirable to use as little heavy machinery as possible. The dangers from flood were considerable, and it was necessary to arrange the plant with reference to its safety in time of freshet.

A few hundred feet below the dam site there was a low wooden dam which had caused a deposit of sand, gravel and boulders 6 or 7 feet deep over the whole of the solid rock bottom between the cliffs which originally had a smooth level surface. In this loose material the low-water flow of the creek had excavated a shallow channel to which it was confined for a large part of the time during the summer months when the work was in progress. In the beginning a wooden flume about 8 feet wide and 2 feet high was provided by the contractors to carry the dry-weather flow of the stream, and excavation for the foundation was commenced as soon as the flume was put in service. Simultaneously vertical grooves about 8 feet wide and 8 feet long were blasted out of the opposite sides of the gorge from top to bottom of the cliff to receive the ends of the dam. This excavation was easily made in the usual way, and the stone was removed to solid hard strata and was dressed with faces normal to the line of pressure so as to provide stepped skewbacks for the masonry. When the excavation was commenced in the creek bottom it was found that the loose material was saturated with water and much difficulty was encountered in keeping the pits free. Finally the old wooden dam was removed, and, as a result, the ground-water level was lowered 3 or 4 feet, so that much of the upper part of the excavation was made with teams and scrapers.



Ithaca Dam during Construction: Buttress, Cofferdam and Runway for Concrete.

Early in the progress of the work there was a sudden freshet which increased the flow to a stream 6 feet deep and 90 feet wide with a velocity of 6 or 8 miles an hour, and washed out the 500 feet of flume which had previously been ample to provide for the entire flow. This demonstrated that any artificial by-pass was likely to be insufficient, and the contractors abandoned the plan to build the full length of foundation at once and commenced work from both ends of the dam toward the center, making short excavations from 10 to 20 feet long and building up the concrete in them above water level. The character of the material on top of the rock bottom was such that it was difficult to build cofferdams or sheet the excavation by ordinary methods, and, as it was so open that the water flowed through it readily, difficulty was encountered in draining even a small excavation. The method finally adopted was to lay a large round log or boom about 60 feet long across the bed of the creek just above the upper side of the foundation excavation. A ranger piece was blocked out a few inches beyond this log and against it were driven 2x9-inch square edge planks about 10 feet long like poling boards in a tunnel roof. These were driven to rock, but because of the numerous boulders encountered it was found very difficult to drive them with regularity, and their angles varied considerably. As fast as they were driven sand bags were set behind them between the log and the ranger, and the excavation was commenced on the down-stream side so as to undermine the sand bags. More sand bags were added and were thus forced down close to the sheeting as the pit was extended and finally formed a solid bank against the under side of the sheeting with a wide base on the rock bottom. Wagon loads of loam were dumped on the upper side of the sheeting and worked down along the upper surface of the planks so as to fill in between them and the sand bags. In this way a tolerably good cofferdam was constructed, which enabled the excavation to be drained by a number of Edson diaphragm hand pumps.

The rock in the bottom of the pits was picked and blasted until the excavation was carried down to solid hard strata at a maximum depth of 17 feet 9 inches. The trench was then rammed full of concrete and wooden moulds were commenced at the original rock surface for the lower part of the curved dam. Both up-stream and down-stream sides of the dam are faced with a single thickness of 3x4x9-inch vitrified paving bricks laid flatways with ⅜-inch joints of mortar made of one part of Alsen's Portland cement, one part creek-sand and one part crusher-dust. The brick was laid to a height of 3 or 4 feet in advance of the concreting and, above the tops of the six buttresses which were built on the up-stream side to provide stability for the unloaded structure, the brick face walls alone retained the concrete and obviated the use of temporary forms. Horizontal steel rods ⅝ inch in diameter and 4 feet apart with double nuts on each end are built into the masonry, as shown in the cross-section at B-G, C-F, etc. These rods engage 3x3-16-inch horizontal curved steel bars parallel to the faces of the dam which form ribs against which there is a continuous sheet of steel wire netting embedded in 3 inches of mortar between the face brick and the concrete.

To facilitate erection the contractors were allowed to make the ⅝-inch rods long enough to temporarily project beyond both faces of the brickwork, where they engaged horizontal and vertical timbers reaching across several rods and forming bearing strips and cantilevers to strengthen the thin brick shell. Besides these, on the up-stream face, a thin flat steel bar, or a No. 10 steel wire, was in some places laid in the horizontal joints every fourth or fifth course. These wires were long enough to reach from end to end of the dam and were secured to the sides of the rock bearings by cement mortar.

The brick facing on the down-stream side, of course, presented its convex surface to the concrete and so developed abundant strength as an arch to resist the weight and lateral pressure of the concrete. On the up-stream side the concrete packed against the concave face of the brickwork, and it was at first thought necessary to strengthen the latter with the tie-rods, wooden beams and horizontal wires above described. As the work progressed, first the beams and afterwards the wires were dispensed with, and it was found that after the cement had set at least 36 hours the concave shell of brickwork developed sufficient strength to safely hold 3 to 5-foot courses of concrete laid across the full width of the dam, so that the upper part of the structure was built entirely without bracing or forms, except at the crest, where wooden beams were necessary. The intaken tower was built with circular and octagonal concrete walls 6 inches thick faced with brick, and was erected like the dam. The face bricks were lapped instead of cut at their intersections on the corners, and served as the outer walls of a mould in which the concrete was laid in courses 5 feet thick, and a wooden core was built to form an inner mould for the concrete.

The flow of the creek was carried through its natural bed in the center of the gorge until both ends of the dam were built up to a height of 10 or 15 feet above the rock bottom. The gap was closed by a section of concrete about 40 feet long which had at each end tongued and grooved points in vertical radial transverse planes. The foundation for this section was carried down to a depth of 17 feet 9 inches below the surface of the rock, and the pit was drained with difficulty by a large force of men operating hand pumps, most of which discharged up-stream so as to avoid lifting the water to a higher level to clear the debris on the down-stream side. After these foundations were in, the normal flow of the creek was passed through the dam in three permanent steel pipes of 12, 24 and 60 inches diameter.

The concrete was made of one part Alsen's German Portland cement, two parts creek-sand, two parts creek-gravel screened from the sand and two parts of crushed drift boulders which were collected from the bed of the creek for a mile above and below the site. They were broken to fragments from 1 to 4 inches in diameter by a steam-driven Climax crusher located in the basin about 500 feet above the dam, where greater security could be provided against the danger from freshets. A one-yard Ransome drum mixer driven by a kerosene engine was located about 100 feet above the dam.

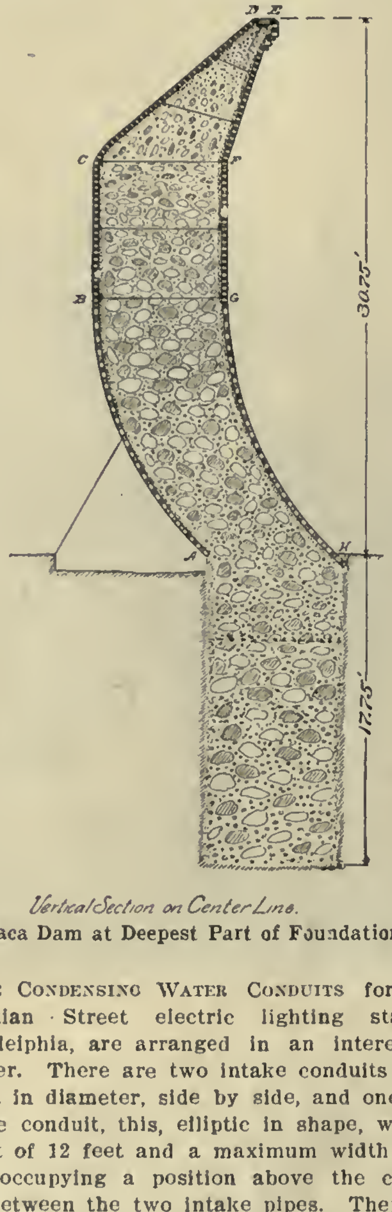
Stone, sand and cement were wheeled to a platform just above the mixer and were there filled by hand into a wooden measuring box, which was balanced on a horizontal pivot so as to be emptied into the drum and returned automatically to position after its contents had been discharged. In order to be safe from floods the mixer was placed at such a height that it could be connected with the top of the dam by a moderate incline. It was therefore deemed economical for it to discharge into wheelbarrows which delivered the concrete to the work without the use of derricks. It was originally intended to handle all concrete by means of two guyed derricks, one at each end of the dam on top of the cliff. These derricks were erected and their booms were long enough to meet over the center of the dam so as to command the entire work. They would have been necessary if the dam had been built to the full height, but after the changes in plan it was found that there would be no difficulty in wheeling the concrete and that it could be handled more cheaply in that manner than by incurring considerable expense for the operation of the derricks, so that finally the latter were not put in service. As the concrete was laid one-man stones were bedded in it as thickly as possible without contact and so as to project above the horizontal surfaces of the different courses and bond them together. The concrete was laid very wet and was thoroughly worked with bars and rammers. The maximum amount laid in 10 hours was about 80 cubic yards.

Brick and cement were delivered through special chutes from the railroad track on top of the cliff. The cement chute was 24 inches wide, 12 inches deep and about 400 feet long. It had a maximum inclination of about 45 degrees, but the lower end was curved to a horizontal tangent which terminated in the cement storage house. The upper end of the chute was 110 feet above the lower end and terminated in a hopper. Bags of cement were thrown from the car into the hopper and arrived in the storage house a few seconds later. An ingenious device was provided to diminish the velocity of the bags. Near the foot of the chute a horizontal strip was nailed across the upper edges and to it was nailed the upper end of a 1x12-inch board 20 feet long. The lower end of the board rested on the bottom of the chute and was loaded by several pieces of timber spiked to the upper side. The descending cement bag wedged itself into the angle between the board and the chute and lifted the former. The spring of the board and the weight at the lower end opposed considerable resistance to the passage of the bag which emerged at a greatly reduced speed. After the chute had been in use some time the surface became so smooth that it was necessary to add a second and finally a third brake to check the speed of the bags. A similar chute 5 inches wide was provided to deliver the bricks.

The work on the dam was carried on simultaneously with that of a filter plant which was under construction for the same owners, and as the men were shifted from one job to the other their labor was irregular and no attempt was made to complete the dam before the rest of the improvements were finished. Work was commenced in September, 1902, was suspended for about four months during the severe winter weather and was concluded during the next summer. A maximum force of about 75 men was employed, but the average number was about 50, including those occupied in collecting the cobblestones and crushing them. The total quantities for the main dam included about 500 cubic yards of excavation, 1,000 yards of concrete, 5,000 pounds of steel and 120,000 bricks, and its cost was about $25,000, exclusive of about $3,000 for 1,800 barrels of cement.

The dam is owned by the Ithaca Water-Works Company, was designed by Professor Williams and was constructed under his supervision, with Mr. Weston E. Fuller as assistant engineer. Both it and the filter plant described in the first part of this article were built by Messrs. Tucker & Vinton, 156 Fifth Avenue, New York, Mr. Philip H. Trout being their superintendent.

The 800-Kilowatt Generating Plant of the Rockland Light & Power Company, Nyack, N. Y., is a noteworthy instance where many of the especially promising machines and apparatus of modern power-plant development have been installed. An independently fired superheater, built by the Power Specialty Company, an American Blower mechanical draft outfit, an Alberger fan-draft cooling tower, an Alberger jet condenser and a 400-kilowatt Westinghouse steam turbine form part of the equipment. The plant is in charge of Mr. John S. Avery, general manager of the company.



Vertical Section on Center Line.
Ithaca Dam at Deepest Part of Foundation.

The Condensing Water Conduits for the Christian Street electric lighting station, Philadelphia, are arranged in an interesting manner. There are two intake conduits each 7 feet in diameter, side by side, and one discharge conduit, this, elliptic in shape, with a height of 12 feet and a maximum width of 8 feet, occupying a position above the center line between the two intake pipes. They are formed of concrete and the mass enclosing the three is made to serve as the foundation for the partition wall between engine and boiler rooms. The wall stands immediately above the discharge conduit, bringing one intake conduit under the engine room, while the second is under the boiler room. The condensers are served in the former case, and the various pumps are disposed along the partition wall in the boiler room, served by the second intake. The two intake pipes are connected together at several points by cross-pipes 4 feet in diameter. For reinforcement of the concrete under the wall, a grillage of 20-inch I-beams, imbedded in the concrete, extends the length of the conduit and additional beams placed across these at the building columns act to distribute the load over the entire structure.

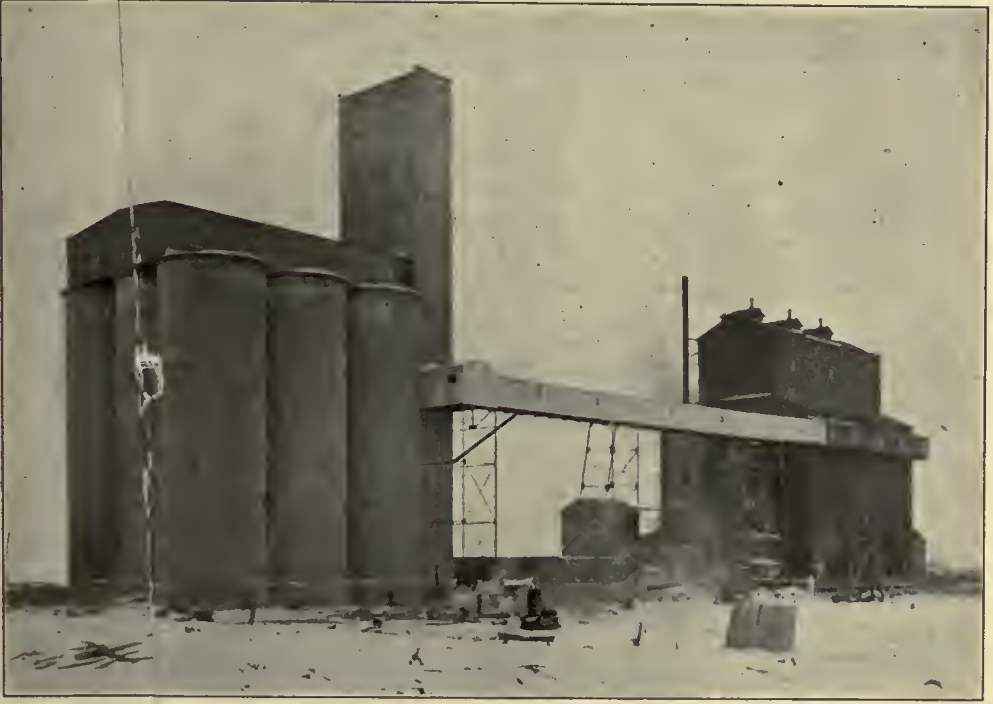
The Canadian Pacific Grain Elevator at Port Arthur, Ontario.

The Canadian Pacific Railway Company's new elevator at Port Arthur, Ontario, has just been built to provide storage until shipment for low-grade grain and wet wheat which has been treated in the adjacent large drying plant. It has a capacity of 443,000 bushels which can be stored in nine 43,500-bushel cylindrical tanks and in four 13,100-bushel rectangular spaces between them. The elevator occupies a ground area of about 105x98 feet on the shore of Lake Superior, which was covered in some places to a few feet in depth before construction was commenced. It has nine vertical cylindrical tanks 30 feet in diameter and 90 feet high which have a one-story steel-frame and tile cupola covering most of the space on their flat tops with its roof 109 feet above grade. There is also a 16x36-foot steel tower 166 feet high which contains the elevator machinery and a three-span steel bridge 230 feet long supported on steel towers 60 feet high. The bridge supports a covered gallery in which there is a 36-inch reversible belt-conveyor to transfer grain from the drying plant to the elevator or from the elevator to vessels which have abundant dock facilities here, and are loaded through four dock spouts.

The equipment includes the elevator leg with a capacity of 15,000 bushels per hour, two 36-inch belt filling conveyors over the tops of the tanks, three 36-inch belt-conveyors under the tanks to receive grain from them and one 36-inch belt-conveyor transverse to these to carry grain from them to the leg. There is one garner, weighing scale and shipping bin with ample facilities for loading cars. The elevator is provided with electric lights, bell signals, speaking tubes and a complete modern equipment for handling grain efficiently. The machinery is operated by power transmitted through a rope-drive from the engine house of the old elevator.

The elevator was built to meet special conditions and is considered by its designers, to be unlike any previously existing structure. The centers of the bins are at the intersections of three longitudinal and three transverse lines 30 feet apart in both directions. The walls are of reinforced concrete 9 inches thick on foundations 24 inches thick which are carried down to offset footings on a stratum of clay, sand, gravel and boulders at a maximum depth of about 16 feet below grade, or 7 feet below water level. The conical tank bottoms are seated on a rammed sand fill. Under the center of each row there is a concrete lined conveyor tunnel 7 feet wide, 7 feet high and about 86 feet long. At one end of the building these tunnels open into a basement room about 15 feet wide and 78 feet long which extends across the front of the elevator and contains the transverse conveyor-belt and the boot tank for the elevator leg. Across the tops of the tanks there are several riveted steel trusses supporting the floor and roof of the cupola. The semi-circular portions of the tanks outside the walls of this cupola are covered with flat roofs sloping slightly to the outer edges of the tanks. The tank roof, the roof and floors in the conveyor house and the floors in the elevator tower are all made of book tile laid on steel T-bars supported by I-beams. The roof tiles are covered with composition felt and gravel, and all floor tiles are covered with 1 inch of Portland cement mortar. The walls of the tower and cupola are made of tile reinforced by wire netting and anchor-bolted to the steel framework.

The walls of the cylindrical bins have a uniform thickness of 9 inches, except where the adjacent bins are tangent and the acute angles between the convex surfaces are filled in solid for a width of 7 feet and a maximum thickness of 2½ feet. They are made of machine-mixed concrete, one part Invincible Portland cement, three parts sand and five parts Lake Superior gravel. They are reinforced against bursting by horizontal circular steel bars 12 inches apart vertically which decrease in size from the bottom upwards. The circular bars or hoop bands are in pairs, one near each surface of the wall. For the first 15 feet above the base their cross-section is 1 square inch, for the next 35 feet it is 0.88 square inch, for the next 20 feet it is 0.75 square inch and above that it is 0.50 square inch. Besides the horizontal bars there are in each tank twenty-seven equi-distant vertical rods ½ inch in diameter built in the wall to give it permanent reinforcement. Where the walls are thickened at the contact points of tangencies, they are reinforced by horizontal layers of 2-inch mesh galvanized wire netting 12 inches apart vertically. At these points they are also reinforced by two horizontal 1¼x5/16-inch contact anchors 12 inches apart vertically, which hook over the hoop bands.



Old and New Elevators and Connecting Conveyor Bridge, at Port Arthur, Ontario.

The spaces enclosed between the convex surfaces of each group of four bins are also used for grain storage, forming quadrilateral bins with the sides concave outwards. In some other elevators the unbalanced pressure caused by filling such bins when the main bins were empty has produced injurious effects, and to prevent it these bins are reinforced by tension rods passing through the opposite walls near each corner, as indicated in the general plan. These rods have a diameter of 1¾ inches up to a height of 20 feet, 1⅝ inches for the next 30 feet, 1½ inches for the next 20 feet and 1⅛ inches from that point to the top. The screw ends have nuts bearing on beveled washers which are seated on flat steel tie-plates which distribute the pressure over the cylindrical walls and connect the ends of adjacent rods. The upper parts of the cylindrical walls are finished with brick and have moulded terra cotta blocks let into their outer faces, as shown in the detail, to form a cornice.

The bottoms of the circular bins are approximately conical surfaces with 3 inches of cement concrete finished with Portland cement mortar 1½ inches thick. The concrete is laid on a well-rammed bed of sand filling and is not reinforced. The sides deviate from a true cone to converge to a flat chute 10 feet long and 1 foot wide with a 15x15-inch gate near the center, through which the contents are discharged to the conveyor-belt in the tunnel below. The four corner bins have their bottoms highest in the center and slope to outlets at one corner of each, from which there are chutes carrying the grain to the center of the tunnel over the conveying belts. The tunnels are made with solid concrete floor, walls and roof, and the roof only is reinforced with ⅝-inch horizontal transverse rods 4 inches apart on centers. Where the roof carries the walls of the bins, it is made thicker and is reinforced by pairs of transverse 24-inch I-beams and by 1-inch rods 3 inches apart on centers. The footings under these points are also reinforced by 1-inch transverse rods 7 inches apart on centers which extend through both walls of the same tunnel. Over the tops of the basement windows the walls are reinforced by ⅝-inch rods.

Steel Construction.—The 90x60-foot house on top of the tanks is 17 feet high and has its longitudinal axis coincident with the centers of the middle row of tanks. Its framework contains four longitudinal lines of light riveted steel trusses, two of which are 13 feet 4 inches, and two are 15 feet deep, spaced 20 feet apart on centers. This brings one line in each of the outer walls and the other two lines pass through the building dividing it into three equal aisles. The outside aisles are each divided into two 10-foot spaces and the space nearest the center is occupied by the conveyor system 7 feet above the bin floor. The trusses are built of light channels and angles and are braced together by transverse struts and diagonals. The book tiles which form the floor and roof surfaces are supported in both cases on 2x2-inch T-bars 18 inches apart carried by 12-inch transverse channels 6 feet apart. The channels are supported on the top chords of the longitudinal trusses, and from the bottom chords of the longitudinal trusses and the tops of the bin walls in the roof and floor respectively.

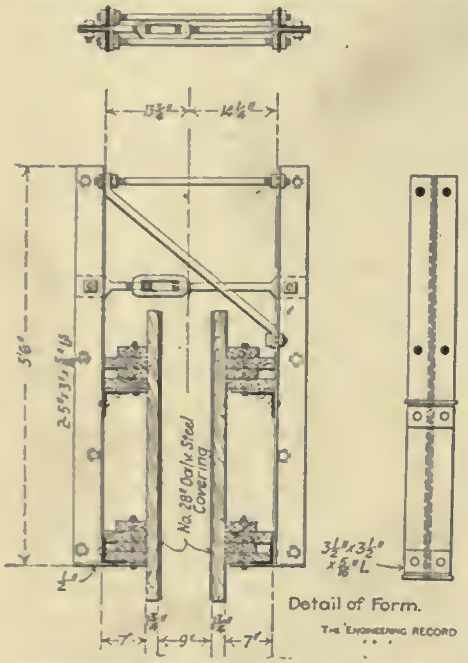
Outside of the longitudinal walls of the cupola the floorbeams are continued with a downward inclination to rest on the edges of the tank walls and carry the longitudinal T-bars and tiles which form the half circle roof over them. One end of the building is connected to the elevator tower and its floor and roof are supported from the tower columns. The steel framework of the tower has six horizontal struts from about 12 to 23 feet apart vertically across each side, each panel thus formed being X-braced by single 4x3-inch or 3x3-inch angles. At the top of the tower some of the columns are made with single 3x3½-inch angles with their flanges turned inwards and some with pairs of 4x3-inch angles latticed. The sections of the columns increase downwards and the heaviest ones are composed, at the foot, of one 3½x3½-inch angle and two 12½x5/16-inch plates, or of four 5x3½x7/16-inch angles and one 12x⅜-inch plate. There are in the tower four floors, the first at a height of 55 feet 8 inches from the ground is at the level of the bridge connecting it with the old elevator; the next floor at a height of about 90 feet is at the top of the bins; the third floor 32 feet higher is called the scale floor and the fourth floor 22 feet 8 inches higher is the machinery floor. At the height of the roof over the bins, about 12 feet above the bin floor, the columns are all spliced and the tower is stiffened by 5-foot plate-girders across the narrow ends. The girders also form the sides of garners and shipping bins. Similar girders are introduced at the level of the upper floor. The connections of all tower members are field-riveted to gusset plates which are shop-riveted to the columns.

The conveyor bridge has three 61-foot 8-inch spans at a clear height of about 57½ feet above the ground. Each span has a pair of light riveted trusses 8 feet 4 inches deep and 10 feet apart on centers. They have eight panels with vertical posts and zigzag diagonal members and are connected by top and bottom transverse struts and zigzag laterals. The upper transverse struts are knee-braced at both ends and carry on the center line a very light longitudinal strut made with two angles latticed which supports the center of the double-pitched roof. The chords of the trusses are made with pairs of 3½x3½x5/16-inch angles and the web members are made with single 2½x2½-inch angles, all riveted to connection plates between the chord angles. The floorbeams are 8-inch channels bolted through their top flanges and clip angles to the lower chords of the trusses at panel points. They carry six lines of longitudinal angles and channels which support the conveyor and rope-drive apparatus. The spans are supported on four-post towers made with two vertical bents 15 feet apart. Each bent has one vertical and one battered post and is 20 feet wide at the base and 10 feet wide at the top. The posts are made with pairs of angles riveted together back to back with connection plates between their flanges. The angles are reduced from 6x4 inches at the base to 5x3½ inches and 5x3 inches in the upper panels. They have wide horizontal base-plates stiffened by the vertical connection plates and seated on 4x19-foot concrete piers 10 feet deep. They are anchor-bolted to reaction washers embedded in the pier footings and each pier is carried down to hard pan 20 feet below water. The piers were built in open coffer-dams sunk through loam and boulders, in which it would have been difficult to drive piles as was at first proposed. Each face of the tower is divided vertically into four panels by horizontal struts composed of pairs of 3½x½-inch angles back to back and the panels are X-braced by single 3x3-inch angles.

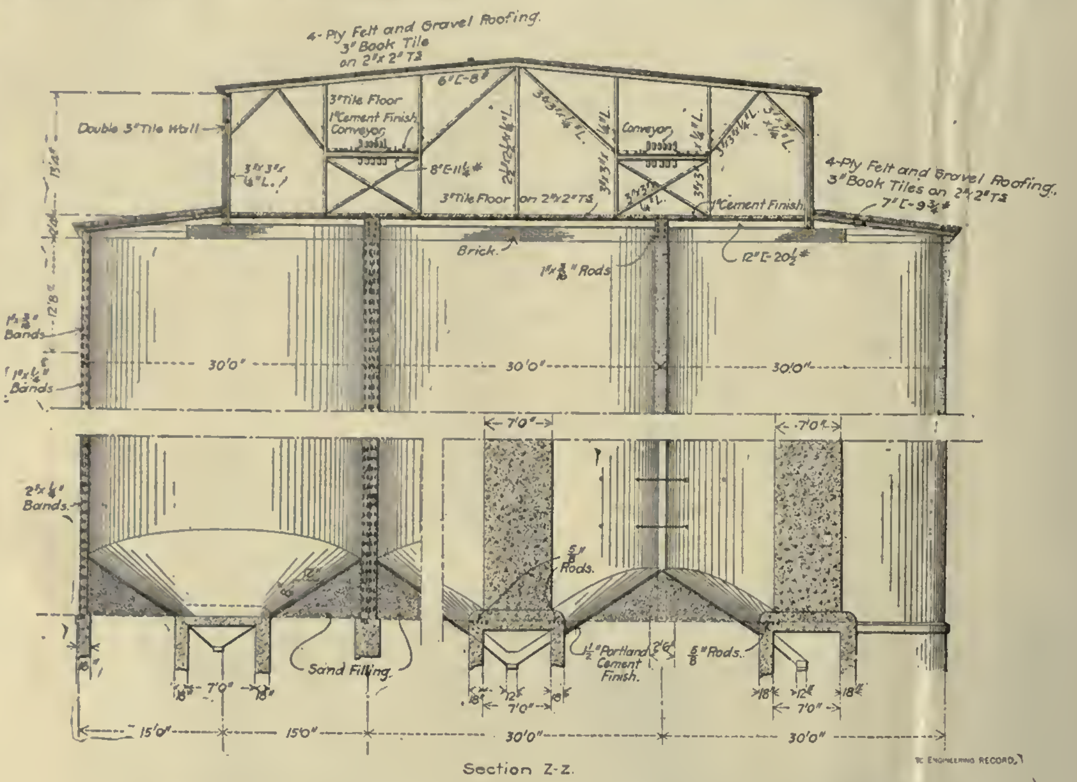
The garner is a 13x15-foot rectangular hopper-shaped bin 5 feet deep with a W-shaped bottom, and is made with ¼-inch plates and 3x3-inch angles. The scale hopper is 12 feet square and 9 feet deep with a pyramidal top having an opening about 7 feet square. It is made with

3/16-inch side plates, 6x5/16-inch splice plates, 3x3-inch inside corner angles and 2½x2½-inch stiffening angles. The pyramidal bottom is 5 feet deep and has an opening 2 feet square in the center. The 13x15-foot shipping bin is made of ¼-inch steel plates spliced by 6-inch plates without angles. It consists of upper and lower pyramidal sections with their horizontal bases field-riveted together. Each section is about 6 feet deep and has a 2x2-foot opening at the vortex. The total weight of the steel work in the elevator is about 400,000 pounds.

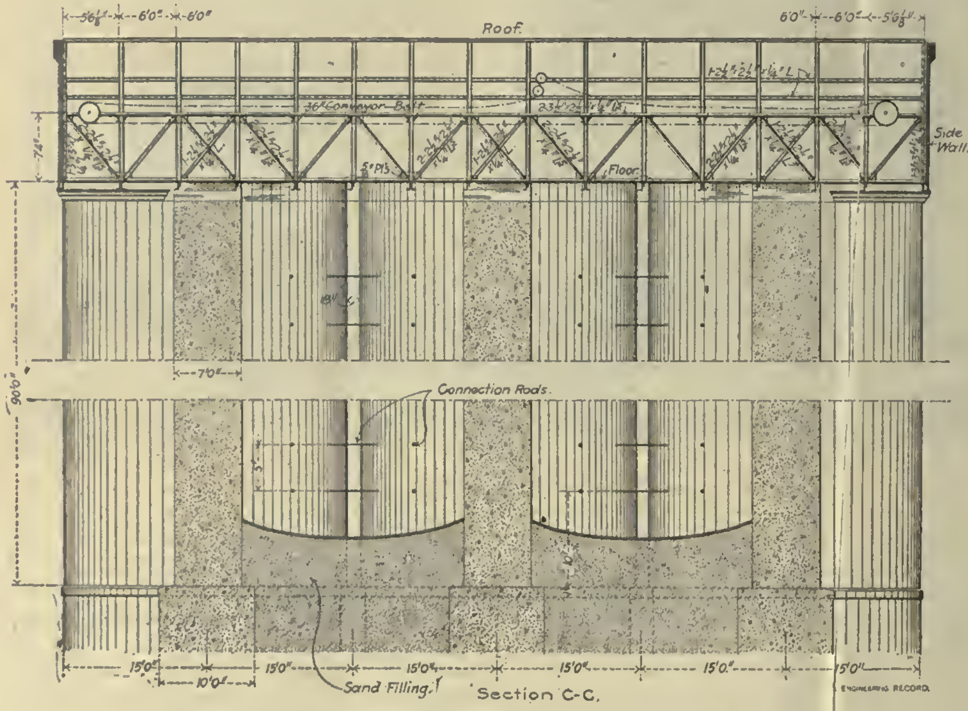
Construction.—It was originally intended by Chief Engineer McHenry to support the elevator on piles, but an investigation by test piles and borings showed that the underlying soil was hard-pan and boulders, and it was determined to omit the piles and carry the substructure to satisfactory bearing on hard stratum. The lake side of the site was enclosed by a coffer-dam consisting of an earth embankment with a center line of double 3-inch sheet piling. This was found satisfactory and enabled the water to be drained from the site by a centrifugal pump with a 10-inch discharge pipe. The sand, silt and ashes covering the site were excavated from 3 to 6 feet to the stratum of clay, sand, gravel and boulders and leveled 15 feet 8 inches below top of foundation. Sand and gravel were delivered on scows and were unloaded by a derrick rigged with a



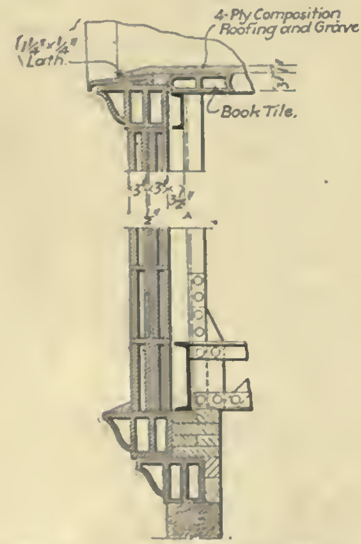
Connection between Rims and Outer Walls of Forms.



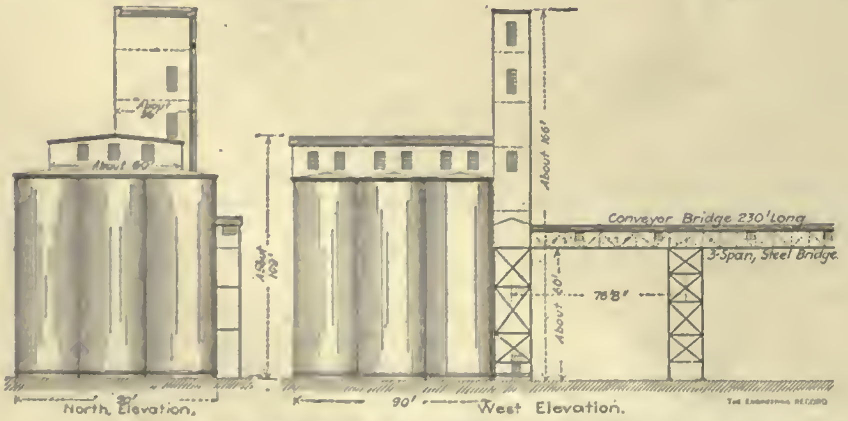
Transverse Section through Cylindrical and Intermediate Bins.

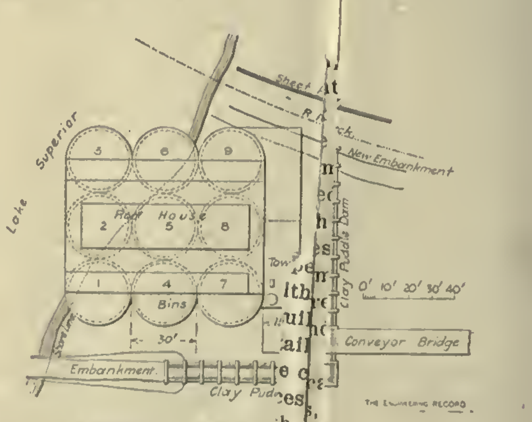


Longitudinal Section through Intermediate Bins.



Tile Wall of Roof House.

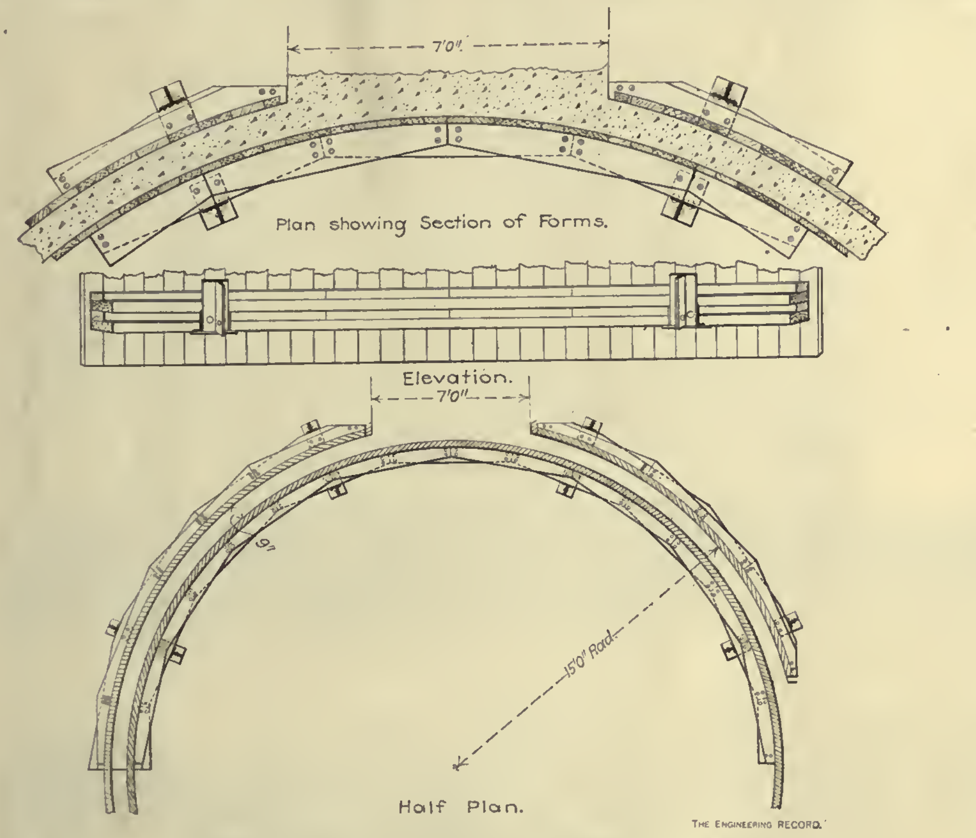




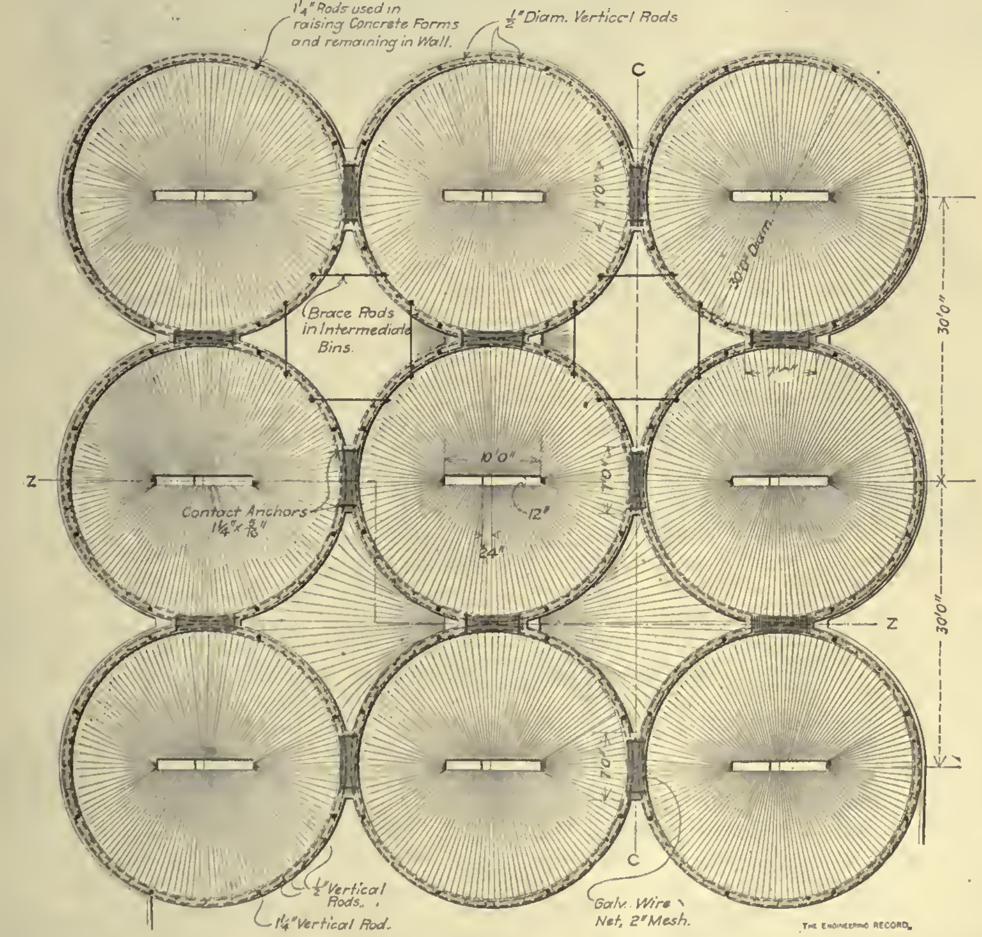
THE GRAIN ELEVATORS OF THE CANADIAN PACIFIC RAILWAY, AT PORT ARTHUR, ONTARI clam-shell bucket which also served the Smith machine in which the concrete was mixed. The mixer delivered to wheelbarrows which were elevated by a brick hoist to the tops of the successive courses of the walls and there dumped into the forms.

The concrete walls of the bins were made in movable cylindrical forms 4 feet high. The curved surfaces of the forms were made of 2-inch vertical planks spiked to inside and outside circular horizontal chords. The chords were made like ordinary arch centers with four thicknesses of 2x8-inch scarf planks bolted together to break joints and make complete circles inside the tanks and circular segments of 270 degrees or less on the outsides of the tanks. The moulds were faced on the inside with No. 28 galvanized steel and were maintained in concentric positions with a fixed distance between them by means of eight U-shaped steel yokes in radial planes. Each yoke consisted of an inside and outside vertical post with a radial web and flanges engaging the inner and outer faces of the circular chords. The posts projected about 2 feet above the tops of the moulds and were rigidly connected there by means of heavy braces and an adjustable tension rod. These yokes were bolted to the inner and outer chords of the moulds and virtually united them in a single structure. The lower ends of the vertical yoke posts were seated on jack-screws which were supported on falsework built up inside the tanks as the walls progressed. The inside surface of the mould was a complete cylinder, but the outer surface was made in two, three or four sections to allow for the connections between the concrete walls at the points of tangency of the different tanks.

The Engineering Department of the Canadian Pacific Railway, Mr. E. H. McHenry, chief engineer, furnished the elevator specifications and issued requirements concerning the size and location of bins, legs, belt-conveyors, scales, shipping bins, dock spouts and other governing data. From these data the Barnett & Record Company designed the elevator and erected it including the steel work and machinery and the foundations. The structural steel work was furnished by the Canadian Bridge Company, Limited, Walkerville, Ontario, and the machinery was furnished by the Stephens-Adamson Manufacturing Company, Aurora, Ill. The contract was awarded in January, 1903, and the elevator was finished ready for operation January 3, 1904.



Sectional Forms for Cylindrical Concrete Grain Bins.



Horizontal Sections through Cylindrical Bins Showing Intermediate Bins, and Hopper Bottoms.

Cuban State Roads.

The influence of good roads upon the development of a country having possibilities is well shown by the observations of an engineer from the United States during successive visits to Cuba. Mr. C. C. Vermeule, consulting engineer for the Cienfuegos, Palmira & Cruces Electric Power & Railway Company and for the new water works and sewers of Cienfuegos, has recently returned from a trip of about three hundred miles on horseback between Cienfuegos, Trinidad, and Santa Clara, Cuba. He has noted some remarkable results from the building of macadam roads in the country between Cienfuegos and Manicaragua Valley. One year ago, when he passed over the same route, a macadam road was built five miles out from Cienfuegos to Caonao, and the road between Caonao and Guaos was then under construction. Guaos is fourteen miles from Cienfuegos. Between Guaos and Cumanayagua preparations were also being made for an extension of the highway, and an important bridge was being built over the Rio Aramao. At that time there were about three stage trips daily being made between Cienfuegos and Caonao, and beyond Caonao the travel was practically nothing, the highway being merely a cart road of the roughest description. This year the macadam road is finished to Guaos, and stage trips are made hourly between Cienfuegos and Guaos, and these stages are running full and doing a large business.

The macadam road is now under construction between Guaos and Cumanayagua, and will be completed to the Aramao bridge in August. Traffic over this portion is still confined to carretas or ox-carts, but there is every indication that when the macadam road is done traffic will show the same remarkable increase that is shown this year between Caonao and Guaos. This is a fair illustration of the tremendous importance of improved highways in the development of Cuba. As an illustration of the recuperative powers of the island, even without highways, Mr. Vermeule states that at the close of the war, less than five years ago, not a single house existed beyond Caonao in the entire district which he traversed on horseback. Caonao was a reconcentration camp, and beyond that point the opposing armies had devastated everything, and the country was uninhabited except for a few Cubans who hid themselves in the forests of the Trinidad Hills. At the present time this entire country is dotted with houses, the Manicaragua Valley alone having a population exceeding 5,000, and many American planters have scattered themselves over the territory on tobacco or coffee plantations. Some of these planters have commodious habitations. The whole country traversed shows the greatest activity and rapid development.

The sugar crop in the vicinity of Cienfuegos will this year amount to 1,600,000 bags, or about 240,000 tons, worth nearly $10,000,000. It is 20 per cent. in excess of last year's crop, and prices are better than those of last year.

Railway Location in the Florida Everglades.—II.

By William J. Krome.

The field party traveled as light as possible. Tents were abandoned after leaving the pineland and a couple of flies used to protect the goods and as a shelter in heavy rains. All cooking utensils were of aluminum and a complete outfit for eight men nested in one pot, and weighed barely 15 pounds, entire. A tin box, such as is used for fishing tackle, and containing a supply of needles, thread, copper wire, awls, beeswax, scissors, screw driver, pliers, copper rivets and various odds and ends was in great demand and took the place, to a considerable extent, of the usual camp chest. A similar box held drafting materials, and a steel straight edge, an 18-inch rolling parallel rule, and a small drafting board completed the necessarily meagre office outfit.

View on the Trail to Long Key in the Everglades.

Medicines were carried in what is known as a country doctor's buggy-case. Made of heavy sole leather, with a compartment for surgical instruments and bandages, and fitted with a good number of bottles of various sizes, it answered the purpose well. Such a case is of much the same size and shape as the ordinary 4x5-inch camera and slung over the shoulder does not add greatly to a pack load. The stock of medicines was selected to meet the needs of the climate and could be replenished from a supply at the permanent camp. A surgical kit containing several lancets, scissors, forceps and flesh needles and a twist or two of silk was ample for our needs and came into use several times. Small pocket cases, each holding an hypodermic syringe and two small phials, one filled with a 10 per cent. solution of permanganate of potash and the other with 1/50th grain tablets of strychnine, as an antidote for snake bites, were distributed amongst the party so that one would always be at hand if needed.

The climate was healthful, for the water in the Everglades is pure and fresh, and malaria is an unknown quantity. So by keeping watch of the men pretty carefully and meeting ailments before they had made much progress, the party was kept in splendid trim during the entire six months and no time was lost through having a big sick roll.

Sleeping bags of light felt with a waterproof canvas cover were used by most of the men and were very satisfactory. As no cots were carried, and boughs fit for bedding were seldom obtainable, the usual mattress was a pile of sawgrass. Dry camping places were the exception and as the mosquito bars were often pitched in the open, the canvas covers of the sleeping bags were a double protection from rainfall and from the wet ground. Rolled up with the mosquito bar inside, they were carried on the owner's pack when on the move.

The machete was used for clearing line, opening up camp sites in the jungle, cutting sawgrass and for every purpose for which the axe and brush hook are usually needed, except the felling of large timber and the driving of stakes. It is strange that this useful implement has not come into more general use on preliminary and location surveys. It is far superior to a brush hook, as it can be handled much more easily, has no helve to break, and as far as my experience goes is of a great deal better metal. Axe men are prone to lose brush hooks by misplacing them while using the regular axe, but the machete may be carried in a sheath hung to the belt without hindering the movements and need never be laid down while in the field.

The stadia was particularly adapted for this piece of work. It allowed a small party to do the work thoroughly and took the place of the chain or tape where the use of the latter in some cases would have been impossible. There are stretches miles in length through the Everglades where stakewood of any kind cannot be obtained and where even the hubs necessary for the stadia work had to be carried long distances. This would have seriously handicapped regular stationing and ordinary marking pins would have been useless on account of the depth of water and soft muck. When the Whitewater Bay region was reached, numerous streams, islands and stretches of coast were meandered where the dense mangrove swamp extended out into the water for fifty feet or more beyond the shore line. As a mangrove swamp is about as hard to cut through as a solid wall, a chain survey would have had tough work making half a mile a day. By zigzagging the streams and cutting from one projecting point to another along the coast, the stadia party, operating from the boats, made 3½ to 4 miles per day, regularly. Special 12-foot rods, built as light as possible, were designed and canvas covers furnished to protect them when not in use. A steel tape was kept in camp and when the chance offered a few of the longer sights were tested by careful measurement as a check on the adjustment of the wires.

One radical departure from usual methods, which will probably shock stadia theorists, was made early in the survey. The country was so level that after the first few miles the reading of the vertical angle was abandoned entirely. This simplified instrument work somewhat and reduced to a minimum the labor of computing the length of sights. It certainly did not seriously impair the accuracy of the results for a carefully chained location which has since been run through a considerable portion of the territory, checked out with the exploratory line remarkably well.

Good instrument points were, as a rule, hard to get, and it was no uncommon occurrence for the tripod head to be at the water level with a footing of soft muck that increased the probable error in angular measurements alarmingly.

A computed bearing was carried throughout and any sudden deviation from the needle would quickly point out any mistake or large error in taking the angle. Sights of from 600 to 800 feet were about the usual length. When meandering streams the average would be shorter, while in work along the coast, where the failure to secure some projecting point might mean a half day's heavy chopping around the shore of a cove, sights of over 2,000 feet were occasionally made and the readings taken in halves.

The closed traverses, after being balanced, were platted from the same system of co-ordinates, and the tie lines and laterals were built up on this trunk. The field map drawn on heavy canvas-backed paper, was platted to a scale of 1 inch to 5,000 feet. As the outline of the whole southern end of the State had been previously put on from the government coast survey charts, the position of the party could be learned at any time and the work ahead blocked out.

Continual scouting ahead was necessary and in these trips seldom more than two men took part, enabling the field party to continue their work without interruption. As such expeditions often lasted several days, each man carried a light pack containing sleeping bag and mosquito bar, one or two small aluminum cooking utensils and a limited supply of provisions. A leather haversack held flag cloth, a ball of strong cord, note book and a pocket compass with folding sights. A pair of Trieder binoculars, machete, rifle and belt of cartridges completed a load that by nightfall seemed to its bearers only fit for a two-horse team. A start was always made from some point on the stadia meander and a careful record of courses and approximate distances kept. When the new territory had been penetrated for some distance trees were climbed at intervals of about a mile and observations made in every direction from them. The lack of a pair of light steel climbing irons, such as are used by ornithologists, was keenly felt, but this need had not been foreseen when the outfit was gotten together. As the trees used were often lone pines on some isolated rock reef it was no mean task to "shin up" them. The observer carried the ball of cord with him and could then haul up the pocket compass, field glasses and note book. Bearings would be taken on as many known points behind as could be observed and then the character of the country ahead in several directions noted. Before descending, a flag fastened to a sapling was hoisted and securely lashed in the top of the tree. The tree was then marked with the blaze of the survey, a long chop with a hack above and below. If the territory developed by this system of scouting proved to be important, it was more fully investigated by a stadia line; if not, it could be platted up with sufficient accuracy for the purpose in view from the notes already obtained.

A Typical Mangrove Cluster.

The party was in the field from the first of December, 1902, until the early part of June, 1903. Trail building and the establishment of a base of supplies held back the work for a month and in the remaining five about 300 miles of stadia line was run besides accomplishing considerable work in channel sounding. The exploration was under the general direction of Mr. E. Ben Carter, chief engineer of the Florida East Coast Railway.

The most serious obstacles encountered were the heavy muck and dense saw grass of the Everglades, and the jungles and mosquitos of the Whitewater Bay region. The muck with proper drainage will eventually become fine farming land and the mosquitos will disappear to a great extent as the country opens up. The malaria breeding species of this insect is evidently not present, for that disease was conspicuous in the party by its absence.

As a result of the expedition the lower extremity of the Biscayne pine land was defined, Long Key, a pine island of some 18,000 acres, lying in the Everglades, the very existence of which was previously doubted, was thoroughly mapped. Whitewater Bay was reduced to one-half the size shown on former maps and two-thirds of the area known as the Great Mangrove Swamp was discovered to be open prairie.

A Typical Camp in the Everglades.

Table Showing Results of Stadia Survey in the Everglades.

Title.	Total length of traverse. Feet.	Number of sides.	Number of instrument points.	Closing error in computed bear.	Total closing error. Feet.	Error to 1,000′ of traverse. Feet.	Average length of sights. Feet.
Biscayne Pineland	206,966	85	359	0° 14′	165	.80	576.5
Connecting Link, No. 1....	106,418	28	152	0° 11′	79	.74	700.1
Long Key, No. 1..........	120,210	37	169	0° 13′	121	1.01	711.3
Long Key, No. 2..........	59,450	15	76	0° 7′	38	.64	782.2
Long Key, No. 3..........	30,126	8	40	0° 3′	94	3.12	753.2
Long Key, No. 4..........	38,112	14	51	0° 5′	42	1.10	747.3
Hammer Island	23,420	6	31	0° 3′	16	.68	755.5
Connecting Link, No. 2....	87,281	127	138	0° 21′	141	1.62	632.5
Whitewater Bay, No. 1....	39,958	61	61	0° 19′	32	.80	655.0
Whitewater Bay, No. 2....	19,804	18	18	0° 4′	14	.71	1,100.2
Coot Bay	14,771	7	8	0° 1′	45	3.04	1,846.5
Peter's Prairie, No. 1.....	10,683	10	16	0° 1′	8	.75	667.7
Peter's Prairie, No. 2	13,193	11	18	0° 8′	23	1.74	733.0
Black Creek	96,144	67	127	0° 8′	87	.91	757.0

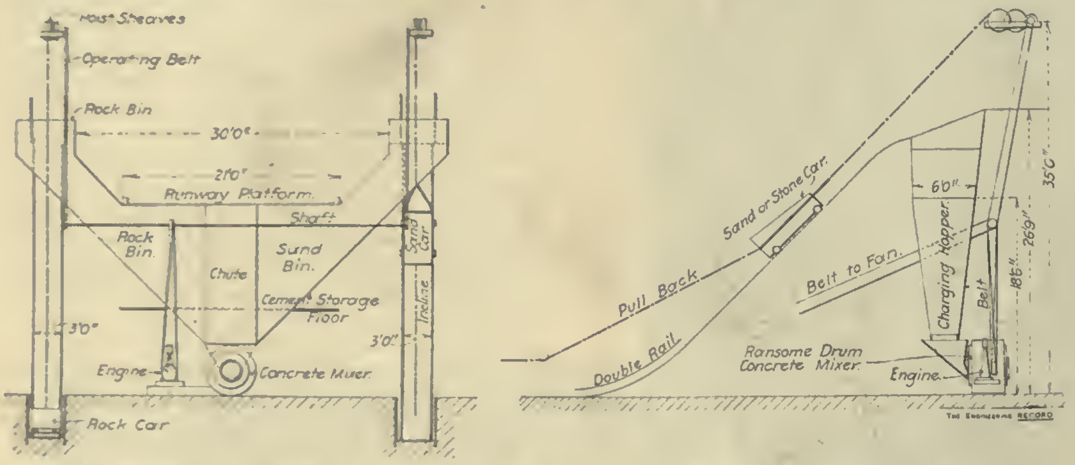
The accompanying table compiled from the closed traverses may be of interest to those who have had stadia work to carry on.

Progress in Sewage Disposal.

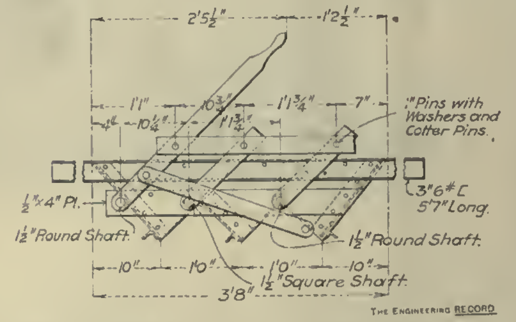
Progress in Sewage Disposal was the sub- of the presidential address recently delivered by Mr. W. D. Scott-Moncrieff before the Association of Managers of Sewage Disposal Works, in England, and printed in "The Surveyor." Speaking of the year's progress, Mr. Scott-Moncrieff quotes a suggestion in his address of a year ago which has borne fruit. The passage is as follows: "After having been in the grit chamber long enough to allow of the deposition of the detritus and in the anaërobic tank long enough to hydrolise the organic matter, the raw incoming sewage should be diverted to a second set of grit chambers and tanks, and the liquid which has been longest in the anaërobic tank should then be circulated so as to pass again through the first grit chamber so as to complete the hydrolysis of the suspended organic matter which will otherwise appear as sludge." It has been discovered that the deposit from open hydrolysing tanks, which have been in constant use and undisturbed for four years, after being discharged over the surface of a field and dried, is indistinguishable from fine garden mould and is absolutely odorless and inoffensive. The old question as to how far these aërobic changes, which occur in a properly constructed filter, can be depended upon to reduce the entire organic matter in solution in ordinary hydrolised fluid is the only one that remains, and the answer, based upon a wide experience in Staffordshire and other districts, is quite positive. If a sufficient depth of filtering material is provided, and the requisite quantity of air for the life processes of the organisms is supplied to them, there can be no doubt about the satisfactory character of the effluent. The only factors to be dealt with are: (a) The depth of filter required to produce the necessary standard of purity in the effluent. (b) The quantity of air necessary for the life processes of the organisms. (c) The proper rate of flow per unit of filter bed surface in order to obtain the best results, and (d) The best period of rest between successive discharges to prevent gelatinuous growths in the filtering material.

A Concrete Mixing Plant for a Power House Foundation.

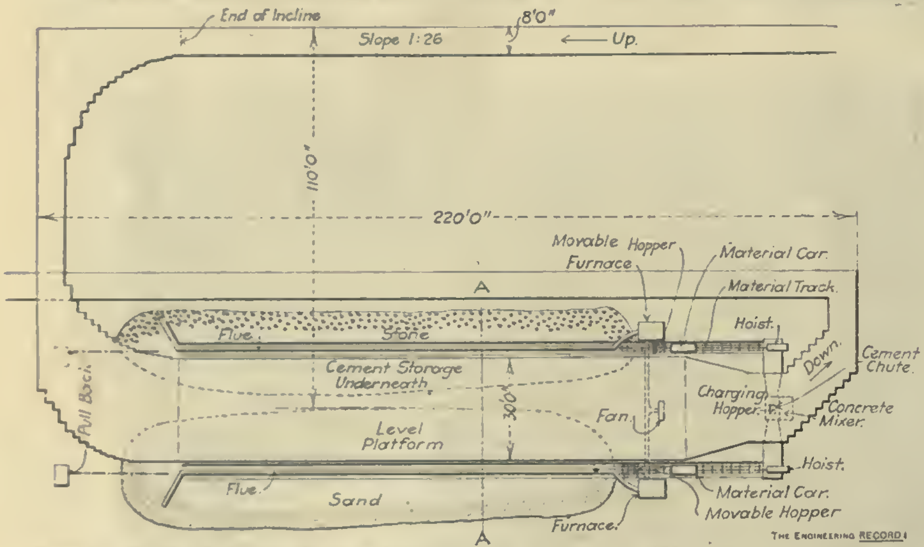
The power house near Thirty-fourth street and East River, Long Island City, N. Y., for the Pennsylvania, New York & Long Island Railroad Company, will furnish power for the operation of the suburban trains of the company and eventually for a portion of its tunnels to the New York terminal. It will occupy a 200x500-foot lot about a block from the river front. At present only the river end of the building will be completed, and the 200x280-foot excavation for it has been made and piles driven over its entire area 32 inches apart on centers in both directions, except under the smokestack, where they are closer. The piles will be covered by a monolithic mass of concrete averaging about 6 feet in thickness and containing approximately 11,000 cubic yards of 1:2½:5 concrete made with Atlas Portland cement and gravel. Probably the gravel will be excavated in the vicinity and the large stone and boulders found in it will be bedded in the concrete.



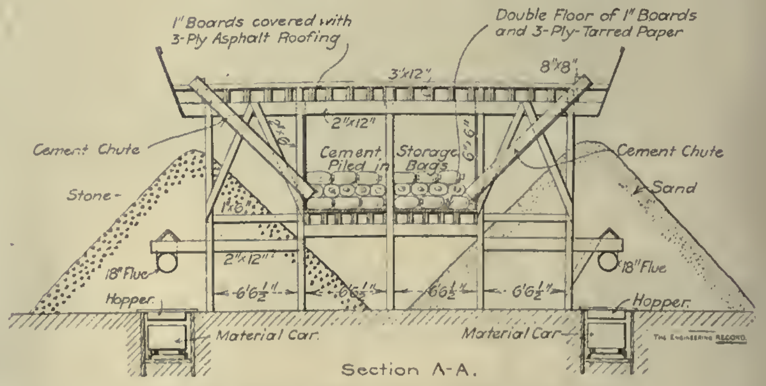
Transverse and Longitudinal Elevations, Showing Delivery of Materials to Mixer.



Movable Stone and Sand Loading Hoppers.



General Plan of Storage of Materials and Plant for Heating and Handling.



Unloading Platform, Storage and Delivery Tracks.

PLANT FOR MIXING AND PLACING CONCRETE IN FOUNDATIONS OF POWER HOUSE, AT LONG ISLAND CITY, NEW YORK.

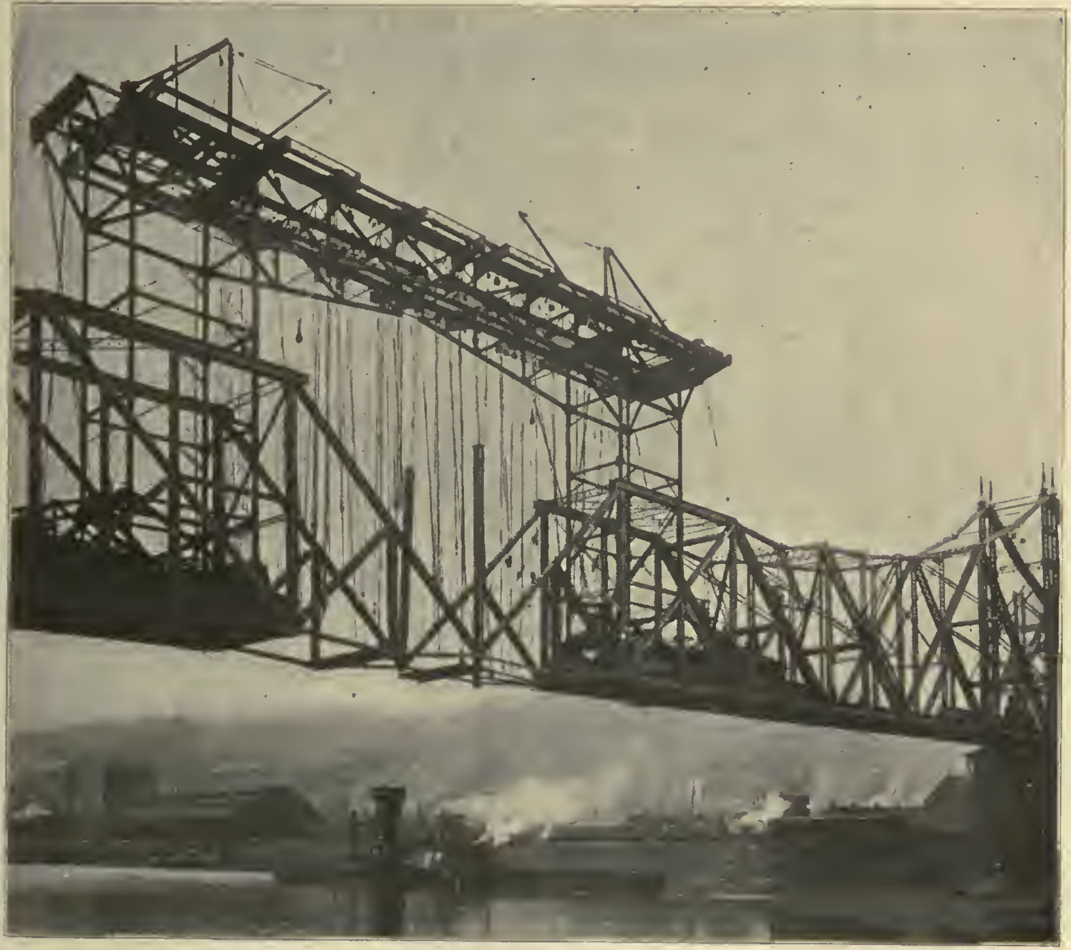
A plant has been designed and constructed for the handling and storing of materials and for the mixing and distributing of 300 cubic yards of concrete in each 10-hour day. The arrangement and equipment have been carefully designed to suit the special conditions and facilitate rapid and economical concreting. The plant includes some interesting features combined in a novel manner. These are here described from the concrete specialists' general plans, which were made in accordance with the requirements of the contractors for the power house. Sand, gravel and cement are delivered by barges at a dock near the site, and are thence hauled by wagons entering the lot near the river end of one long side. From this point a timber platform carried on piles slopes upwards to the shore end of the lot, where it crosses over to the center line and returns with an increased width to the middle of the shore end of the area to be concreted. This part of the platform has a width of 30 feet, slopes slightly downwards towards the river, and is at an average height of about 18 feet above the bottom of the pit. Materials are dumped from this platform to storage spaces underneath it, and the empty wagons continue from the river end of the platform on a narrow inclined gangway, which runs parallel and adjacent to the storage platform and allows them to pass under the approach gangway and emerge at street level on the shore end of the lot. There is thus formed a continuous circuit for the wagons without in any way interfering with the storage or concreting. The aggregate is delivered by automatic steam-hoisted cars to elevated storage hoppers, from which it and the cement are discharged by gravity through a measuring hopper to the mixing machine, which delivers to cars on elevated longitudinal and transverse tracks commanding the entire foundation area.

Underneath the full length of the main platform there is on the center line, a cement storage house, as indicated in the cross-section, with the top, bottom and sides covered with double layers of boards with tar paper between to exclude moisture. Cement in bags is delivered to its floor through side chutes which receive it as dumped from the wagons on the platform above. The bags are piled on the sides of the room, a gangway being left in the middle for their delivery by hand trucks to the storage hopper. The edges of the platform are protected by bulkheads, over which the wagons dump stone on one side and sand on the other. These materials form long piles extending partly under the platform, and are delivered to the storage hoppers by four-wheel dump cars running on depressed tracks carried under the piles on their center lines and rising at the end of the platform to a level above that of the hoppers. The cars are always filled by hand from the material at the base of the river end of the pile, which fills the track trenches and is removed from them as the face of the pile recedes. In order to keep the sand and stone warm and dry in the cold and wet weather, through which it is intended to vigorously prosecute the work, horizontal flues 18 inches in diameter have been carried through the base of each pile from end to end. These are connected with furnaces by means of which the air is heated. The hot air is forced through the flues by a disc fan driven by a belt from the mixer engine. The cars are pulled up the 45-degree incline at the river end of the track by a single ½-inch wire cable on drums operated by the mixer engine. At the upper end of the incline the cars revolve part way so as to dump their contents into the hoppers, and, when released, descend by gravity to the trench where, for a short distance, the wheels engage an upper rail which prevents danger of derailment. A tail line is attached to the rear of the car and when the latter ascends the incline, it raises to a comparatively short height, a heavy weight suspended from a four-part tackle. When the car descends the weight overhauls the tail line and pulls the car back to the starting point at the end of the material pile, thus making the operation automatic, except as controlled by the hoisting drum.

In good weather, when it is not necessary to heat or dry the sand and stone, the wagons deliver directly to the storage hoppers instead of being dumped over the sides of the platform. The storage hoppers for sand, stone and cement are set below the level of the cement storage floor and have a combined capacity of about 100 cubic yards. The lower ends are closed by vertical steel-plate gates which slide in angle-iron frames and are operated by long hand levers. As it will take some time for the hoist cars to make a round trip at the maximum haul, special provision has been made for loading them rapidly so as to avoid all delay and secure a practically continuous delivery of materials to the storage hoppers when the mixer is running to its full capacity. This is accomplished by providing a movable hopper which travels over the trench clear of the car, and being kept close to the foot of the material pile, allows the car to pass under it and receive its load. In order to save head room, this hopper is made with a W-shaped bottom having double inclined doors pivoted to an operating link which opens them simultaneously by means of a hand lever, as shown in the detail.

The materials from the storage hoppers are drawn into the charging hopper until they fill the latter to successive marks when the gates are closed, and as soon as the contents of the mixer have been discharged, the gate in the charging hopper is opened and its contents are immediately delivered to the mixing machine. This is a standard No. 14 Ransome drum mixer having a capacity of 1 cubic yard in 40 seconds. The mixer discharges into a small steel hopper with double gates which deliver directly to wheelbarrows on a runway platform about 3 feet above grade, or 9 feet above the bottom of the foundation pit. This permanent platform is carried at a slight downward slope transversely across the center of the building. On each side of it there is a movable longitudinal platform on which the concrete is wheeled to the sides of the lot or intermediate points and dumped where required. It is intended to place 1-foot layers of the concrete across the full width of the lot in successive narrow strips until the area is all covered, and then to repeat the operation until the foundation is finished, rolling each layer thoroughly. With this plant 84 cubic yards of concrete have been made and laid in one hour and 584 one-yard batches have been made in eight hours, double the designed capacity.

Messrs. Westinghouse, Church, Kerr & Company are the contractors for the power house building and equipment, and the plant here described was designed and installed by The Ransome Concrete Machinery Company.


Monongahela River Bridge: Final Position of Travelers Assembling Members of Center Panels.

The Erection of the Monongahela River Bridge, Pittsburg.

Part III.—Permanent and Temporary Pin-Connections, Special and Adjustment Apparatus.

Toggle Pins.—At some of the truss joints the members were assembled on the pins in several separate operations often made at successive positions of the traveler. These were called temporary joints, and were marked "toggle" on the erection diagram, so as to distinguish them from the joints which were permanently completed at the first operation and were marked "pin." In most of these joints the number of pieces engaged by the pin was so great and they were so rigid and had so little clearance that, with the difficulties caused by deflection, displacement and inconvenient positions, it would have been extremely troublesome to drive the pins by the ordinary method. A simple and ingenious system of auxiliary pins and sectional pilots was therefore devised by Mr. Mitchell and found very efficient and satisfactory.

The toggle joints were made by inserting reduced-diameter pins through the stiff members and the bars packed inside of them before erection. Outside bars were then assembled on the ends of the toggle pins. In the bottom chords of the anchor arms the permanent joints were made by supporting the assembled members while the toggle was drawn out by a line attached to a loop-eye screwed into the end of the pin, the permanent pin being meanwhile driven through the joint independently with an ordinary pilot nut. In all other cases the rear ends of the toggle pins were screwed to the forward ends of the pilot nuts which formed a connection with the permanent pin so that the members were always connected by the pins, and the toggle pin was not removed until all the bars had engaged the pilot. The pilots were made in such short sections that they could be built up to narrow points when the conditions required it, or could be left short when the bars were well matched, but would in any case form a single cone with proper slope.

One of the most difficult of the toggle joints was at 14-U, where the chord pin is 15 inches in diameter, 7 feet long and has thirty-two eyebars assembled on it. As these bars have maximum dimensions of 14x1 25/32 inches, are over 4 feet long and are bored to fit the pin within 1/50 inch, it would manifestly be very difficult to center them at first on a full-size pin. The members were therefore assembled on a rough toggle pin about 5 inches in diameter and 7 feet long which could easily be inserted through holes that were decidedly eccentric. In each end a 3-inch hole was tapped to a depth of 2 inches. To one end was connected a short capstan-head piece with male threads on both ends, and to it were successively screwed 6-inch hollow sections of the pilot nut which increased to the full diameter of the permanent pin, and was screwed into one end of the latter. In the opposite end of the permanent pin there was screwed a driving nut which received the blows from a 12-inch ram 10 feet long, weighing about 4,000 pounds, which was suspended from the traveler overhang and was swung by men working on a suspended platform. As the permanent pin was driven through the assembled members, the toggle pin was driven out and the forward end was secured by a line through a loop screwed into it. After the pin was completely driven, the toggle, driving nuts and sections of the pilot were unscrewed and the permanent disks were bolted to the pin.

All of the long pins engaging numerous bars were driven in a similar manner, four different sets of sectional pilot nuts, two sizes of single piece pilot nuts and several sizes of driving heads being provided. Care was taken in designing the pilot nuts to separate the sections at such points that the large ends would exactly fit different standard sizes of pins, and thus serve separately as independent pilot nuts. The pilot and driving nuts were made of high-grade open-hearth cast steel containing 0.6 to 0.7 per cent. of carbon. They were thoroughly annealed, rough finished inside and outside, reannealed, bored, finished all over, hardened in cyanide of potassium and tempered in oil or water.

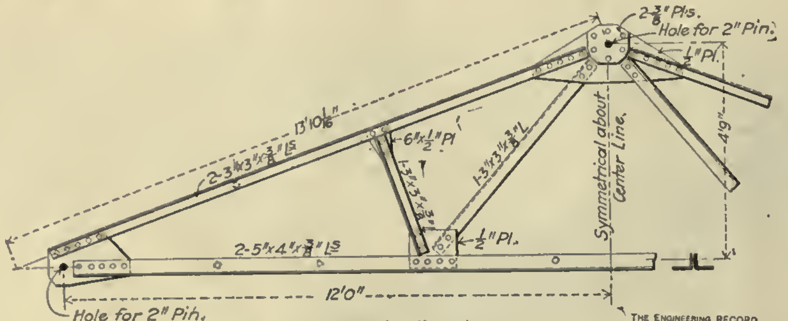
Lifting Appliances.—Numerous special fittings were required for the travelers and derricks and for the different erection operations. Among the most important of these were the appliances for the safe attachment of the hoisting tackles to the long and heavy members. The eye-bars were lifted by balance-beams which were triangular riveted trusses of 24-foot span like simple Fink roof-girders. The center top chord and end bottom chord connection plates were bored for 2-inch pins receiving the shackles of the hoisting tackle and of the clamps respectively. The clamps for the compression members consisted of parallel yokes connected by perpendicular screw rods. The upper yoke was made with a pair of 10-inch channels connected by transverse diaphragms and having a shackle pin connected to the center pair of diaphragms. The bottom yoke was made with a pair of angles riveted together back to back with filler plates between. Wooden friction blocks were placed on the opposite faces of the yokes for contact with the flanges of the bridge members. The ram for driving the pins had a suspension attachment at the center of gravity and was provided with a pair of tapped eye-bolts at each end to receive the tag lines by which it was operated.

Tower Adjustment.—When the traveler stood at the main pier, it erected the lower part of the tower and made the permanent connections 11-L and 12-L, assembling the members indicated by the full lines in the diagram. This involved assembling diagonals 12-L, 13-M, but as the permanent pins at 13-M could not be driven until after the first panels of the cantilever arms were completed, it was necessary to provide temporary supports for them. If the trusses had been erected exactly as designed, it would have been necessary to have the traveler overhang reach from the tower to 15-U and support heavy loads at the extremity. This would have involved undesirably large dimensions and heavy stresses, and in order to avoid them, special provision was made to allow the traveler to advance to 13-L before the permanent members of panel 12-L, 13-L were self-supporting. This enabled the members to be assembled by the one and one-half panel overhang of the traveler which sufficed for the rest of the bridge and secured an important saving in weight and expense. To acomplish it, the upper end of 12-L, 13-M was temporarily supported by diagonal bars arranged as shown in the diagram in detail, so as to transmit balanced stresses to the permanent parts of the truss already assembled and to be easily removed after the permanent connection was completed at 13-M. The vertical reactions of the bars were taken by suspension links connected to a temporary strut in the tower, and the horizontal component was taken by a temporary diagonal to 10-M, as shown by the dotted lines in the diagram. Both of the temporary diagonals were free to move horizontally at their upper ends and were separated by wedges. They were arranged so that by slacking off the wedge, the stresses in the bars were released, and they could be easily removed from the pins.

Bottom Chord Wedges.—After the connections at 13-M had been completed, the adjustment wedges were removed, and were later set in the bottom chords at 18-L to provide for the final adjustments at the center of the suspended span. The cast iron wedge was about 5 feet long tapered 1:12 and made hollow. Guide ribs on its finished faces matched grooves in the corresponding faces of the bearing pieces which had half holes engaging the pins in the tower suspension links or in the bottom chord pieces. A riveted vertical framework was bolted to the bearing pieces and received the end of the vertical operating-screw. This screw was commanded by a ratchet and pawl with a long lever and was turned by a single line from the hoisting engine. When the wedges were set in the bottom chords, they were adjusted to a width of 3 feet 11 inches between pin centers so that at the normal temperature of 60 degrees the lower chords at 24 would overlap 6⅝ inches, and at maximum and minimum temperatures, 40 degrees above and below the normal the overlaps would be respectively 9⅛ and 4⅛ inches.

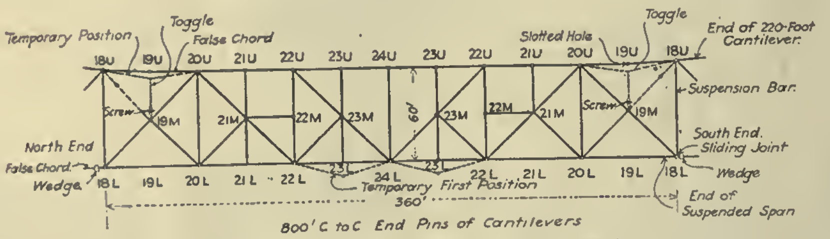
Top Chord Toggles.—When panels 18-U, 20-U were assembled, the permanent bars 19-M, 19-U were replaced by special temporary bars with an adjustable screw connection to pin 19-M, and temporary diagonals 19-M, 18-U were provided. These diagonals had nothing to do with the adjusting device, but were provided to reduce the reach of the traveler from two and one-half to one and one-half panels as at 13-M. This arrangement allowed pin 19-U to be depressed so as to raise the extremity of the cantilever arm. Diagonals 19-M, 18-U were made with pairs of bars borrowed from the center panel of the suspended truss, and were extended to the required length by means of links about 14 feet long made with 24x¾-inch plates with reinforced pin holes. The screw had a diameter of 7 inches at the root of the thread and was 8 feet long with a 5-foot ratchet wheel keyed to it in the center. It was driven by a riveted lever 13 feet long with an iron ring at the end, to which a rope could be attached and led to the hoisting engine. The lever engaged the ratchet wheel with a pair of spring pawls arranged so that either one could be swung in gear and turn the screw to the right or to the left. The bearings of the screw were in cast-steel blocks with horizontal trunnions to engage the ends of the vertical eye-bars and of short stub-plates that were connected to pin 19-M. These castings had projecting ribbed arms which locked them in position by engaging a bracket temporarily bolted to the inclined post 19-M, 20-U.

The screws were at first set so that the centers of the trunnion bearings were 4 feet ½ inch apart and pin 20-U was drawn back 4 inches. At the second setting the screws were turned up to bring the trunnions 3 feet 8½ inches apart and release bars 19-M, 18-U. The deflections when the traveler stood at point 22-L caused pin 24-M to move out 1¾ inches and to drop 1⅞ inches. Pin 24-L moved back 1¾ inches and dropped 12⅞ inches. When the travelers were in this position, the centers of the holes for pin 24-U in the adjacent top chord members were separated 6⅝ inches at the normal temperature of 60 degrees, 4⅛ inches at 100 degrees and 9⅛ inches at 20 degrees. All of these temperature and deflection movements and any other variations in position were corrected by means of the screws and wedges so that the final pins were driven easily under the conditions for which the apparatus had been designed.



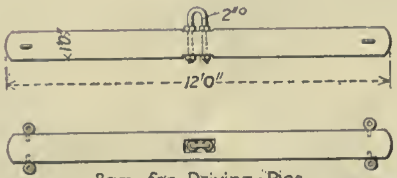
Beam for Lifting Eyebars.

THE ENGINEERING RECORD.



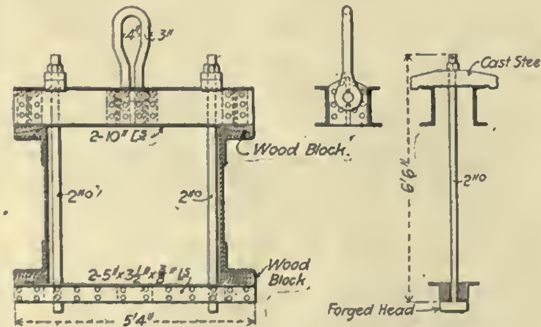
Center Span Erection Adjustments

THE ENGINEERING RECORD



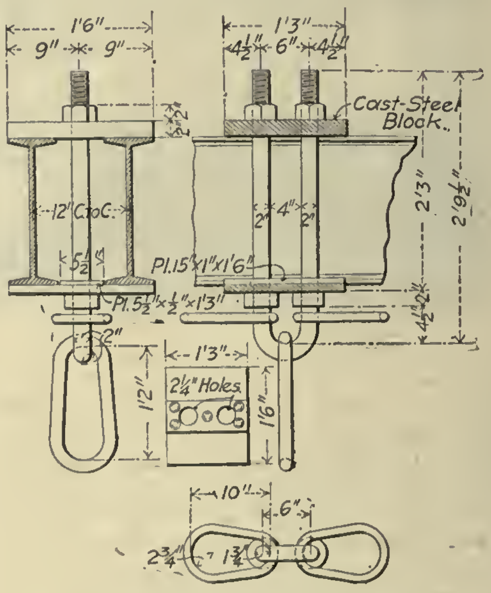
Ram for Driving Pins.

THE ENGINEERING RECORD.



Clamp for Handling 34 Ton Chord Pieces.

THE ENGINEERING RECORD.



Connections for Suspending Tackle from Jigger Beams.

THE ENGINEERING RECORD.

Monongahela River Bridge: Special Erection Devices and Diagram of Cantilever Adjustments.

Connections at 24-L and 24-U.—The final connections were made with the travelers standing at panel points 22-22. The bottom chords overlapped about 4 inches at 24-L at a temperature of plus 20. Pins 23-M were omitted so that members 22-U, 24-L could be revolved about points 22-U, which permitted the last bottom chord pin 24-L to be driven. The overlap in the bottom chords was provided for by buckling these chords at pin 23-L. After pin 24-L was driven, the top chord sections 22-U, 22-U, were set in place, vertical posts 24-U having been set, but 23-U, 23-M not being yet set. As expected, the opening between the chord sections at point 24-U was about 8 inches at a temperature of plus 20. After the top chord sections had been set, the top lateral sway-bracing was put in and verticals 23-M, 23-U were set. After these members were in place, the bottom wedges 18-L were slacked off until the bottom chord became straight, but without stress in the panel 22-L. The top toggles were then slacked until the top chords came together at point 24-U, but without stress between points 22-U and 22-U. In this position of the plant, joints 23-M were made and the top lateral bracing and sway-bracing bolted up complete. The bottom wedges and top toggles were then slacked together until the span was swung. The swinging of the span including the driving of the pins at 23-M and the bolting up of the lateral bracing and chord joints at 24-U occupied 3½ hours.

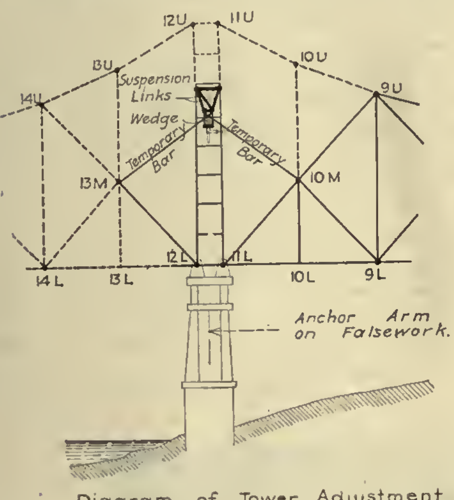
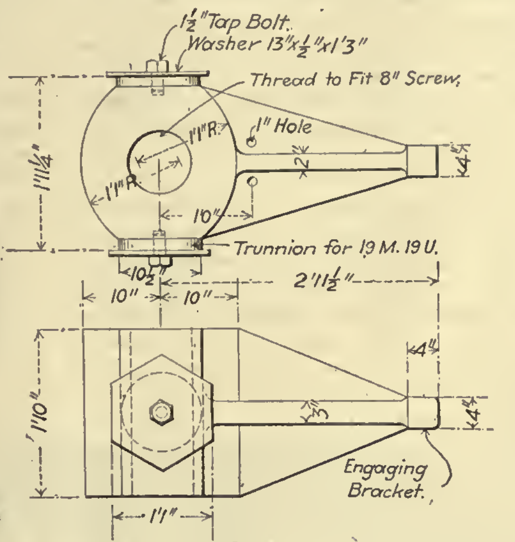
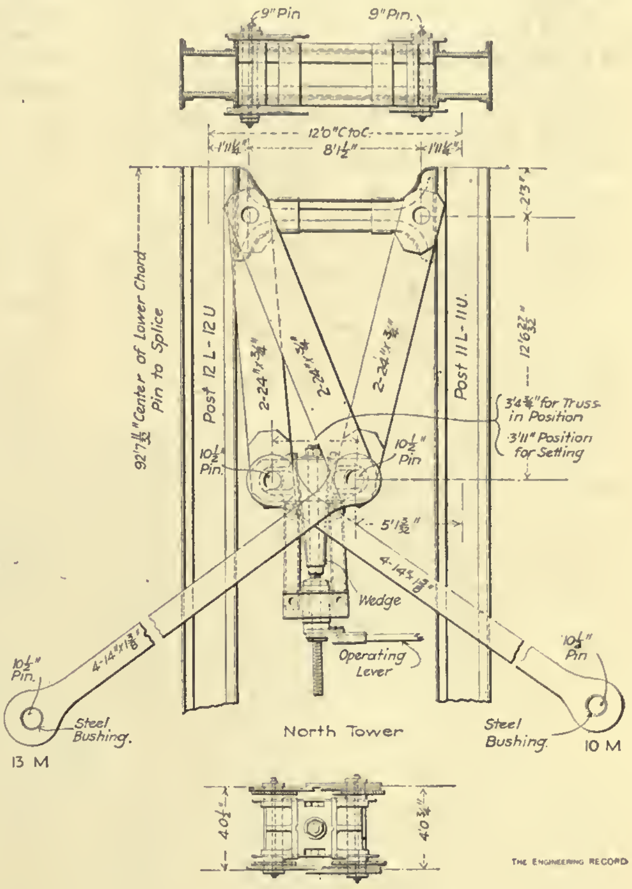


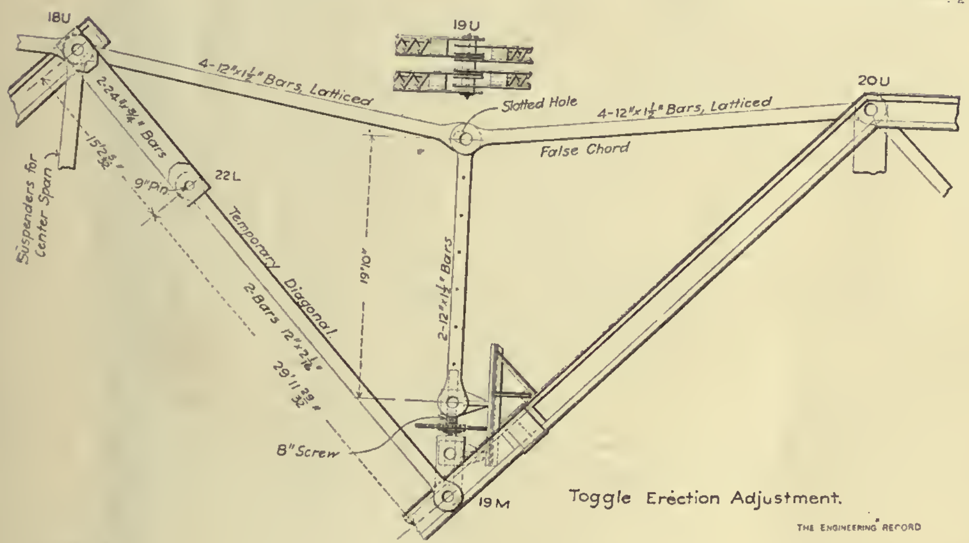
Diagram of Tower Adjustment



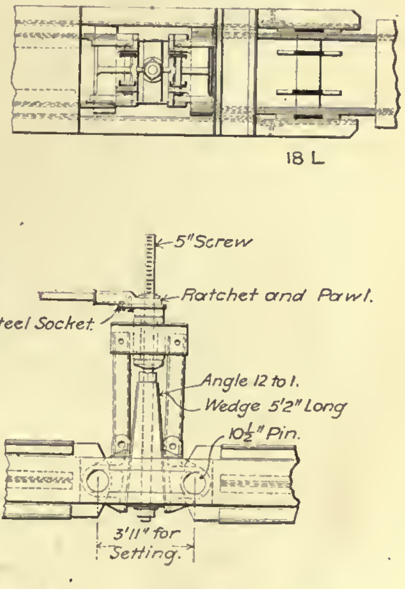
Screw Bearing for Toggle Adjustment.



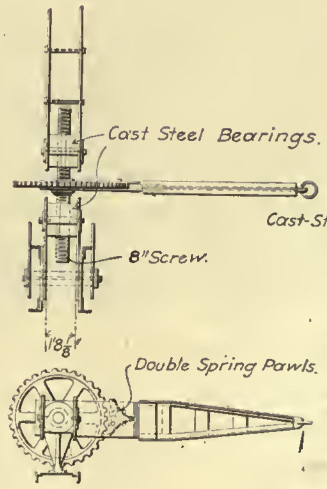
Details of Tower Adjustment



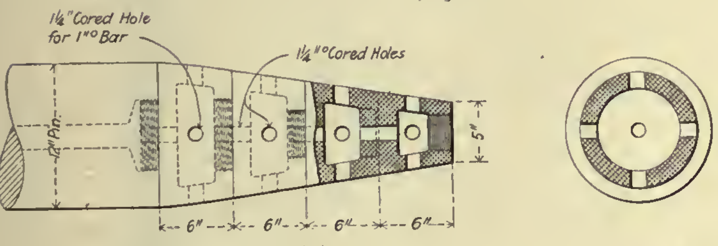
Toggle Erection Adjustment.



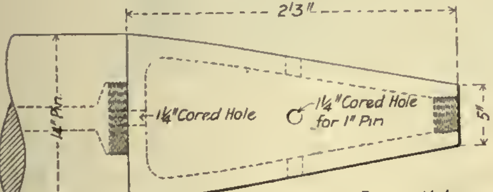
Wedge Adjustment at Tower and at 18 L.



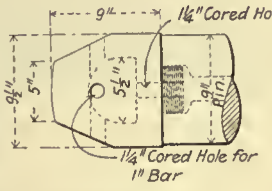
Screw Adjustment at 19 M.



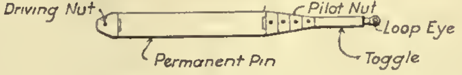
Sectional Pilot Nut



Single Piece Pilot Nut



Driving Nut



Pin and Toggle connected for Assembling Joint.

MONONGAHELA RIVER BRIDGE: PILOT NUTS, TOGGLES, SCREWS, WEDGES AND LINK SUPPORTS USED IN ERECTION.

Comparisons.—The rapidity of the erection and the ease and precision with which the final connections were made reflect equal credit on the design, accuracy of shop work, skill shown in designing special adjustments for use under unprecedentedly heavy stresses and the experience and ability exercised in directing the field operations. There are only three other bridges comparable with the Monongahela bridge in size and erection. The double track Forth Bridge, although much longer, was proportionately lighter and more expensive. It had two 1,710-foot cantilever riveted spans weighing 23,150,000 pounds each, and was erected in about four years. The largest members were not handled at all in the field, but were built up piecemeal in situ. A maximum force of 4,600 men was employed on the work at once, about sixty lives were lost on it and an average number of 100 workmen were paid weekly indemnities for injuries received.

The 820-foot span of the single track Lansdowne bridge across the Indus River required two years for its erection after its trusses had been completely assembled at great expense in the shops in England. The largest truss members were divided into small sections and were reassembled on falsework at the site. Smaller truss members were handled entire by an elaborate system of cableways and the suspended span was erected by the aid of a falsework platform and auxiliary floats. The adjustments were very slow and uncertain, and had to be several times repeated before the cantilever arms were finished. Finally the last members of the truss had to be cut to required length to fit the openings, as described in The Engineering Record of April 9, 16 and 23, 1892.

The longest cantilever span previously built on this continent is the pin-connected double track 790-foot, 5,867,000-pound span of the Memphis bridge. Its cantilever arms were erected on pile trestle falsework, and only the 452-foot suspended center span was erected by the cantilever method. Sufficient adjustment was not provided for making the center connections and great difficulty was experienced in driving the last pins. Finally with a combination of improvised toggles, powerful screws and tackles supplemented by special loading and steam heating to lengthen the chords the camber was increased enough to remove the fixed blocking in the lower chord sliding joints and the trusses were lowered past their previous position until the pin holes matched as illustrated in The Engineering Record of May 14, 1892.

The main span of the Monongahela bridge weighed 7,000,000 pounds, and every piece was shipped completely finished from the shops and erected whole by a single rapid operation. The erection of the river span was made by an average force of about 100 men in about 90 actual working days, and the connection of the last pins was accomplished without any difficulty or delay in assembling of the last panel, the swinging of the bridge was accomplished without trouble or peril, and the closing members of the trusses fitted within 1/50 inch with calculated lengths finished at the shops months previously.

The bridge was designed by Messrs. Boller & Hodge, consulting engineers, New York, built by the American Bridge Company of New Jersey, Mr. Paul L. Wölfel, chief engineer, and erected by the American Bridge Company of New York; Mr. S. P. Mitchell, chief engineer; Mr. H. A. Greene, manager of the Pittsburg division, and Mr. J. A. Sheedy, superintendent.

Steam Turbine Plant of the Port Huron Light & Power Company.

One of the first central station companies to contract for a Curtis steam turbine was the Port Huron Light & Power Company, of Port Huron, Mich., a 1,500-kilowatt turbine-generator having been ordered in October, 1902. This unit has now been in operation for several months and a description of the new plant installed in that connection has been prepared by Mr. James E. Davidson, superintendent of the company, for publication in the "Electrical World and Engineer." The equipment includes a condensing outfit that has shown a remarkable performance and a coal handling plant of considerable interest. From advance proofs of the article the following account has been obtained.

The light and power business in Port Huron was started by the Excelsior Electric Company in 1885. The old plant of this company was burned twice, as a result of which experience the present station is entirely fireproof. In June, 1901, the company was reorganized under the name of the Port Huron Light & Power Company, and a thirty-year franchise was obtained from the city. The property at the time of the reorganization consisted of a fireproof building 125x138 feet, built about five years prior to this time. This building contains two compound condensing 500 horse-power engines, and one tandem compound condensing 1,200 horse-power engine; three 500 horse-power and one 250 horse-power Stirling boilers, two Worthington feed pumps and one Cochrane heater.

To accommodate the new turbine unit a new portion adjoining the old plant was built, 40x80 feet in size with a 9-foot basement. The 1,500-kilowatt turbine unit consists of a Curtis turbine driving an alternating-current generator, the latter being a three-phase, 60-cycle, 1,150-volt machine. The unit runs at 720 revolutions per minute. An Alberger surface condenser guaranteed to maintain 28 inches of vacuum has been installed. The turbine unit is of the horizontal shaft type. Steam enters the turbine through an 8-inch pipe. The governing is accomplished at five ports, the number of ports opened depending on the load. There are two stages in this turbine, with four revolving disks in each stage. To lubricate the machine, an oil pump is operated by a leather belt from a pulley on the turbine shaft between the generator and the second stage. The oil is pumped to the bearing through a ⅝-inch brass pipe and returned through a 1½-inch pipe. Before returning to the pump the oil passes through a water cooler. This cooler consists simply of a water tank with a coil of copper pipe through which the oil circulates. There has been no trouble from heated bearings. The oil at the pump has a temperature of 120 to 130 degrees Fahr.

The turbine is equipped with a mechanical and also an electrical governor. The mechanical governor, which is the emergency governor, is set to operate a butterfly valve when the speed reaches 800 revolutions, or 50 revolutions above normal, the governor tripping a weight which closes the butterfly valve. This emergency valve can also be operated by hand. The electric governor is the one used for the ordinary governing. The governor shaft of the electric governor is run by a 3-inch leather belt from the turbine shaft. The governor shaft runs about 200 revolutions, and is equipped with the regular fly-ball governor. When the shaft is above normal speed, the sleeve of the fly-ball governor makes an electric contact. When it is below speed another electrical contact is made. Supposing that the turbine is above normal speed and the high-speed contact is made, a circuit is established through a magnetic clutch which connects the governor shaft with the port valves, and which runs the governor valves down so as to close some of the row of ports. When the speed is below normal the low-speed contact on the governor operates another magnetic clutch, which causes the governor shaft to operate the valves to open the ports.

This arrangement is, of course, radically different from the balanced solenoid valves very recently used on large Curtis turbine units. The steam ports open into nozzles, and closing of steam ports effects the shutting off of nozzles. There is thus no throttling action, as a nozzle is either wide open or closed. The regulation of speed with this governor with a street railway load varying from 150 to 500 kilowatts, operated together with the other services given by the company, consisting of 500-volt power service, incandescent lighting and induction motors, is within 0.14 per cent. At times the load would vary from zero to 1,500 amperes. In the second stage of the turbine there are two sets of ports with governor valves instead of one set as in the first stage. The current for the operation of the governor magnets is taken from the exciter circuit.

As to the high vacuum it is interesting to note that with a load of 1,000 kilowatts, and intake water at 72 degrees, 28 inches of vacuum have been maintained continuously. With the same load and cooling water temperature at 58 degrees, 28⅝ inches of vacuum has been maintained with the barometer reading 29¾ inches. During the winter months the vacuum has been maintained with but very few exceptions above 29 inches, and fluctuates only with the barometer. Readings within ¼ to ½ inch of the United States Government barometer readings are obtained at all times. This, of course, is with the cooling water in the neighborhood of 40 degrees Fahr. By closing the valve between the condenser and the vacuum pump, a vacuum within ¼ inch of barometer pressure has been obtained. A vacuum of 28½ inches has been recorded with the exhaust from both exciting engines going into the condenser, and the vacuum pump discharging into the condenser, and with the exhaust from the circulating pump engine going into the heater. A mercury tube and not a gauge was used in all these tests.

The Alberger surface condenser with which the turbine unit is equipped is supplied by a 15-inch centrifugal pump made by the same company. This centrifugal pump is driven by a standard Westinghouse 8½x8-inch engine direct-connected to the pump. The water is pumped from the hot well to the heater by a duplex pump. Circulating water is taken from a well open to the river. This well has cement walls 12 inches thick. The water is let in from the river through a 16-inch cast-iron pipe. The well is divided by a screen partition with ⅜-inch mesh, the inflow from the river being on one side of the screen and the suction from the circulating pump on the other side. The circulating pump suction is a 16-inch cast-iron pipe. A 16-inch free exhaust to the atmosphere is provided so that the turbine can be run non-condensing. The exhaust of the auxiliary engines can either be condensed or sent to the feed-water heater. Condensed steam from the turbine is used as far as it will go for feed water. The air cylinders of the vacuum pump are water jacketed. The jacket water is run into the feed-water supply, and furnishes sufficient extra feed water.

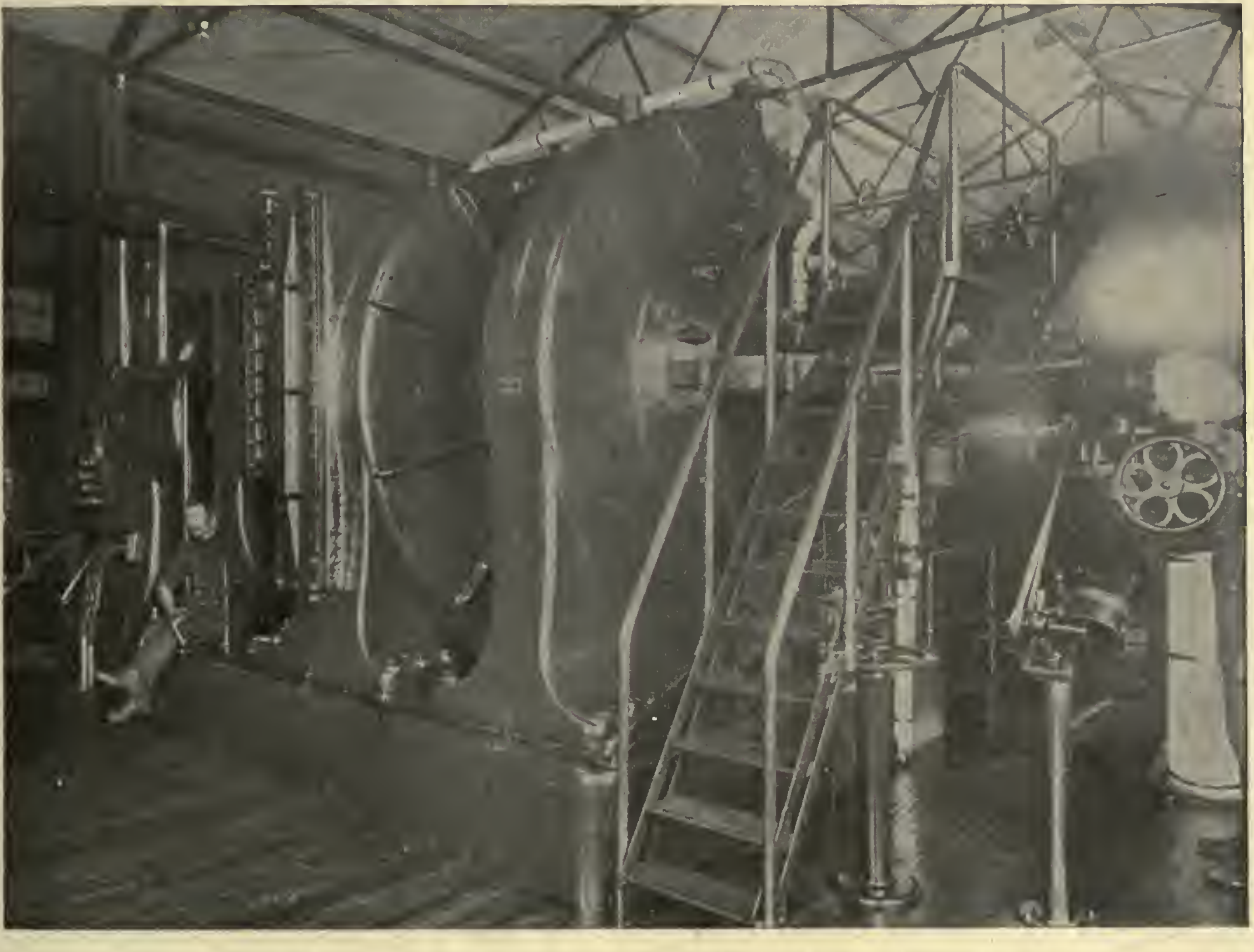
The steam pressure carried on the turbine unit is 150 pounds. Standard extra heavy pipe is employed, with brass corrugated gaskets. A receiver 5 feet long and 3 feet in diameter, made by the Jenks Ship Building Company, which erected the piping, is placed at the point where the live steam pipe enters the turbine. The drip is taken from the bottom of this receiver. The steam from the boilers enters near its top and the pipe to the turbine leaves directly at the top. A Kieley standard trap is used on the receiver. Crane valves are used throughout except the throttle valve on the turbine, which is a Chapman gate valve. The 6-inch air discharge on the vacuum pump is outside the building. As to long runs, two of the hardest months in the year, November and December, the turbine was operated almost 1,500 hours without stopping. It was then stopped to clean out the surface condenser. The turbine will maintain its speed and run at one-half its capacity with steam pressure at the boilers as low as 80 pounds.

In connection with this plant there is a very complete system for unloading, conveying and storing coal. There is a gantry crane operating on tracks running parallel with the dock front and spanning the coal yard. The surface equipment for hauling coal from the coal storage to the boiler room consists of a system of industrial railway and charging cars, designed and constructed by the Russell Wheel & Foundry Company, of Detroit, Mich. The outdoor tracks are laid 18 feet 6 inches between centers, covering the coal-storage space between the legs of the gantry crane, and connect by means of curves and switches to a track leading to the boiler room. All cars must pass over a two-ton capacity track scale of special design.

The outer tracks, 20½ inch gauge, are made up of 16-pound rail, spiked to oak ties. The curves are of special design, 12 feet radius to center of track, and made of cast steel. The tracks, curves and switches within the boiler room are of cast-iron, cast in plates, and arranged so that the full charging cars may stand in front of the boilers and the empties may be passed around them.

The charging cars are of malleable iron and steel, of 1½ tons capacity. The running gears are so designed that the cars run around the curves of 12 feet radius easily. The doors of the cars when lowered form an apron from which the coal is shoveled into the boilers. The ashes are removed by means of a 12-cubic-foot tip car, to vacant property across the street.

The gantry crane which operates on the track along the dock front is designed to unload coal from the holds of vessels and automatically convey it to a coal storage pile on the dock, the coal pile being 100 feet wide by 250 feet long and 20 feet high. To accomplish this the crane spans the coal dock, running on tracks on the ground level, 110 feet center to center, and the bottom cord of the bridge is 27 feet clear of the dock level, giving ample clearance for a coal bucket over the coal pile. The crane consists of a bridge with a movable apron, a back pier that supports the end of the bridge away from the water, and a front pier carrying the hoisting and traveling mechanisms and the operator's house. Both piers are carried on wheels and a power-driven squaring shaft running across the bridge is connected by means of sprocket chains to the driving wheels on each pier.



Horizontal Curtis Turbine Unit in the Port Huron Light & Power Company's Station.

The bridge and its hinged extension, the 35-foot apron, carrying a runway for a trolley, and supported from the trolley by means of the hoist rope is the hoist block to which is attached the coal bucket. On the front pier there is a platform upon which stands the operator's house. On the platform a scale is placed where the bucket can be landed so that each bucket of coal can be weighed before being stocked, if so desired.

When the crane has been placed opposite a hatch from which coal is to be unloaded, the apron is lowered, giving a 35-foot extension over the vessel's deck. The trolley carries a clam shell bucket of 2,000 pounds capacity, which is run out over the hatch and the bucket lowered into the coal. The trolley with its load is run back along the bridge to the dumping point, where the bucket is opened as it passes under the dumping trigger, the coal falling to the stock pile below.

In rehandling the coal from the stock pile to the cars that carry it to the boiler house, the crane is used in connection with a movable bin. This bin stands on a track of wide gauge and has a capacity of 40 tons, being sufficient to supply the power-house needs for 24 hours. The small coal cars run under it on a narrow-gauge track and are filled by opening a valve in the bottom. In the morning the bin is filled from the stock pile with the clam shell.

In unloading the vessels the motions of hoisting and trolley traveling occur every time a bucketful of coal is handled, while movements of the entire crane are necessary only when the crane moves from a hatch that it has just emptied to a full hatch. For this reason the machine has been given a hoisting speed of 100 feet per minute, a trolley travel speed of 600 feet per minute, and a crane travel of only 60 feet per minute. These speeds will enable a skilful operator to handle the buckets at the rate of one trip per minute from the hold of the vessel to the stock pile and return, and while the clam shell is in operation, only one man should be necessary in the hold of the vessel.

The coal yard being 250 feet long, it is not deemed advisable to rehandle the coal into a stationary bin, as this would make the operation a slow one, and as traveling the whole crane 250 feet to deposit one ton of coal in the bin would be too much like sending an elephant to pick up a peanut, the movable bin has, therefore, been adopted. One hour's work with one man in the operator's house and one man on the coal pile should suffice for rehandling all the coal necessary for the next 24 hours.

The crane has been built in three separate pieces; the front pier, the back pier and the bridge. At the front pier the bridge is suspended in such a manner as to allow it a limited motion in a horizontal plane about a king pin. At the back pier the bridge is allowed universal motion, this pier simply supporting the load. This form of construction permits the crane to automatically adjust itself to any reasonable track variations, and one pier can, if necessary, travel 4 feet in advance of the other before the wheel flanges will bind. The crane was designed and built by Whitehead & Kales Iron Works, of Detroit, Mich., and is flexibly constructed, yet having but two tracks.

The officers of the company are: Mr. Henry McMorran, president; Mr. Charles F. Harrington, vice-president, and Mr. W. F. Davidson, secretary and treasurer. Messrs. Field, Hinchman & Smith, of Detroit, were the mechanical engineers for the new plant.

Some Power Plant Details of interest are to be noted in the mechanical equipment designed by Messrs. Dean & Main, of Boston, for the New England Confectionery Company in that city. The steam pipes from each boiler, 6 inches in diameter, connect into a 12-inch header, where each is provided with a Walnwright expansion joint. The steam pressure is 145 pounds. The boilers are of the tubular pattern, 78 inches in diameter and 18 feet long, and have a total heating surface of 2,376 square feet, with a grate surface of 49 square feet. The main engine is operated condensing, with salt water for that purpose, and this is carried through cast-iron piping coated inside and out with tar. The unit has a 370-kilowatt Crocker-Wheeler generator and a Filer & Stowell engine and there are 40 motors aggregating 365 horsepower. A 50-kilowatt unit for night and noon-hour loads is driven by direct connected Ames engine.

Power Production and Transmission in the Stuyvesant Elevator, New Orleans.

The Yazoo & Mississippi Valley Railroad Company erected a grain elevator in New Orleans about a year or so ago for which the rope system of power transmission was adopted. It has a capacity of 1,500,000 bushels of grain, and a modern power plant was built just outside of the elevator proper, containing 1,500 horsepower in compound condensing engines for furnishing the power for operating both the elevator building and a system of belt galleries running from the elevator and along the wharf, the elevator being located near the Mississippi River.

The elevator proper is of the usual timber construction, with the main portion containing the bins and the headhouse or cupola given over to the garners and weighing hoppers and distributing conveyors and spouts. A feature of its construction is the use of Monier tanks in the ground, instead of steel tanks, to keep river water and seepage from the elevator boots. The bin portion of the building is 330 feet long and 100 feet wide, and the bins are mostly 14 feet wide on centers across the building and 15 feet lengthwise of the building. Above their hopper bottoms the bins are 60 feet deep, the bottom 30 feet being constructed of 8-inch cribbing and the upper part of 6-inch cribbing. They are supported at the corners by a group of 14x14-inch timbers in each case, making a forest of posts over the whole site, spaced on the 14 and 15-foot centers. Owing to the nature of the soil, piling had to be used and each group of posts rests on a separate set of piles on a foundation expanding to a bearing of 9½x6½ feet at the top of the piles. There are two railway tracks underneath the bins, extending, as usual, longitudinally through the building, and there are seven of the Monier tanks into which grain may be emptied from the cars. The headhouse above the top of the bins rises to a height of 83½ feet, and is 51 feet wide above the distributing spout story and 40 feet at the roof. The total height of the building from ground level is about 170 feet and from the bottom of the Monier tanks to the ridge of the cupola it is nearly 190 feet.

There are two elevator legs corresponding to each Monier tank, fourteen in all, which elevate the grain to the garners in the upper part of the cupola, from which in turn it is passed into the weighing hoppers and thence distributed by trolley spouts or a belt-conveyor, or by a combination of both, into any one of the 145 bins. The building is provided with an automatic sprinkler system, with Grinnell sprinklers. The system is maintained under pressure from a tank supported above the ridge of the cupola, and it is connected with a fire pump in the power-house.

One engine in the power-house, of 1,200 horsepower capacity, is reserved for driving the machinery in the elevator. An 8 7/16-inch countershaft in the power building is continued into one end of the elevator and at that point there are three rope sheaves, one for driving the shovels in the bottom of the elevator, one for driving the headhouse machinery, including the elevator legs, and a third for a fan in the first story. The drive from the engine to the countershaft consists of 14 lines of 1¾-inch rope, run at about 4,500 feet per minute. The headhouse is connected with this jack shaft, which is driven at 120 revolutions, by thirteen lines of 1¾-inch manila rope, carried to a driven sheave in the top story of the headhouse, 152 feet distant from it. Both the driving and driven sheaves are 120 inches in diameter and the shaft speed in both cases is thus 120 revolutions per minute. The American system of rope transmission is employed, so that the rope is in one continuous line and tension as well as idler pulleys are employed.

The cupola line shaft carries fourteen sheaves placed in pairs for the fourteen elevator legs, a pulley for driving the passenger elevator at one end of the elevator, a sheave for the belt conveyor in the lower part of the cupola and a sheave for the fan drive. In the case of each of the rope sheaves a friction clutch is provided, these having a capacity of 55 horse-power for each elevator leg, a capacity of 35 horsepower for the belt conveyor drive and of 60 horse-power for the fan drive. The shaft has a total length of 316 feet and ranges in size from 8 7/16 inches to 3 15/16 inches and is supported by 31 bearings. This makes a total of 865 horsepower connected to the shaft, based on the ratings of the friction clutches, not including the drive for the passenger elevator. Each of the drives for the elevator legs comprises seven lines of 1¼-inch rope running from a 30-inch sheave on the line shaft to a 116-inch sheave on the shaft for each elevator, reducing the speed of this shaft to about 31 revolutions per minute. The shaft is 4 5/16 inches in diameter and carries two bearings and a 21-inch face pulley over which is passed the elevator itself. For this purpose it is covered with 4-ply rubber. The pulley having a diameter of 84 inches, the elevator has a linear velocity of about 650 feet per minute. Its capacity is 12,000 bushels per hour.

The belt-conveyor is driven from a three-groove 60-inch sheave and the ropes are carried down to the driving shaft of the conveyor, likewise arranged to run at 120 revolutions per minute. This carries the driving or head pulley, which is 30 inches in diameter and rubber covered. The belt, which was furnished by the Boston Woven Hose Rubber Company, is thus driven at a speed at about 1,000 feet per minute. The rope drive to it is arranged with two friction clutches on the conveyor floor so that by the use of one or the other the direction of the belt may he reversed.

The shovel line shaft in the first story of the elevator is driven by eight lines of 1¼-inch rope at a speed of 65 revolutions per minute, and a single friction clutch of 85 horse-power capacity is fitted next to the driven sheave so that the entire shaft is controlled from one point. It is 301½ feet in length, and ranges in size from 4 7/16 inches to 2 15/16 inches and is carried by 22 bearings.

The belt system for serving the wharf comprises a gallery along the wharf, some 1,400 feet long, and two belt galleries connecting the elevator with the wharf gallery. These connecting galleries are run at an angle with the elevator, so that while 235 feet apart in the elevator building, they enter the wharf gallery at two points 850 feet apart. One of these is 447 feet in length and the other is 540 feet. Each of them carries two belts and is arranged to discharge upon two belts in the wharf gallery, one belt discharging upon a belt moving in one direction from the connecting point and the other belt upon a wharf belt running in the opposite direction from the connecting point. The connecting galleries of this marine system are sloped upward from the elevator building to the wharf. At the elevator the belt gallery is 16 feet above ground and at the wharf line 52 feet, making a rise of 36 feet.

The drive for the marine galleries is, as stated, obtained from a separate engine in the power-house. This, as indicated in the accompanying engravings of the power building, drives an overhead countershaft from which is carried two lines of rope, one to one of the connecting belt galleries and the second to the other. The belts in each gallery are enclosed in a covered bridge and the rope drives are run underneath the bridge, with a suspended walk by which access may be had to the rope sheaves and bearings. The rope drive for each belt gallery is carried from the power-house to a point underneath the connecting gallery and then run longitudinally with it. At the connecting point with the wharf gallery an elaborate system of turns has been developed, for here the two belts for each connecting gallery is driven and also the two belts running in opposite directions from that point in the wharf gallery. The ropes are driven at a speed of 2,375 feet per minute and the belts at 1,080 feet per minute. They have a capacity of 18,000 to 20,000 bushels per hour. The belt in the wharf gallery is connected with the corresponding belt in the connecting gallery by means of a short chute, into which the latter belt empties and which, bent round, delivers upon the wharf belt. Along the wharf there are some 30 discharging spouts for loading vessels and there are a number of trippers, built by the Webster Manufacturing Company, which furnished the belt conveying system throughout. The trippers are run along the belt opposite any desired spout, in the usual way. The loading spouts have telescoping sections and a hand hoisting system of ropes by which they can quickly be placed in position for the delivery of grain into a vessel alongside the wharf.

The lengths of rubber belt are wired together as it has been found that rats cut through ordinary lacing. The belts of the marine system are 36 inches in width and that in the elevator cupola 38 inches, and they are run on the so-called concentrating rollers. For transferring the grain from the cupola belt to any one of the universal spouts above the bins a reversible tripper is used, as required from the fact that the belt is installed for operation in both directions.

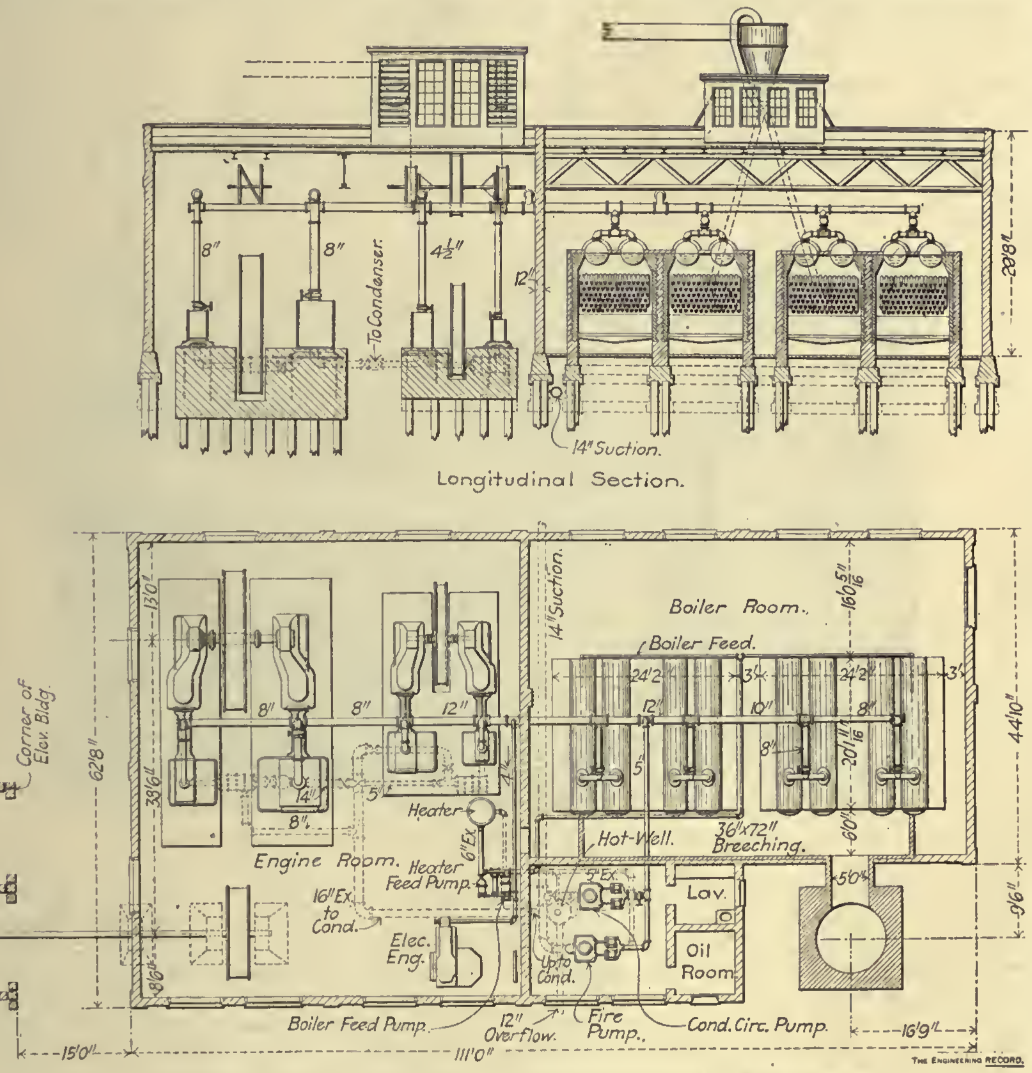
The power-house is arranged as shown in the accompanying plan, with boiler and engine rooms end to end, so that the steam main over the boilers is run directly into the engine room. The boilers are of the water-tube type and the engines are run condensing, but a feed-water heater has been provided as usual for the utilization of the exhaust steam from the auxiliary machinery. The condensing equipment, together with the fire pump, is located in a separate room back of the boiler room, as shown, and the smokestack rises outside of the building.

The boilers were built by the Aultman & Taylor Machinery Company and are set in two batteries of two boilers each. The walls, as indicated in the longitudinal section, are carried on piles, the back, front and bridge walls in the same manner as shown for the side and center walls. As indicated in the section engraving of the boiler room, arrangement has been made for burning the dust collected in the elevator building. The collecting cone has been placed in the monitor over the boiler room and two spouts are run from the bottom of it through the fronts of two of the boilers. The products of combustion are carried from the boilers in a brick breeching supported overhead back of the boilers, so that the floor space is entirely accessible all around the boiler settings. The chimney is 5 feet in diameter and 175 feet high. A boiler pressure of 125 pounds is normally carried. It will be noted that the boiler connections into the steam header are made in the bottom and, as usual, the branches to the engines are taken from the top. In the total length of header, some 95 feet, there are no valves.

In the engine room there are two main horizontal cross compound units built by the Vilter Manufacturing Company, of Milwaukee, and a simple engine for lighting purposes, built by the Ball Engine Company, of Erie, Pa. The engine for driving the machinery in the elevator has cylinders 24 and 48 inches in diameter with a 48-inch stroke and runs at 80 revolutions per minute. The engine for the marine conveyers has 14 and 28-inch cylinders with 28 inches stroke and runs at 100 revolutions per minute. The plan drawing shows in dotted lines the steam connections between cylinders, by which steam passing into the receiver from the high-pressure cylinders may be conducted either into the low-pressure cylinder, or when necessary, into the main exhaust directly. Both high and low-pressure cylinder has a direct connection from the main steam header and there are ,in each case, two valves in both branch pipes. The exhaust connections are all carried underneath the floor line and the main exhaust is passed into the condenser room, where it rises to a point above the roof to the condenser, which is of the syphon type. The lighting unit comprises a 10x12-inch engine, run at 300 revolutions and direct-connected to a Milwaukee dynamo of 40 kilowatts capacity at 125 volts. The engine room has a concrete floor, white painted brick walls with black wainscoting around the lower part and black painted roof trusses. A lantern has been provided in the roof and through this are taken the rope drives from the smaller engine for the marine conveyors.

The circulating water for the condenser is handled by a Fairbanks-Morse 10x14x12-inch duplex pump and the discharge of the condenser falls into a hot well. The feed water may be taken from this, but it is ordinarily received from an 18-inch artesian well 725 feet deep. The water stands within 12 feet of the top. A 7x4½x10-inch Fairbanks pump discharges the well water into the heater, which is of the vertical open type, and one of two 12x6x12-inch duplex pumps delivers into the boilers. The latter are installed in duplicate and with the heater are located in the engine room. The fire pump is an 18x10x12-inch Blake pump of 1,000 gallons capacity.

The elevator was built by the George B. Swift Company, of Chicago, Mr. George F. Jenkins, superintendent, from the designs of Mr. E. Lee Heidenreich, consulting engineer, of Chicago. It is known as elevator E of the Stuyvesant docks at New Orleans.



Power Plant for Grain Elevator, Stuyvesant Docks, New Orleans.

Fires in Coal Piles.

In answer to a question regarding experience in the prevention of fires in coal piles, the Home Insurance Company of New York, submitted to the New England Association of Gas Engineers at a recent meeting in Boston an opinion on the subject, which is of sufficient interest to warrant publication in part.

The liability to spontaneous ignition and combustion appears to be most marked in free-burning or so-called high-steaming coals which usually contain a large percentage of volatile constituents in combination with a modicum of oxygen; and in this class the tendency to spontaneously heat is particularly aggravated when impurities such as lignites of sulphur in any of its forms, but especially when in the nature of iron pyrites, are present in the mass. Dirty or unsorted coal, known as mine-run, presents the most decided tendency to heat, regardless of any specific trade name or grading as to quality when sorted, and the comminution of such coal accentuates the probability of spontaneous heating. When the lot is stowed away the finer particles are prone to sift through the mass and form the bottom of the pile, where they become subject to the effect of pressure and consequent heating.

The best authorities of the present day appear to be agreed in the conclusion that heating is ascribable to chemical change in the substance resulting from the absorption of oxygen, and that this absorptive quality of the carbon constituents of the coal increases with any rise in temperature of the mass however produced, whether through chemical action due to slow oxidation, or as the result of the mechanical force exerted through the pressure of the mass, due to height and volume and that the conditions thus arising are considerably stimulated in action by the presence of pyrites or moisture. It has been assumed by some authorities that anything in excess of 2½ per cent. of sulphur is indicative of danger in respect to heating.

Practical experience in coal fires ascribable to spontaneous combustion seems to indicate a native, but varying propensity to heat in the several classes of bituminous coal in general use in the Eastern and Middle States in about the following order of susceptibility: Nova Scotia, or Dominion, Pocahontas, New River, Clearfield, Berwind-White, Pittsburg, Georges Creek. So far as specific records and information may prove a guide, there has never been a fire properly ascribable to spontaneous combustion in the Georges Creek grade of coal.

The experience gained in the handling of coal used and stored by steam railroads seems to have demonstrated the following points as tending to minimize if not to entirely prevent the occurrence of serious self-ignition fires:

Accumulations of bituminous coal in any one pile, heap, pocket or bunker should in no case exceed 1,500 tons in volume.

Where more than one accumulation of such or less volume is necessary at contiguous localities, there should be established a clear space of not less than 5 feet between the piles, and this space should be maintained absolutely free for complete ventilation and dispersion of occluded gases from the mass.

No accumulation of coal, of 1,500 or less tons in volume, should be piled in excess of 12 feet in height when "trimmed off" or "squared," but where such accumulation is delivered from dump-cars on trestle over 12 feet in height, the extreme height of the pile, formed by the natural run of the coal as dumped from the cars, should not exceed 15 feet to the apex of the triangle of coal produced by this method of deposit.

All accumulations of bituminous coal, whether large or small, should be rod tested with frequency and regularity, in order to discover any tendency toward dangerous heating; the degree of such danger line should be set at about 160 degrees Fahr. When this temperature has been reached the exact locality of increasing heat may be designated by the use of iron piping inserted into different sections of the mass, into which piping a self registering thermometer should be lowered and allowed to remain for sufficient time to record the intensity of heating, thereby enabling prompt measures of relief to be undertaken by those in interest, without waste of time and unnecessary handling and shifting of material to locate trouble.

While it is not at present probable that shippers of bituminous coal make it a practice to advise consignees of the percentage of sulphur or its compounds which are known to exist in shipments, it is very desirable that such information should be had, in view of the apparent consensus of expert opinion that the presence of this deleterious material tends to an increase of fire hazard.

The Greenfield Street Railway Bridge.

The Greenfield & Deerfield Street Railway crosses the Deerfield River, between Cheapside and Greenfield, Mass., on a bridge about 503 feet long from center to center of abutments and about 30 feet in clear height above low water level. The low water channel of the river is about 270 feet wide and 15 feet deep in the middle, and in it are built piers 2 and 3, 141½ feet apart on centers. These piers and the similar piers 1 and 4 carry three single-track through steel-truss spans, 140 feet long on centers. The main spans are on a tangent, but the single 20-foot approach span at the Greenfield end and the 30-foot and 28½-foot approach spans at the Deerfield end are deck skew spans each made with two lines of 18 or 24-inch I-beams. The trusses are 22 feet deep and 15 feet apart on centers built of medium open-hearth steel and proportioned for an assumed dead load of 800 pounds per linear foot and a moving load of 1,400 pounds per linear foot, or for concentrated loads according to the specifications of the Massachusetts Railroad Commission, under whose inspection the work was built.

The main span trusses are built entirely of stiff members with field-riveted main connections. The depths are somewhat greater than the usual proportions and the lateral bracing was made ample, as the bridge is intended to be rigid under heavy loads, without undue vibrations under traffic, thus avoiding troublesome speed restrictions. The top-chords and end posts are of the standard cross-section made with two 9-inch channels and one 14-inch cover-plate. The vertical posts all have I-shaped cross-sections made with two pairs of angles back to back latticed, and the diagonals have U-shaped cross-sections made with two angles latticed. The bottom chord has an I-shaped cross-section made with two pairs of angles riveted back to back and connected by lattice-bars and short web plates in a horizontal plane.

The transverse depths of the lower chords, vertical posts and diagonals are made equal so that the connection plates shop-riveted to the flanges of the lower chord and to the webs of the top chord channels form jaws receiving the ends of the verticals and diagonals. Each top and bottom chord was shop-riveted in three lengths. All other members were shipped separately. The trusses have end-pin bearings in fixed and sliding shoes. The sway-bracing consists of transverse lattice-girder struts 3 feet 8 inches deep made with pairs of 3½x3½-inch angles for the flanges and single 2½x2½-inch diagonal angles. They are riveted with end flange angle connections to the flanges of the vertical posts and to the webs of the top chords, and at the lower ends are kneebraced to the vertical posts by pairs of angles about 4½ feet long.

The portal struts are similar to the intermediate struts, except that they are 5 feet 4 inches deep and that their connections to the end posts and top chords are made by web plates riveted to the cover-plates. The top laterals consist of X-bracing in each panel and are made with single 2½-inch angles riveted to horizontal connection plates engaging the top flanges of the chords and transverse struts. The angles are all in the same plane and one in each panel is made continuous, while the other is cut to clear it and spliced by the connection plate, which is also riveted across the continuous angle.

The bottom laterals are single 3x3-inch to 5x3-inch angles riveted to horizontal plates connected to the lower flanges of the floorbeams, and by shelf angles to the vertical flanges of the lower chords. Their vertical flanges are all turned downwards and the horizontal flanges are riveted to the stringers at intersections. One angle in each panel is made continuous, and the other is cut to clear it and spliced with a 5x3-inch angle on the horizontal flange and a 3x3-inch angle on the vertical flange, both of them being also riveted to the continuous angle. The floorbeams are 20-inch 65-pound I-beams with fourteen ¾-inch rivets at each end through their vertical connection angles and the gusset plates at the lower chord panel points. The stringers are two lines of 18-inch 55-pound I-beams 6 feet apart web-connected to the floorbeams with fourteen rivets at each end. Their lower flanges are flush with those of the floorbeams and they are braced by zigzag 2½-inch angles just above the center lines.

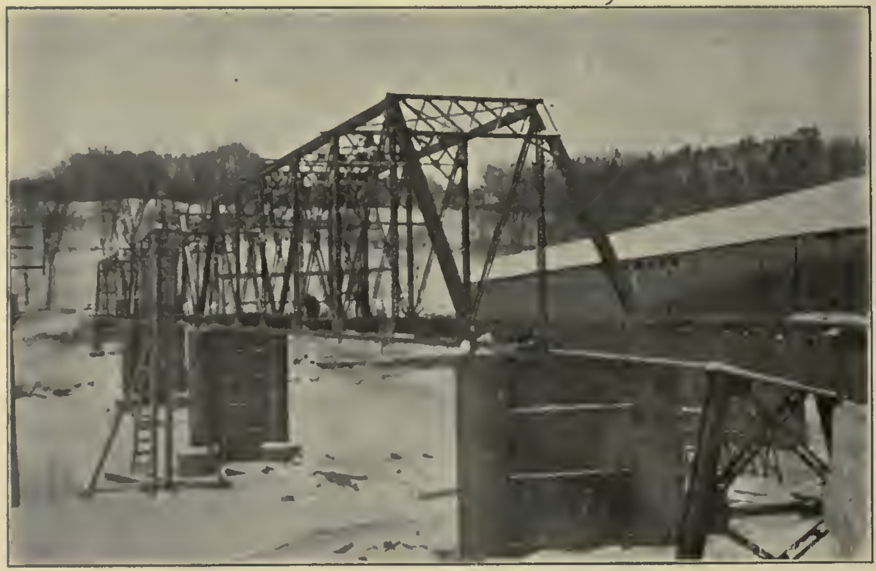
In the deck approach spans the main girders serve as stringers to support the 5x7-inch oak ties 12 inches apart on centers, and are braced together by zigzag lateral angles and by sway-brace frames at the ends and at the middle points. At one abutment the sliding ends of the approach girders are seated on cast-iron bed plates which have the upper surface corrugated and planed to receive the beam flanges. Here the lower flanges of the girders have slotted holes 3 inches long for 1-inch anchor bolts with round holes in the bed plates. The fixed ends of the girders rest on steel base-plates 16 inches square.

The adjacent ends of the two approach spans at the Deerfield end of the bridge are supported by a single steel trestle bent 14½ feet high. It has two columns battered 7⅜ inches to the foot and connected together by top, bottom and intermediate horizontal struts and by X-bracing in each of the two panels. The inclined columns have I-shaped cross-sections made with two pairs of 5x3-inch angles back to back latticed and having horizontal cap and base-plates riveted to the milled ends. The outstanding flanges of the column are in a transverse plane and connection plates are shop-riveted across both sides of them to form jaws receiving the horizontal and diagonal struts. All struts have U-shaped cross-sections made with pairs of angles connected by tie plates, and at the ends their flanges are field-riveted between the jaw plates. One diagonal in each panel has the flanges of the angles reversed so as to clear the intersecting diagonal, to which it is field-riveted.

The piers under the truss spans are each made with a pair of steel cylinders on the center lines of the trusses connected by a solid vertical transverse diaphragm plate. Piers 2 and 3 were sunk to a much greater depth than the end piers and are made with enlarged lower portions, as shown in the drawings. They have a total height of 44 feet to the bottom of the cylinder and their tops are 29 feet above low water level and 2 feet above high water level. For each pier two clusters of thirteen piles each were driven and cut off 5 feet below low water level and 8-foot cylinders 17 feet long were sunk around these piles to a depth of about 5 feet below the river bottom. The 4-foot upper cylinders 31 feet long and 15x15-inch vertical timbers 19 feet long were then centered in the lower cylinders with the base of the upper cylinder 4 feet below the top of the lower cylinder, as shown in the drawings. Both cylinders were filled with 1:2:5 Portland cement concrete sloped up from the top of the lower cylinders so as to form a conical surface enclosing the foot of the upper cylinder. The cylinders were capped with octagonal steel plates ⅜ inch thick and 4 feet 8½ inches in diameter bolted through slotted holes to the top flanges of the cylinders. The bed plates for the pedestals of the trusses and girders were bolted to the cap plates, and bearing for the latter was insured by thoroughly grouting the top of the concrete in the pier.

The 4-foot cylinders are made with 5-foot courses of 5/16-inch plates having vertical and horizontal butt joints covered with single shop-riveted splice plates. The lower cylinders are of similar construction, except that two upper courses are 6 feet high. In both cylinders the metal is 5/16 inch thick, and there is ¼ inch clearance at all joints. The connecting diaphragms are made of 5/16-inch plates 5 feet high and about 11 feet long. They are spliced by horizontal cover-plates on both sides and have a single stiffening angle riveted on each splice plate. The connection to the cylinders is made with pairs of 3x3-inch vertical flange angles shop-riveted to the diaphragms and field-riveted to the cylinders. The upper diaphragm plate serves as a transverse girder to receive the ends of the stringers on kneebrace brackets riveted to the vertical web stiffener angles.

The piers under the shore ends of the spans are similar to the upper parts of the pier just described, except that they are shorter. Each one has a 4-foot cylinder enclosing five piles. In one of them the cylinders are 25 feet long and are connected by four courses of diaphragm plates. In the other the cylinders are 16 feet long and are connected by two courses of diaphragm plates. The four cylinder piers and bracing contain about 45 tons of steel. The superstructure weighs about 145 tons, and was built for the Bay State Construction Company, Clapp & Abercrombie, engineers, by the United Construction Company, Albany, N. Y., Mr. J. R. Watt, president, and Mr. Walter R. Marden, vice-president and chief engineer.



Street Railway Bridge over Deerfield River, at Greenfield, Mass.

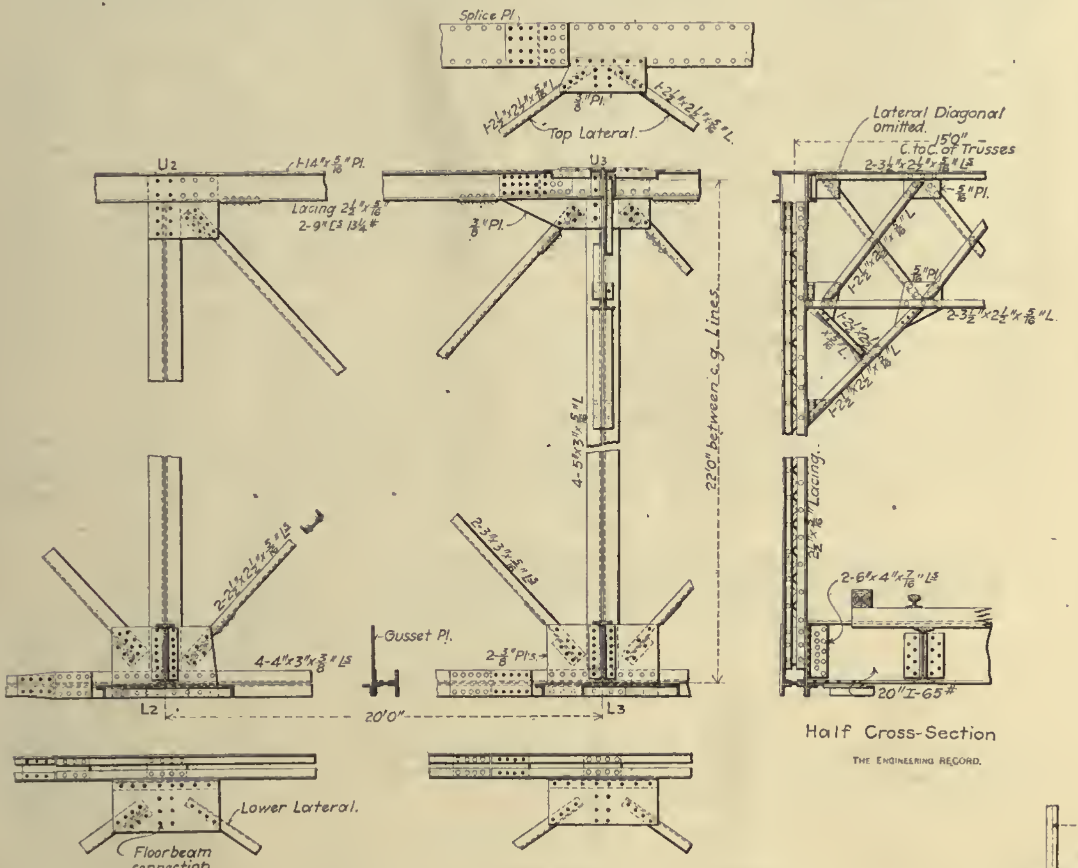
The Proposed Ferry Bridge at Bordeaux.

A high level steel bridge of unprecedented arch span has been proposed to carry a heavy highway traffic across the Gironde River, at Bordeaux, France. It will be of the transporter type, of which several examples have already been built abroad and some are proposed for this country, notably at Duluth, and will combine a high level foot bridge with a movable low level wagon platform or ferry car which is intended to give practically uninterrupted passenger service without obstructing navigation and with a minimum cost for superstructure. Elaborate plans have been detailed by Messrs. Dayde & Pille, the eminent French engineers and contractors, who have built many important works abroad, and "The Engineer," London, which describes the design, believes that the bridge is likely to be constructed.

There is a single arch span with two steel trusses which have a clear span and rise of 1,312 feet and 328 feet, respectively, dimensions far exceeding those of any arch ever built. The trusses are in vertical planes 80 feet apart on centers and are seated on masonry piers 100 feet wide and 1,412 feet apart on centers, which also carry the portal towers 1,394 feet apart on centers and about 150 feet high to the bases of their finials. The trusses are of a peculiar form, which is claimed to be entirely novel. The top and bottom chords intersect at the crown and at points near the haunches, thus dividing each truss into four sections hinged at the nodes and making the two center portions of the truss act as a three-hinged arch supported on long inclined trusses reaching to the abutments. The ends of the top and bottom chords have fixed seats on the piers at the same level, and at this point the trusses have a radial depth of about 60 feet. The maximum radial depth of the trusses between haunches is about 40 feet, and the rise of that portion is about 170 feet on pin centers. The distance between lower pins is 990 feet, which may be assumed as the span of a secondary arch rising from the end portions of the trusses at the roadway level.

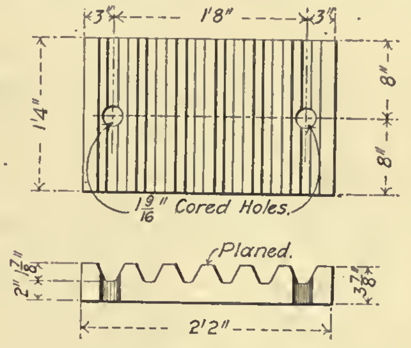
Above the lower hinges the trusses are braced together with horizontal transverse struts and X-bracing, and from each lower chord panel point there are two transverse diagonal sway-rods to points on the suspended girders. Each chord is practically composed of two unbalanced plate-girders 28 inches deep with their flanges unequally reinforced. Vertical members have I-shaped sections made with a web plate, four flange angles and two wide flange cover plates.

The diagonal members and all of the wind braces have rectangular cross-sections made with four angles latticed. The lower portions of the main trusses between the end haunches and the portal towers are connected together only by heavy horizontal-transverse struts at the tops, thus leaving the space between them free of bracing so as to clear the suspended car which is free to move to the portal towers. At the lower chord panel points of the upper portions of the trusses, vertical suspenders 41 feet apart support a horizontal platform just below the lower hinges and the tops of the portal towers. This platform serves as a foot bridge and to carry the tracks for the transporter car,

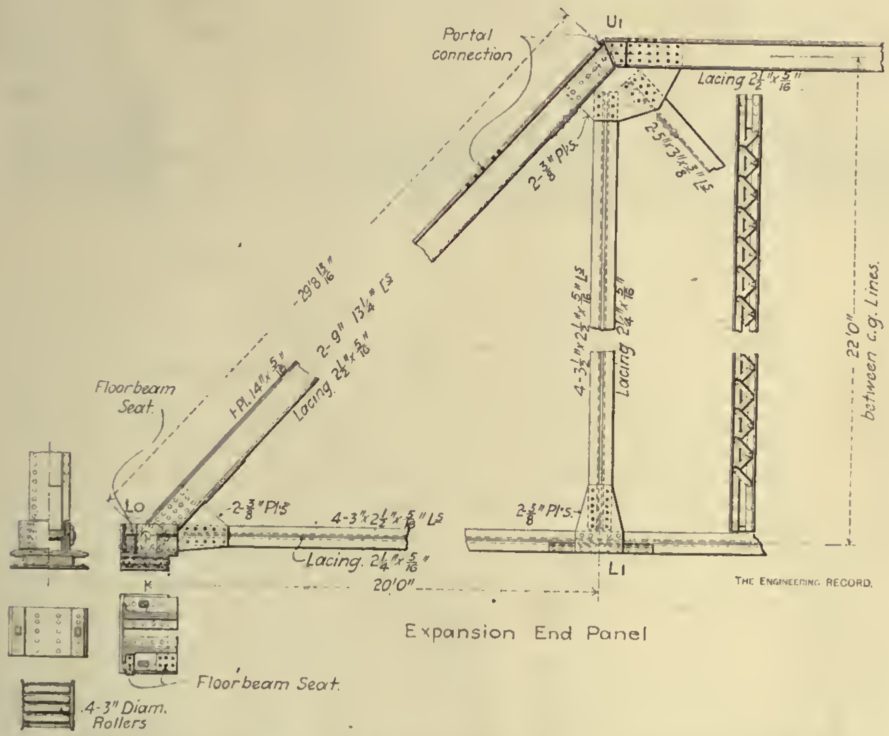


Half Cross-Section

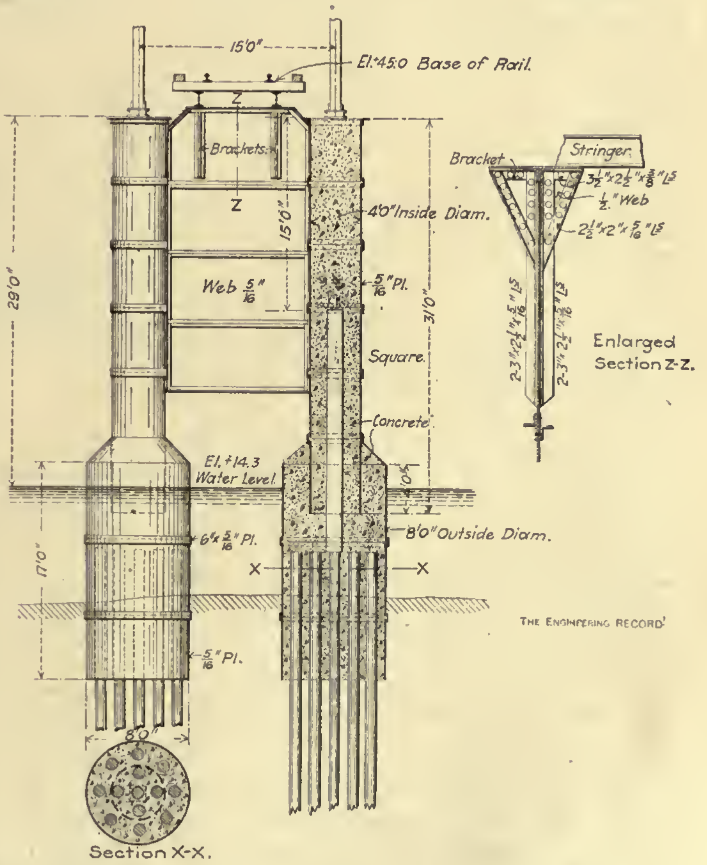
Typical Panel and Principal Members.



Cast Bed-Plate.



Expansion End Panel



Section X-X.

Enlarged Section Z-Z.

STREET RAILWAY BRIDGE AT GREENFIELD: DETAILS OF TRUSSES AND CYLINDRICAL PILE PIERS WITH DIAPHRAGMS.

and is intended to have great lateral rigidity so as to transmit the wind stresses to the portal towers. It is composed of two horizontal plate-girders 88 feet deep with flanges made up of 3½x3½-inch angles and several 12-inch cover-plates. It is supported on plate-girder floor-beams with latticed webs at panel points. Horizontal X-brace angles connect the flanges so that the construction is very massive and is equivalent to a box-girder made up with a combination of horizontal plate and lattice-girders.

A 72x39-foot transporter car is suspended by diagonal rods from the trolley with 64 wheels running on tracks suspended from the horizontal platform. These tracks have I-shaped stringers with the horizontal flanges of their lower flange angles turned upwards to carry the 2x2-inch solid square rails. Each car has a capacity of 100 tons, and with 150-horse-power motive force is calculated to make a round trip, including loading and unloading, in twelve minutes. The end towers will be provided with stairs and elevators to give access to the finished foot bridge, and an inspection and repair walk will be built on the lower chords of the arch trusses.

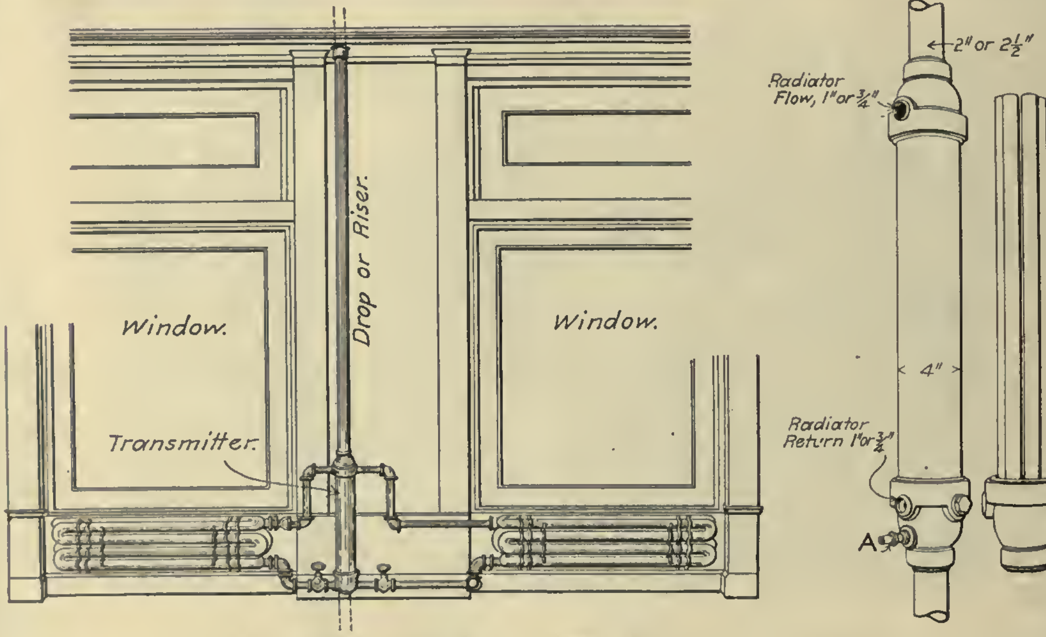
Combined Steam and Hot Water Radiation.

In the Union Trust Building in Providence, a twelve-story office structure, there is installed a system of direct radiation for heating, which may be operated with hot water or steam, at will, from a system of low-pressure steam mains. If the system is regarded, for the purpose of explanation, at the instant that steam is first admitted, both mains and radiation will be filled with steam. The condensation gradually formed is not, however, allowed ordinarily to pass into the return system until the radiators are entirely filled, and by means of a transmitter, so-called, the radiation is thereafter kept full of water so that, except when otherwise desired, the radiation is operated on the hot-water system.

Reference to the accompanying illustrations will assist in explaining the apparatus, which is the subject of a patent, held by Messrs. Lynch & Woodward, of Boston, who were the engineers and contractors for the heating installation in this building. In the present case the overhead system of steam distribution is employed, and the radiators, whether of the ordinary type or of groups of coils, are located under the outside windows, and the steam supply pipes are drop lines fed from a system of mains in the attic of the building. The steam supply pipe to each radiator is not, however, connected directly into it, but delivers into the transmitter, from which, in turn, is run the supply pipe to the radiator. The transmitter virtually consists of an enlargement of the drop pipe, constructed of 4-inch pipe about 2 feet long, with special reducing connections at top and bottom for attachment to the drop pipe, as indicated in the sketches. In general, in this building, two radiators are supplied from each drop pipe, and from the top of each transmitter are two openings for the flow pipes to the radiators and at the bottom the two return connections from them. The opening from the transmitter to the continuation of the drop pipe is not made directly from the bottom, but through the top of the group of pipes supported within the transmitter, as shown, one view being the transmitter assembled and the other the transmitter with casing removed.

The operation is as follows: Steam admitted in the first place fills the transmitter and can pass from the upper openings into the radiator and entirely fill it. The condensation gradually formed enters the transmitter at the bottom. The water having no means of egress, rises in the transmitter and, of course, in the radiator, until the tops of the inner group of pipes are reached, when the water will overflow into those pipes and in that way reach the drop pipe continuing from the bottom of the transmitter.

As shown in an accompanying sketch giving the connections for a pair of windows, it will be noted that the transmitter stands higher than the radiators, so that the pressure head of the water in the radiating coils is approximately about 1 foot. The steam passing through the drop pipe heats the water surrounding the group of tubes in the transmitter, and the water thus heated starts a local circulation from the transmitter through the coils and back again. For regulation one valve only is provided for each radiator, and this is inserted in the return pipe so that the velocity of the circulation can be varied to suit the temperature conditions. It will thus be seen that the system is one providing for hot-water radiation with its comparatively low local temperature and capability of regulation for different conditions of the weather and yet without a large volume of water filling the long system of both mains and branches in the tall building.



Hot-Water Radiation Supplied by Steam Main, and the Transmitter.

At the point A, in the sketch of the transmitter, is a valve by which water may be discharged directly from the radiator into the drop pipe. This allows for operating the radiation on steam, and the apparatus is thus equipped by this provision for meeting unusually severe states of the water, when the hot-water radiation might not prove equal to transmitting the large amount of heat transmission then necessary. In the case of the Union Trust Building, a 2½-inch drop pipe supplies the radiation on every one of twelve stories, about 2,000 to 2,400 square feet all told. This gives each transmitter capacity to carry 200 square feet of radiation.

The heating apparatus in the Union Trust Building is supplied from two tubular boilers 54 inches in diameter and 13 feet long, that contain 63-inch tubes 12 feet long. They deliver into a 6-inch pipe which is continued vertically through the building to the attic. Here some eleven drop pipes are supplied, for the radiation set around the exterior walls. The bottoms of the drop pipes are connected into a system of return mains which are collected into a 2-inch pipe at the boilers. There are 7,462 square feet of radiation in the building, supplied, as outlined, by a 6-inch steam main and a 2-inch return main. It is stated that only one boiler is required in the severest weather. Data are not yet forthcoming regarding the performance of the present winter, but it is said that during the entire month of January the average daily consumption of coal was less than 1,500 pounds. The heat is kept on the building throughout the 24 hours. This indicates a consumption of about 1/5 pound of coal per square foot of radiation per day. The cubic contents of the building amount to 419,000 cubic feet, so that the corresponding daily coal consumption is 3.6 pounds per 1,000 cubic feet. It should be stated that some of the steam is condensed in indirect heating coils in the basement in connection with a blower system of ventilating the banking rooms on the first floor. Briefly, this comprises a 50-inch Sturtevant fan, driven by a direct-connected 3-horse-power motor and the usual heater coil. The motor is a 500-volt direct-current motor of the enclosed type, with field regulation. The ventilating unit is designed to deliver about 3,000 cubic feet of air per minute, and the banking room having 50,000 cubic feet of space, is provided with ventilation at the rate of four changes an hour, if dependence is placed on the fan alone.

Since the foregoing was written, further information has been received concerning the coal consumption of the plant. From October 1 to April 1; 409,090 pounds of coal were burned. One-half of this was No. 3 red-ash buckwheat and one-half New River steam coal. Without considering the fan coil heater, which comprises 1,000 linear feet of 1-inch pipe coils or 345 square feet of surface, 54.8 pounds of coal were burned during the six months per square feet of radiation. The average daily consumption per square foot of direct radiation, based on the six months' experience, was 0.3 pound of coal. The grate surface under each boiler is 20¼ square feet and the heating surface 624 square feet. As one boiler only was used at a time, this means for the average of 2,235 pounds of coal burned per day that 4.6 pounds of coal were burned per square foot of grate per hour, this figure, it must be remembered, being based on the fact that the apparatus is in operation throughout the 24 hours. For the season of 1902-3, that is from October 1, 1902 to June 1, 1903, 243 days, the average daily coal consumption was 1,740 pounds. This is roughly equivalent to one pound of coal per cubic foot of the building contents over 240 days of a heating season more nearly an average one than the present severe winter.

The cost of the heating plant, including the boiler setting, fan, heating and ventilating apparatus complete, was $11,916. On the basis of the cubic contents of the building already stated, the cost of the heating installation per cubic foot of contents was thus 2.84 cents.

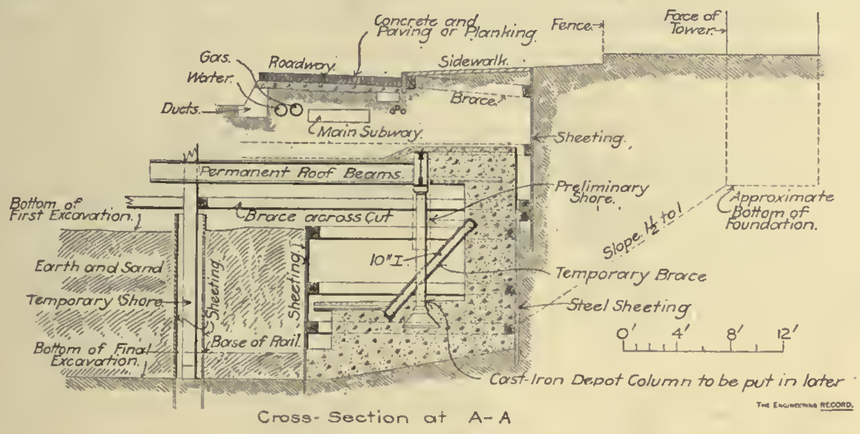
Safeguarding the Foundations of Trinity Church Spire, New York City.

The spire of Trinity Church on lower Broadway, New York, is noted for its height and beautiful proportions. It rises about 284 feet above the street and has heavy masonry buttresses extending to points about 15 feet horizontally from the excavations for the subway now under construction by the Rapid Transit Railroad Commissioners, the width of which is here greater than the normal so as to provide for a station platform opposite the church. The concrete foundations of the tower are carried to a depth of about 10 feet below the surface of the ground and are believed to extend to within about 9 feet of the subway extension, which is to have an eventual depth of about 23 feet at this point. The soil here is dry sand varying from coarse to very fine. The theoretical slope line, or line of repose, drawn from the nearest point of the foundations intersects the lower corner of the subway excavation, and on account of the great height and weight of the spire and the possibility of undermining the footings by any movement of the soil which might result from the sand running into the excavation special provision has been made to prevent any possible disturbance of the sand outside the trench. This is accomplished by driving a wall of steel sheeting along the edge of the subway in front of the spire before the excavation is carried below the level of the foundations of the spire. This sheeting will be thoroughly secured by horizontal transverse braces as the excavation is continued, and will remain permanently in the ground after a very heavy concrete retaining wall has been built against it in the trench.

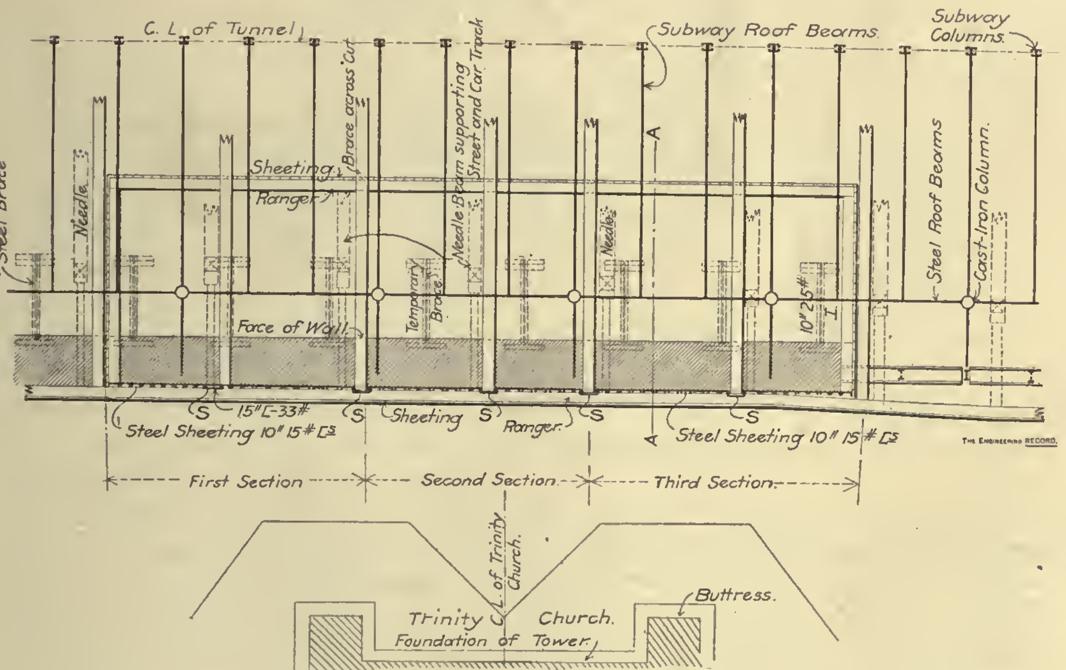
In front of the church the upper part of the trench has already been excavated to a depth of about 11 or 12 feet by the methods described in The Engineering Record of October 24, 1903. The sides of the excavation are retained by ordinary sheet piling and the pavement, sidewalks, street-car tracks, pipes and conduits are supported from needlebeams carried by vertical shores set in pits dug down to sub-grade, as indicated in the cross-section. This leaves a working space under the street where a 17x56-foot rectangular area opposite the tower will be braced and sheeted as indicated in the drawings. On the side adjacent to the tower the sheeting consists of 10-inch channels 12 feet long driven by hand, with the backs of their webs against the rangers on the bottom of the present excavation. Where these rangers are braced by transverse horizontal struts the latter are not removed, but the sheeting under them consists of 15-inch channels cut in 30-inch lengths and driven successively under the struts by means of a follower notched to clear the strut and take bearing on the upper ends of the channel flanges. As fast as one piece is driven down the succeeding one is web-spliced to it and the driving resumed.

The other three sides of the pit are protected with ordinary tongued and grooved wooden sheeting, and the excavation is made in three successive sections, the one in the middle being done last. After the first section is excavated a solid mass of concrete will be laid in the bottom up to the under side of the first horizontal strut. After it has set so as to afford reaction for the foot of the steel sheeting, the lower horizontal strut will be removed and new concrete properly bonded with the old will be filled in to the under side of the second strut. After it has set so as to support the sheeting the second strut will be removed and the remainder of the concrete will be filled in in two more similar layers, after which grout will be forced behind the steel sheeting. The side walls will be additionally braced by temporary inclined shores seated against steel backing. These will give additional resistance to lateral pressure until the strength of the concrete is developed and the construction of the subway is completed, when they will be removed.

Mr. William Barclay Parsons is the chief engineer for the Rapid Transit Railroad Commissioners, and the work is being executed for the Rapid Transit Subway Construction Company by the Degnon Contracting Company, Mr. H. C. Sanford, chief engineer. The Foundation & Contracting Company has been retained as consulting engineer for the interests of the Trinity Church Corporation.

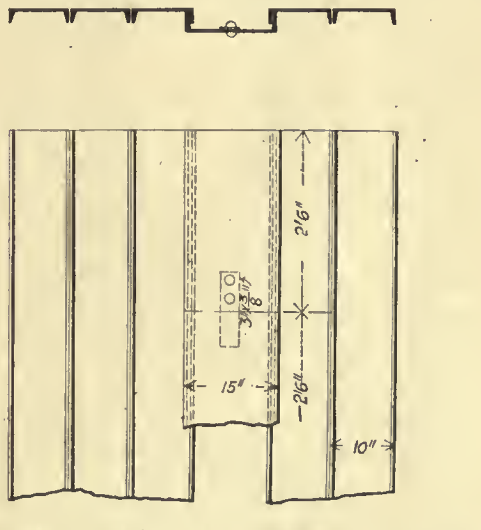


Cross-Section at A-A



Rapid Transit Subway, New York: Special Sheeting and Bracing to Protect Foundations of Trinity Church Spire.

Explosive Mixtures of fuel gas, with reference to the bearing of the subject on gas-engine practice, were discussed some time ago before the British Association for the Advancement of Science by Messrs. L. Bairstow and A. D. Alexander. According to their experiments mixtures in which the ratio of the volume of gas to that of air was 0.215 gave pressures on explosion of 90 and 88 pounds per square inch after stirring the mixture of air and gas, which were admitted separately to the experimental cylinder, while they failed to explode before that operation. In the case of mixtures having about 1 volume of gas to 5 volumes of air small variations in the proportion proved to have very little effect on the maximum pressure.



Splice in Sheeting under Cross Strut, at S-S, Etc.

The Engineering Record

The Power Plant, of Kynoch, Ltd., Birmingham, the performance of which was noted in the issue of March 26, in the article on "The Cost of Generating Electric Power," includes an equipment of 500 kilowatts, usually run during the daytime, and another portion, of 200 kilowatts, used at night. The steam is not superheated nor are economizers in use. The plant is run condensing during the daytime and noncondensing at night; the condenser pumps are electrically driven. The coal consumption and cost of operation may be compared with the corresponding figures for the Watson plant, which has both superheaters and economizer. The equipment of this plant was outlined in the same issue on page 381.

The Relation of Forests to Water Supply.

Questions relating to the effects of deforestation and afforestation upon rainfall and water supply have been frequently discussed in this country and in Europe for many years. Some conclusions on the relationship of woods to domestic water supplies were stated recently in a leaflet issued by the Board of Agriculture and Fisheries of England, and condensed in "The Surveyor," from which the following paragraphs have been taken:

The foliage, branches and stems of the trees intercept much of the rain and snow, so that it never reaches the ground at all, the amount so intercepted usually ranging from 30 to 45 per cent. of the total, but much depends on the character of the rainfall and on the species of tree. In a district of heavy annual rainfall a smaller proportion of the precipitations is caught by and evaporated from the trees than where the rainfall is light. Similarly in the case of heavy and long-continued rain, as contrasted with gentle showers; in the latter case, in fact, but little of the water reaches the ground through the leafy canopy of a dense forest. Then, again, much depends on the kind of tree, evergreens intercepting more water throughout a year than deciduous trees, and a larger proportion of the rainfall is evaporated from the leaves and branches in summer than in winter.

But (the leaflet continues) although less rain water reaches the soil of a wood than finds its way to the ground in the open country, the moisture in the soil is much better conserved in the former than in the latter case. Long-continued observations have shown that more water drains from a wooded area than from one devoid of trees. The greater abundance of water in forest soil, in spite of the trees intercepting a large proportion of the rainfall, is due partly to the reduction of evaporation owing to the exclusion of the sun's rays by the foliage, partly to the air in a forest being more humid, and thus better fitted to discourage evaporation, and partly to the absorbent and retentive character of the decaying vegetable matter that covers the ground of a dense and well-managed wood. The lace-work of tree roots, too, that occupy the soil of a forest offers mechanical resistance to the rapid surface-flow of water. It is also to be noted that roots penetrate to great depths, and when they die they leave holes through which water readily penetrates from the surface. The friable condition of the soil of a wood, too, permits ready percolation of water, whereas in the open country the denser character of the surface of the ground is less favorable to the entrance of water. The consequence is that streams in a wooded country are not so subject to rapid rises and falls, the flow being maintained more equably throughout the year. Where water supply for domestic or industrial purposes is concerned, the avoidance of violent freshets on the one hand, and scanty flow on the other, is alike desirable. Not only may the water of sudden and heavy floods be lost owing to the incapacity of the reservoir to contain it, but such floods have also the disadvantage of carrying much mud and similar material in suspension, and this gradually silts up reservoirs, besides entailing increased expenditure in filtering.

When a catchment area is covered with trees, and with the vegetable matter that accumulates on the surface of the ground, the water that reaches the soil as rain is impeded in its flow, and its evaporation is hindered, so that the general effect is equivalent to an increase in the size of the reservoir. It is also important to note that snow melts more slowly underneath trees than in the open country, so that at a time of thaw the snow water is yielded up more gradually. Nor must the fact be overlooked that when snow in a forest melts, the ground absorbs the water to a much greater extent than happens in the open country. In the latter case the ground is probably frostbound, so that the snow water cannot be absorbed by the soil, whereas forest soil, being protected by trees, never freezes to the same extent, and is consequently in a better position to absorb snow water. The result is that not only does a forest mitigate the violence of floods, but the snow water that flows from its area is less muddy than would otherwise be the case.

Forests not only affect the degree of moisture in soil, but they also exert considerable influence on the soil temperature. Although this influence is greatest at the surface of the ground, it is also perceptible to a depth of several feet. On the average of a large number of continental stations it was found that woods of various species and ages depressed the mean annual temperature at the surface of the ground by about 2.6 deg. Fahr., while even at the depth of 4 feet the reduction of temperature was 2 deg.

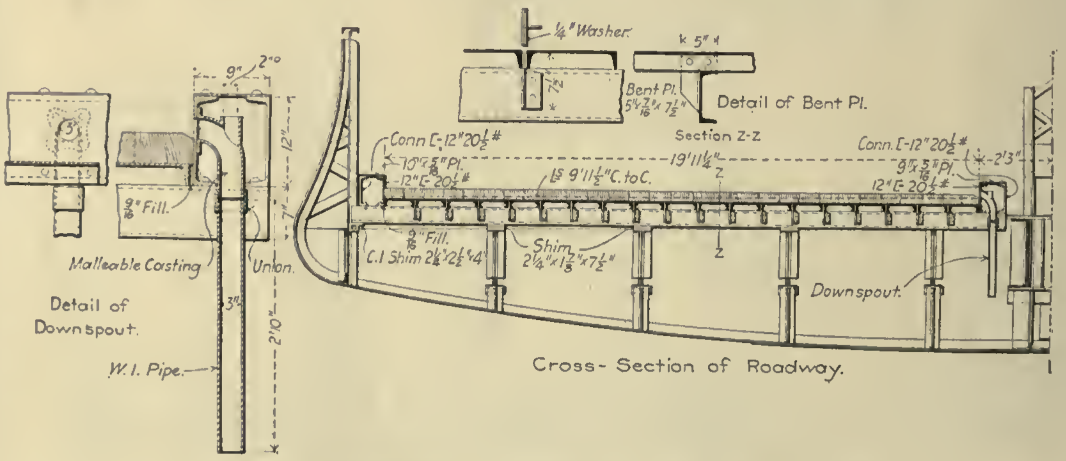
This general cooling influence is due to a variety of causes. The foliage of the trees excludes the sun's rays, the decaying vegetable matter that covers the ground prevents the free exchange of air between the soil and the atmosphere, while the water in the soil absorbs much heat without its temperature being much affected.

While woods have a depressing influence on the mean annual temperature, it is found that this effect is much greater in summer than in winter. On the average of eleven German stations the July temperature of the surface soil in the forest was found to be 7 deg. Fahr. lower than that in the open field, whereas in December the former was rather warmer than the latter. Forests, therefore, tend to equalize the temperature of water collected in them, the temperature being slightly raised in winter and markedly reduced in summer. This result would appear to be of considerable practical and hygienic importance where a supply of water for domestic purposes is concerned. To the credit of forests is also to be placed the fact that they exercise a purifying influence both on the air and on the soil, germs of all kinds being markedly scarcer in a well-wooded district than in a similar extent of treeless country.

In Refrigerating Work the effective production of cold per horse-power-hour of the compressor varied in a number of tests reported by Mr. H. Lorenz in the "Zeitschrift" of the Society of German Engineers from 8,560 to 15,800 British thermal units.

The Fireproof Floor of the Williamsburg Bridge, New York.

The two 20-foot cantilever roadway floors of the 1,600-foot main span of the Williamsburg Bridge and the corresponding floors on the shore spans from anchorage to anchorage are to be covered with a wooden block pavement supported on a solid steel platform. The floor-beams about 20 feet apart carry plate-girder stringers about 5 feet apart with their top flanges a few inches below those of the floor-beams. Transverse channels 7 inches deep and about 2½ feet apart are seated on the top flanges of the stringers and support 12-inch 20½-pound longitudinal channels laid across them close together with the backs up. The flanges of the longitudinal channels are riveted to bent plates which are riveted to the webs of the transverse channels, and they are also field-riveted together with ½-inch washers midway between these connections. The channels have butt joints without splice plates midway between bearings. The transverse channels are shimmed up by [illegible] on of the stringers so as to slope gently toward the axis of the bridge. The longitudinal channels form a smooth flat surface 19 feet 11¼ inches wide which terminates at both edges with the steel curb made with a pair of 12-inch channels and a 9x 5/16-inch cover-plate. Wrought-iron drain pipes about 10 feet apart are bolted to the inner face of the curb on the lower edge of the roadway. At distances of about 10 feet 1½x1½-inch transverse angles are bolted across the backs of the longitudinal channels to form guides for the paving blocks. Especial provision is made to protect the steelwork of the floor platform from oxidation, and the specifications on this point are unusually minute. It is required that the mill scale shall be removed and the steel painted with pure linseed oil while still hot from the rolls. Afterwards the steel shall be dipped in an enamelling compound and baked for two hours at a temperature of 300 degrees Fahrenheit in a dry heat. The enamel thus produced must not vary more than 1/100 inch in thickness; it must resist scratching by the finger nail, must not fly when struck by a hammer, and must not crack when spread on a thin sheet and bent 180 degrees ten times. It must be equal in smoothness, hardness, toughness, elasticity, adhesiveness and in resistance to chemical action to the coating produced by the Sabin process. It must be unaffected by soaking for 48 hours at 70 degrees Fahrenheit in solutions of sulphuric, hydrochloric or acetic acids and in saturated solutions of carbonate of soda and carbonate of ammonia. All heads of field rivets and all abraded places shall be painted three coats. The steel surface of the platform is paved with transverse rows of long-leaf yellow pine blocks,



Solid Steel Paved Floor of Williamsburg Bridge, New York City.

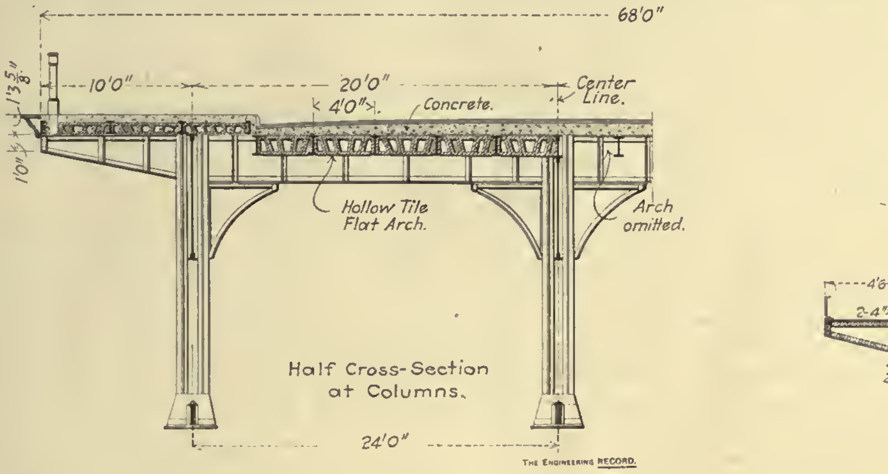
4 inches deep, 4 inches wide and 8 inches long transverse to the bridge axis. These are planed to uniform width and rebated 1½ inches by ¼ inch on the upper long sides to make the transverse caulking joints. The blocks are treated by the creo-resinate process and are set on the steel channels in hot asphaltic cement. They are driven tight against the transverse angles by wedges or jacks and the rebated joints are rammed full of fine gravel. All joints are filled with hot asphaltic cement or creo-resinate mixture and covered with sand or crushed stone. The United Engineering & Contracting Company, of New York, is the contractor for the roadway floor.

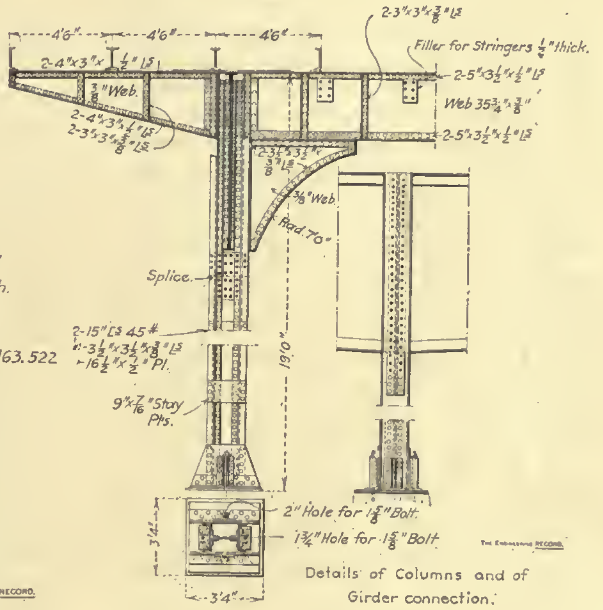
A Cantilever Plate-Girder Highway Bridge.

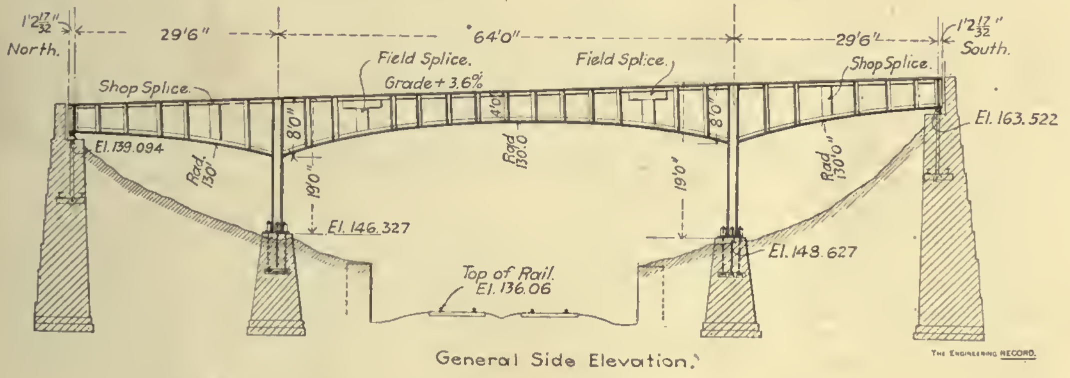
Benton Boulevard, Kansas City, crosses the two tracks of the Kansas City Belt Railway Company at an angle of about 83½ degrees on a deck bridge about 126 feet long over all and 68 feet wide. It is designed for a 40-foot roadway and two 14-foot cantilever sidewalks. The three lines of plate-girders were erected as double cantilevers with unequal arms and connecting center spans supported by two trestle bents with three vertical columns each, thus giving a center opening of 64 feet and two side openings of 29½ feet. The latter are spanned by the anchor arms which, at the abutments, have pin bearings engaging vertical eye-bars connected to reaction platforms built into the masonry. The center opening is spanned by girders which are made with arched lower flanges so as to secure a minimum depth of web in the center and afford maximum clearance there over the railroad tracks. This span was erected with two cantilever arms 12 feet long and a connecting span 40 feet long. The sections forming each adjacent anchor and cantilever arm were riveted up solid in the shops and shipped as single girders about 43 feet long, and their connections to the center spans were made with solid field-riveted splices, so that in service each line of girders consists of three continuous spans with rigid joints and deep riveted connections to the vertical posts of the intermediate bents.

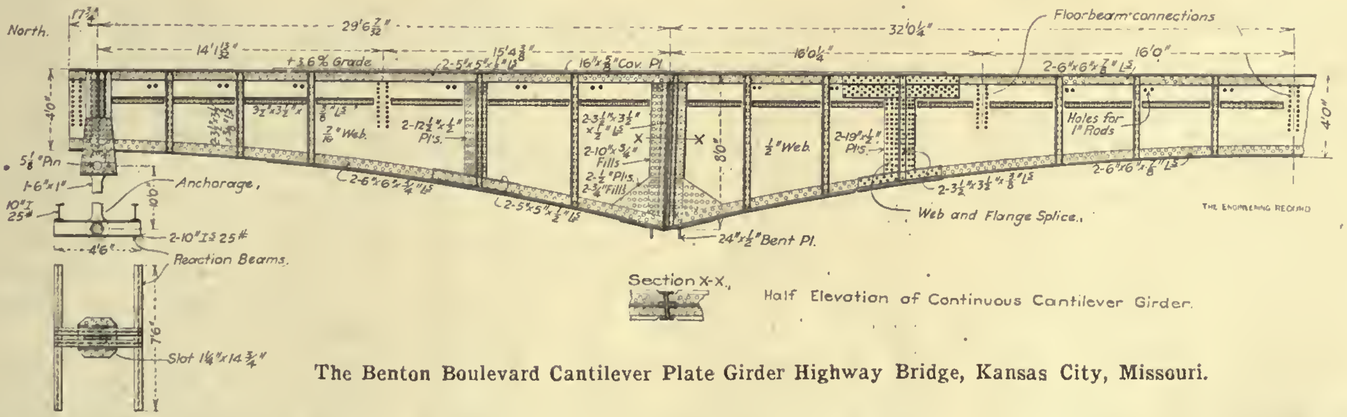
The girders are connected by floorbeams parallel with the abutments and about 15 to 16 feet apart. The panels between the floorbeams are X-braced by horizontal 6x½-inch bars riveted to the upper flanges of the girders, floorbeams and 15-inch stringers 4 feet apart. The stringer webs are connected by 1-inch tie rods about 4 feet apart, and their lower flanges support flat arches of hollow terra cotta blocks covered with concrete filling and an asphalt pavement. Plate-girder cantilever brackets 9 feet long are web-connected to the girders on both sides of the bridge and carry the stringers, which are seated on their top flanges to raise the surface of the sidewalks about 6 inches above that of the roadway. The sidewalk floors have a cement surface carried on flat arches of hollow terra cotta similar to those in the roadway, but only 10 inches thick.

The field-splices of the main girders are made with six vertical rows of rivets for the web; the top chord is spliced with a pair of side plates having six horizontal rows of rivets and with a cover-plate having four rows; the bottom flange is spliced with a pair of cover angles and a cover-plate having altogether two rows of rivets in the sides and four through the flange. At the deepest part of the girder, where it is supported by the vertical posts, the web is reinforced by side plates and angles and is shop-riveted to a transverse diaphragm with flange angles on both the vertical edges. This diaphragm provides for the connection with the webs of the vertical columns in the bents supporting the girder. The column channels extend to the top flange of the girder, which passes between them and is field-riveted to them through the diaphragm flanges. The joint between the column and the inclined lower flanges of the girder is covered with bent plates shop-riveted to the girder flanges and field-riveted to the column flanges. The anchor ends of the girders have vertical side plates riveted to the end web-stiffener angles and projecting below the lower flange, where they have horizontal flange angles and base plates riveted to them to form pedestals for the seat on the masonry. The pins through these pedestals engage the upper ends of single 6x1-inch eye-bars 10 feet long, which pass through a slot in the base plate and engage, at the lower end, pins in reaction I-beams built into the masonry.









The Benton Boulevard Cantilever Plate Girder Highway Bridge, Kansas City, Missouri.

At the trestle bents the floorbeams are web-connected to the webs of the post channels and are seated on long solid-web kneebraces. The intermediate floorbeams are web-connected to the main girders and the upper corners are sheared at an angle of 45 degrees to clear the top flanges of the girders. Tension plates are riveted across the top flange of the girder and of the floorbeam and sidewalk brackets to splice the latter. The columns in the trestle bents have I-shaped cross-sections made with a web plate and four angles and a pair of channels. They are anchored to the masonry with four

1⅝-inch upset bolts 6 feet long engaging cast-iron reaction plates built into the concrete piers. Except the anchor bolts, which are soft steel, the bridge is built of medium steel and all rivet holes are reamed 3/16 inch. All intermediate stiffener angles are crimped and the ends of the floorbeams and stringers are faced. All field connections of the main girders and floorbeams to the columns were reamed to cast-iron templates. All abutting ends of compression members are faced. The piers and abutments are built of 1:3:5 Portland cement concrete. The exposed angles of the concrete were rounded to a radius of 3 inches. The coping is of 1:2:3 concrete.

The bridge was designed by Messrs. Waddell & Hedrick, consulting engineers, Kansas City, and was built at the Chicago plant of the American Bridge Company. It was opened for traffic in December, 1902.

Book Notes.

The Tenement House Problem. Including the Report of the New York State Tenement House Commission. By various writers; edited by Robert W. De Forest and Lawrence Veiller. New York, The Macmillan Co.; cloth, 9x6 ins., two volumns, about 1,000 pages, many illustrations, $6.

This is a work which merits a place in the library of all students of municipal affairs, for it concerns the homes of the poorer classes in large cities. The editors have been familiar with the conditions in New York for many years, and a large part of the present measure of success in the public control of tenement houses in that city can be traced to them. It is a very old subject in New York, and there are some passages in the book which indicate that Mr. Veiller, who is the historian of tenement house reform, hardly appreciates the value of the work done by the men who gave their time and money to its study years ago. The tenement house problem is extremely complicated, and the attacks made upon it in the past by these public-spirited citizens were invaluable in developing the nature of the complications. When the problem was once understood it was not difficult to secure the appointment of a commission to solve it. It was these early investigators, who showed what was the condition of the tenement house districts and interested the public in its improvement, who rendered possible the great work of the present commissioners.

There are many official reports, as well as special papers in these two volumns. Among the latter there are particularly interesting chapters by Mr. Veiller, on a statistical study of New York tenement houses, and on the varions attempts made to improve their character, one on tenement house sanitation by Mr. Albert L. Webster, one on small houses for workingmen by Mr. H. L. Cargill, and one on the financial aspects of recent tenement house operations in the city by Dr. E. R. L. Gould. These should be studied carefully for they contain the pith of the subject. The remaining pages in the volumes are supplementary to them and need not be read by those whose time to put on the topic is limited.

The importance of the subject to the engineer depends mainly on the unsanitary condition likely to exist in the crowded sections of a city. It is his duty to provide well paved streets there and to insist on good building construction in the houses. The filthy conditions in parts of New York recently are almost beyond belief, and are dangerous to the health of the entire community. This book shows that good houses paying a reasonable return on their cost, have already been built in New York for very low rentals. Thousands of these houses must be built in place of the present rookeries before the people of these quarters can be reasonably expected to be good citizens. The wholly unnecessary squalor of the average tenement house is a blot on our municipal life.

Condensation of Steam in Covered and Bare Pipes. By Charles P. Paulding. New York, D. Van Nostrand Co.; cloth, 9x6 ins., 102 pages, illustrated, $2.

This is a very interesting attempt to harmonize the experimental investigations of Messrs. Barrus, Jacobus, Brill, Norton and the author with Péclet's theory of the emission and transmission of heat, as stated in his "Traité de la Chaleur." Although Lord Kelvin has expressed his very grave doubts respecting Péclet's experimental results, the author regards them highly, and a large part of the book is a translation of a portion of his treatise. The purpose of the book is to reduce to a useful shape the available experimental and theoretical information concerning the loss of heat from bare and covered pipe. Tables and diagrams are given to aid in estimating the value of different thicknesses of the leading non-conducting materials, with pipes of various diameters under the usual steam pressures. The book is the pioneer work in this particular specialty, and is written with the evident intention of furnishing information of practical value to the designing engineer. While it may seem to a considerable number of readers that more extensive experiments are needed to furnish all the data requisite for a complete analysis of the pipe covering problem, the author has supplied a book of distinct value to any one who employs it carefully.

In view of the interest shown just now in the proposed railways in the Philippine Islands, it should be stated that Mr. J. T. Norton made a reconnaissance of several lines in Northern Luzon about a year ago. One of these lines, in his opinion, should pay a fair return on its cost from the day it is opened, while others will be lucky if they pay operating expenses within a few years. The trouble seems to be that war, pestilence and lack of transportation facilities have kept the country in an undeveloped condition, and it will be some time before even such an efficient pioneer of civilization as a well-managed railroad will be able to produce settled conditions on a land of naturally turbulent people. Mr. Norton's interesting report on his surveys, illustrated by a large map and a number of engravings from photographs, has been issued as Document 206, Bureau of Insular Affairs, by the War Department at Washington.

One of the standard American engineering treatises is Messrs. Johnson, Bryan and Turneaure's "Modern Framed Structures," a work now eleven years old. A new edition, the eighth, has just appeared in which many changes have been made to bring it abreast with current practice or to improve the manner in which a subject is presented. The chapters on truss analysis for uniform loads have been entirely rewritten, several changes have been made in the portion on wheel-load methods, the section on conventional loads has been rewritten and that on lateral trusses is nearly all new. The chapter on plate-girder design has been greatly changed, and that on the design of a pin-connected railway bridge is entirely fresh material. The American Bridge Company's specifications are followed rather than those of the Society for Testing Materials, which is rather unfortunate although the differences between them are slight. A very important change is the introduction of a consideration of impact in discussing various types of formulas for working stresses. The work as it now stands is better than ever, and it was always good. [New York, John Wiley & Sons; cloth, 12x9 ins., 570 pages, $10.]

Notes.

The Board of Direction of the American Society of Civil Engineers, acting for the Society, has purchased a lot of land fronting on West Fifty-seventh Street, New York City, and adjoining the Society's house. The lot is 25 feet wide and has an average depth of 116 feet. The announcement of the purchase was made by the secretary at the regular meeting on Wednesday evening.

For Thawing the Covers of water-works service boxes, which have been frozen into their frames, Mr. Edwin C. Brooks, superintendent of water works, Cambridge, Mass., uses a little benzine, which is poured onto the cover and ignited. At a meeting of the New England Water Works Association, he stated that the benzine did the work perfectly and saved the trouble of running into neighboring houses for pails of hot water.

Leather Crossties were put in the Boston & Albany at the West Springfield freight yard in June, 1901. At this particular place chestnut ties have to be renewed annually on account of the continuous switching over them, but the leather ties are now in as good condition as when first laid, according to Mr. T. J. Sullivan, the division roadmaster. The spikes are stated to be as firm as when first driven. The ties are made of scrap leather and a cementing and preservative substance, the material being compacted under heavy pressure. The ends of the ties have metal caps, which, in a sample recently examined, were held in place by a rod through the axis of the tie Mr. H. L. Handy, Springfield, Mass., who is interested in the tie, states that it can be made in large quantities at a very low figure when its life is considered.

The Contraction of Jets from circular orifices with beveled edges in the bottom of tanks has been estimated in the past by means of an empirical formula due to Rankine. The theoretical analysis of the subject has been investigated by Prof. John Goodman, who supplied an outline of it in "Engineering" of March 11. As the theory of contractions is only barely touched up to the present time, it is particularly interesting to notice this successful attempt to harmonize theory and experiment in a subject still an untouched field of investigation in most of its aspects. Professor Goodman's analysis is based on the following assumptions: When an orifice in the bottom of a tank is uncovered, the weight of the tank and its contents is reduced by the weight of the column of water over the orifice, and the total pressure on the bottom of the tank equivalent to the kinetic energy of the approaching water as it flows over the orifice-plate. The value of the first quantity is readily obtained, but the evolution of the second involves assumptions as to the exact manner in which the water approaches the orifices. If the approach is quite steady, the stream lines may be regarded as flowing in pyramidal passages, whose apices meet at the center of the orifice. On this basis, with the further assumption that the depth of water over the orifice is great, the surface of equal flow will be a hemispherical shell having its center coincident with that of the orifice. The expression deduced from these assumptions gives results agreeing within about one per cent. of those of the Rankine formula.

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Drainage for Good Roads.

It is instructive to observe how steadily the feeling is growing that drainage and not thickness of metaling is the main essential in road building. However much we may respect the memories of McAdam, Telford and other great road builders who first led public authorities toward a sensible method of construction for country highways, the fact remains that many of their recommendations are now known to be misleading. Their advice was important at the time when it was given, but it is not in keeping with the broader knowledge of the present time, gained by careful examination of roads built in strict conformity with well-drawn specifications. Years ago the theory of thin roads met with little favor, but it has been gradually spreading, particularly since it was seen that thin roads are necessarily well-drained roads if they are to be durable. In other words, if the water is removed rapidly from below the metaling it is now well recognized that the amount of broken stone needed to keep the surface hard and smooth is only a small part of the total volume of rock which the old system of telford construction demanded.

The Massachusetts State Board of Health has been paying careful attention to this subject for several years, and its report for last year, which has just appeared, contains some notes on this subject of drainage as a substitute for telford foundations. The Commission states that on heavy, wet soils a center V-shaped drain has been substituted for side drains and boulder base. In the construction of such a road the earth is loosened and thrown toward the sides so as to form a V-shaped ditch with its greatest depth in the center of the proposed roadway. At intervals of about 50 feet, narrow trenches are cut through the sides of this center trench, draining its lowest parts toward the side gutters. The center and cross trenches are filled with field or wall stone, the depth being 12 to 18 inches at the center and 6 to 12 inches at the sides, the thickness being dependent on the character of the soil in the sub-grade. The tops of the large stones are given a crown to receive the surfacing material.

This system of construction is directly opposite to that advocated in most of the accepted manuals on the subject. The old idea has been to get the water off the roadbed just as quickly as possible. To accomplish this the sub-grade has been crowned and rolled and the lower courses of stone are coarse and often of considerable thickness. By the new system of construction the water remains on the roadbed and is collected by the outlet drains at 50-foot points, the drainage not being distributed along each side of the road, but concentrated at a regular series of points.

The proof of the value of this innovation in road building is to be found only in its action under service and in its cost as compared with time-honored practice. It is reported by the Commission that so far as present observations have extended, this V-shaped drain is as effective both for removing the water and supporting the metalling, as side drains and a telford base. Its cost is approximately 77 cents per lineal foot of road less than construction with a telford base and two drains, and 35 cents less than the same base with a single side drain. Hence it would seem as though the innovation was destined to become a useful and economical improvement in road building on heavy, wet soils.

The attention of the reader is drawn to it particularly for the suggestion it makes to those who have to construct roads in the prairie country. Except in dusty or wet seasons, the clay roads of the prairie of Illinois and Missouri are delightful. The carriage passes over them with a springy motion and the horses find the surface easy on their feet. The season of affliction of such roads occurs when heavy rains form pools on their surface or the protracted droughts of summer cover their surface with a mass of dust. The latter condition is largely due to the former, and, as a number of expert road builders have pointed out, the thorough drainage of these clay highways will work wonders toward keeping them in condition. If they are well crowned and the surface scraped and consolidated with a split-log drag after every heavy rain, so that no ruts are allowed to form, their condition will be greatly improved. But even a well-drained roadbed of this character will be cut up by heavy teaming, and it will be impossible to keep it free from ruts under such traffic. It would be well worth the trouble and expense to try in such a case a covering of well-burned clay, such as is used in Missouri and neighboring States for railroad ballast. The material is by no means a substitute for broken stone, but there is some reason for believing that on carefully-drained roadbeds, where it will not be kept soaked with water for any considerable period of time, it may afford just the remedy for ruts that is needed by the prairie thoroughfare. As the clay can be obtained in most places where such roads are constructed, and its burning is not a very difficult matter in the hands of a competent man, the cost of obtaining and applying this surfacing material should not be very great. The experiment may not be successful, but it will be recalled that when the material was first suggested for railway ballast there were very few roadmasters who considered it worth trial. But if it is tried, it must not be forgotten that perfect drainage must first be assured, otherwise the experiment is destined to fail.

The Turbine Ships of the Cunard Company.

By all odds the most interesting development in steam engineering of late has been the determination of the Cunard Company to equip its two new 760-foot vessels with steam turbines. This decision was not reached hastily or for advertising purposes, but was made on the recommendation of a special commission of eminent experts, organized to assist the directors of the company in the selection of the best equipment of their mammoth vessels. The use of the turbine in British ships is comparatively well established. The success of the Turbinia at the Naval Review of 1897 was so marked that the directors of the companies engaged in channel traffic about Great Britain immediately turned their attention to this new type of vessel. The keen competition between rival passenger boats to the continent, as well as to Belfast and the Isle of Man, naturally led to the adoption of turbine vessels for these various services. It is probable that the coal economy claimed for the turbine did not have as much weight in reaching a decision to use these engines as did the advertising gains which their adoption produced. Novelties always have attraction, and there are many people who will doubtless be drawn toward a vessel operated by a steam turbine for no other reason than a desire to say they have traveled on such a boat. These considerations, however, can scarcely be held to have governed the adoption of the turbine for vessels in Australian and New Zealand trade, nor for the two ships of the Allan line, nor the moderate speed steamer which the Cunard Company put under contract some time ago. Vessels for such service cost too much money to build and operate to be the scene of any experimenting. Moreover, the possibility of accident to a vessel engaged in long-distance runs is ever present in the minds of the directors, and while they may be willing to install promising apparatus in small vessels for short routes, they certainly will refuse to place in any ship for trans-Atlantic or similar service any mechanism that is liable to inconvenience the passengers or retard the regular speed.

While the adoption of the turbine for these enormous vessels of the Cunard Company has been the result of very careful investigations, it is surprising how little definite information has yet been made public concerning the grounds for the action taken by Lord Inverclyde and his directors. The commission of experts which recommended the step to him was a really remarkable one. It includes Mr. James Bain, the marine superintendent of the company; Rear-Admiral H. J. Oram, deputy engineer-in-chief of the British Navy; Mr. J. T. Milton, chief engineer surveyor of Lloyd's; Mr. H. J. Brock, of the Dunbarton firm of Messrs. Denny, builders of several turbine ships; Mr. T. Bell, engineer director of John Brown & Company; Sir William H. White, representing C. S. Swan & Hunter, and Mr. Andrew Laing, managing director of the Wallsend Engineering Company. This commission tested vessels in the Channel service and also several turbines in electric central stations, and secured at first hand, as well as by correspondence and compilation, a vast amount of data on the subject.

The statements that have been given out concerning the report of this commission are remarkable for the arguments they do not present concerning the turbine, rather than for those which are advanced. The claim that the new engine will save a large proportion of the weight of the present type of equipment is not recognized. The engines in these new vessels must develop something like 70,000 indicated horse-power in order to produce a speed of 25 knots, and the weight of turbines of this capacity, suitable for the service, is only 3 per cent. less than that of reciprocating engines of the usual type. Moreover, it is understood that the commission has advised the Cunard Company not to add the additional 300 tons thus saved to their cargo capacity, but to reserve it for other machinery. This decision is more surprising than the reports of a similar nature concerning turbines for war vessels, because in the latter type of ships very little steaming is done at full load, while in the mercantile marine the vessels are nearly always driven constantly at full speed. This makes the design of engines for mercantile vessels an easier matter, and at first thought would indicate that the turbine equipment for them might be made considerably lighter and smaller than an outfit of reciprocating engines. Perhaps one reason for the weight and size of the turbines for the new Cunard vessels is to be found in the fact that they are to run at only 140 revolutions per minute, as compared with the 300 to 500 revolutions at which the shafts of smaller turbine-driven vessels are now driven. While the rate of revolution is low, the great diameter of the bucket wheels will bring the peripheral speed up to the normal figure in other Parsons' turbines. It might be stated that the commission considered only the Parsons' type of turbine, because there was no sea experience with others.

The economy in coal consumption of the turbine vessels which were tested was only about 2 per cent., as compared with the consumption in other vessels, although the data from electric light stations show a much greater saving. In the vessels which furnished the information on this subject there were so many influences affecting the steam consumption that the final conclusion must be regarded merely as an approximate one. Where marine turbines run steadily at their rated capacity, as is the case in merchant vessels, there seems to be little reason for any failure to secure results about as economical as those in central station practice, although war vessels which steam most of the time at rates below full load on their engines cannot employ turbines so advantageously.

The objection to the turbine that it cannot be reversed is overcome in the designs for the new Cunarders in an interesting manner. These vessels are to have four shafts. This is the first case where four shafts have been adopted for British vessels, although the Lubeck, of the German Navy, which was recently launched at the Vulcan Works at Stettin, has this number. Each outer shaft will be driven by a high-pressure turbine and is intended only for propulsion ahead. Each of the shafts lying closer to the center line of the vessel will be driven ahead by a low-pressure turbine and backward by another turbine installed solely for reversing. In other words, there will be six turbines for the four shafts, four for moving ahead and two for moving backward. The four shafts are mainly necessary on account of the impossibility of applying 65,000 horse-power to three shafts, with a reserve strength for 10,000 horse-power more in case of storms. Were three shafts employed, each would have to be designed to transmit safely 25,000 indicated horse-power, while with four shafts each will have to carry not much more than 18,000 indicated horse-power, an amount already reached in a few other vessels.

The investigation apparently indicates that the turbine equipment of these vessels is expected to have little effect on the weight and size of the machinery and hardly more on the coal consumption. The gain will apparently come in the greater facility for conducting the engine-room operations.

The Registration of Architects.

In a number of States in this country the practice of registering architects has been followed for several years, without causing any very serious inconvenience to the members of the profession and, it is claimed, with considerable benefit to the public. A number of articles have appeared in this journal concerning the various qualifications required in the different states for legal practice under these laws In no case are the laws very strict nor have they interfered to any noteworthy degree with the architects who were in practice before they were passed. This being the case, it is difficult to understand the serious opposition which arose in England over the bill introduced last year into the House of Commons for a compulsory registration of British architects. That bill was much less stringent in its provisions than is the law in Illinois, for example. It was not passed, but the subject is still under discussion and is therefore of considerable interest to American practitioners.

The object of the bill was stated as follows in the preamble: "It is expedient that persons requiring professional aid in architecture should be enabled to distinguish qualified from unqualified practitioners." To enable the public to so distinguish between the sheep and the goats, the bill provided for a paid General Council of Architectural Education and Registration, and the appointment of registrars in England, Scotland and Ireland to receive the fees and strike from the list of authorized architects the name of any one who fails to pay these taxes. In order that the bill may work no harm to those in regular practice, it was proposed to register without examination fellows and associates of the Institute of British Architects and its allied societies and members of the Society of Architects, as well as any person able to prove that he was actually practicing architecture prior to 1895. After the passage of the act, an apprenticeship of three year, or two years' apprenticeship with five years' service as assistant, or an assistantship of ten years with a registered practitioner, was to be enforced. The standard of examination is defined as "the possession of the knowledge and skill requisite for the efficient practice of architecture."

In examining this bill it is important to notice that the rights of members of the Institution of Civil Engineers and of the Surveyors' Institution are not to be prejudiced for "work of any kind falling within the duties of their calling." Moreover, if they produce certificates from the council of any city, borough or similar authority, they are authorized to prepare plans for buildings, as is now the custom in most British municipalities.

So far as a careful reading of the bill indicates, the only way in which it would assist the public to distinguish qualified from unqualified practitioners lies in the fact that only those who qualify under its provisions would be authorized to call themselves architects. As one critic of the bill pointed out, there is nothing to prohibit a designer of buildings from calling himself an "unregistered architect" and practicing in any way he pleases. Moreover, any one who will call himself a builder and not an architect is not prevented from drawing plans for any kind of a structure. These people would labor under the disadvantage, had the bill become a law, of being unable to recover in courts of law any charges for professional services of an architectural nature; they would likewise be subject to fines of $100 to $250 for the use of any name or title or description as architect registered under the terms of the bill.

This proposal for registration is so mild in its provisions that it is really difficult to understand the serious opposition it encountered. Probably the best explanation of the earnest criticism it received was recently given by Professor Beresford Pite. He pointed out that architecture is really a union of science and art. The architect is essentially an artist qualified by skill in invention and arrangement to design beautifully and to impart to building construction the qualities that attract intellectual appreciation and attain to architectural beauty. He must have the power of expressing thought in form by utilizing dimension, proportion, line, mass, light and shade, and ornament and color, as graphic means for the communication of ideas. In order to attain perfect expression it is essential that he should also be a scientific man, able to design structures which are strong and properly equipped for their purpose.

It is contended by Professor Pite and other opponents of the bill that it is ridiculous to attempt to determine the artistic ability of an architect by an examination. They claim that such ability can only be shown by actual executed works. No examination lasting a day or two can bring out the artistic capabilities of a candidate for registration. Moreover, it is held by these critics that the government is not at all concerned one way or another with the artistic ability of architects, and its sole object is to ascertain whether the candidates are able to design buildings that are safe for their intended purpose and are equipped with fittings of a character that will not injure the health of the people occupying the structures. In other words, these critics claim that the bill really is not intended to register architects, but to protect the public against unsafe construction. Consequently they held that it is not just to register architects and leave the public at the mercy of other men who design buildings.

The bill seems to have been very unfortunately drawn in that such criticisms as these certainly carry considerable weight, particularly in Great Britain, where a large number of buildings, many of them important structures, are designed by builders, surveyors and engineers. In the United States this difficulty has been avoided by requiring, in some states, that no one shall design a building for any purpose who has not qualified as an architect. The purpose of this requirement is not to insure a high order of artistic merit in the buildings, but only to make it certain that they are designed by men who have given evidence of their knowledge of sound methods of construction. The British bill did nothing of the sort, and it is not at all surprising that the architects of the country looked upon it as a reflection on their professional dignity.

It is true that the bill found some advocates among architects, one of whom recently said: "To pose as great artists does us more harm than good, for there is a firm conviction in the public mind that the more artistic the less practical and buiness-like a man is. Herein lies the mistake in the analogy too often drawn between architects, painters and sculptures. The fact that those whose practice is mainly utilitarian should be foremost in claiming a better standard in both the art and the science is of the happiest augury in the future interests of the art." This statement is really the key-note of the whole matter. The practice of medicine is governed by law which make it impossible for a charlatan to pose as a physician. No man can call himself a lawyer until he has passed a formal examination. The doctor and lawyer look after our health and our public and private affairs; the architect, upon whose work depends in a measure the safety and comfort of a large proportion of the people in cities, is allowed to practice without any restriction and any one who can make a drawing is permitted to call himself an architect. There are certainly sound reasons for holding that the man who designs a building should be required to give proof of structural knowledge just as much as the candidate for admission to the bar is required to prove his fitness for his profession. The proposed examination is not an examination of an architect in his dual capacity as an artist and constructor, but merely a test of his technical ability to design structures that are safe for use.

Notes and Comments.

THE FAMOUS GLOUCESTER WATER-WORKS LITIGATION has apparently reached a finish in the United States Supreme Court, where Justice White has written a decision that states the claims of the water company were so attenuated and unsubstantial as to be absolutely devoid of merit. The suit has been fully explained in earlier volumes of this journal.

THE UNION ENGINEERING BUILDING which will be built with the assistance of Mr. Carnegie is the subject of a bill already passed by both Chambers of the New York Legislature. It provides for the incorporation of the United Engineering Society, which will hold the property for the three national engineering societies that have accepted Mr. Carnegie's gift. The bill is modeled after the act incorporating the Cooper Union, the purposes of the two organizations being in most respects identical so far as they relate to the public objects of their buildings. The conference committee in charge of the affairs has selected as the architects to join in a limited competition for the plans for the Engineering Building and the Engineers' Club, Messrs. Carrere & Hastings, Clinton & Russell, Whitfield & King, Ackerman & Partridge, Palmer & Hornbostel and Lord & Hewlett. The committee is about to select a professional adviser to assist it in connection with the architectural part of its work. In addition to the limited competition between the six firms mentioned, each of whom will be paid for its plans, there will be an open competition in which prizes will be awarded for the four best designs. This is contrary to the practice of many leading architectural firms, but it was Mr. Carnegie's wish that the matter should be put on this basis.

THE ORIGIN OF ASPHALT is a subject that has attracted the attention of many chemists and has led to numerous debates of an interesting nature. It was commonly believed, however, that the manufacture of asphalt from herrings and other ingredients, which was accomplished a few years ago at Swarthmore College, settled the fact that it might be of animal nature, although not proving that it could not be obtained as well from other sources. Recently the animal origin of asphalt has received further confirmation through the discovery of a fossil egg near the Gila River in Arizona. It had ages ago passed the stage of offensive ripeness and is now a valued object in the museum of the University of California. According to Prof. William C. Morgan, it is filled with asphalt mixed with crystallized colemanite. The latter he considers an outside substance, but all the evidence at his disposal indicates that the asphalt was derived from the natural contents of the egg. He also states that the process undergone appears to have been very similar to that which occurs inside of a "Chinese" egg. These latter are imbedded in clay by the Orientals to prevent the bursting of the egg, which usually occurs when hydrogen sulphide gas forms due to decomposition. After a period of from six months to three years the eggs are removed from the clay. He has observed several of these and finds that the contents are beginning to resemble, outwardly at least, the asphalt in this fossilized product. The change taking place in a year or two shows that there is certainly a possibility that in thousands of years this bituminous matter could be formed.

THE RECIPROCATING STEAM ENGINE has been somewhat neglected in technical literature lately, owing to the novelty of the steam turbine. Naturally enough the new prime mover has been attracting more attention than the familiar types, and it is not improbable that builders of the latter have been willing that this should be so. It is generally a good plan to let an adversary move first in any encounter where the struggle promises to be long, and in the battle of steam engine types the turbine advocates have had the field entirely to themselves. Now, however, a builder of high-grade reciprocating engines has entered the fight with some very interesting figures to counter those advanced in considerable detail by the turbine adherents. In a recent issue of the "Electrical World and Engineer," Mr. J. A. Seymour, of McIntosh & Seymour, compares the figures of steam consumption at different loads of a Westinghouse-Parsons turbine unit of 1250 kilowatts capacity, given in a recent article by Mr. A. M. Mattice, now chief engineer of the Allis-Chalmers Company, with the results of the acceptance tests of three 1,600 kilowatt units having McIntosh & Seymour engines. The turbine used steam with 76.8 degrees of superheat and had vacuums of 27.1 and 28.1 inches in the exhaust pipes. The reciprocating engines used steam with 81.3 degrees superheat and had a vacuum of 25.6 inches in the exhaust pipes. The economy curve for the reciprocating type shows a better result at light loads and its point of maximum economy is more favorably located than is the case with the turbine curves. Other tests of a similar character are cited to prove that in comparing the steam turbine with the reciprocating engine it is not fair to the latter to use average figures of the performance of the old type. Mr. Seymour claims that the comparison should be drawn with the results of tests of really modern engines which have a low rate of steam consumption at light as well as full loads. He admits that the usual average rate of steam consumption of reciprocating engines at light loads is excessive as compared with the figures at full load, but claims that the usual average engine is an uneconomical and out-of-date machine. This argument is one which will appeal strongly to those who have kept in touch with recent achievements of engine builders. Indeed, the published figures of engine operation at light loads have all along indicated that on the ground of economy the turbine advocates are on the defensive, although it has remained for Mr. Seymour to point out clearly what a tough opponent the latest type of reciprocating engine is, particularly for central station and similar service subject to fluctuating loads.

THE PICKLING OF STRUCTURAL STEEL was probably first done in this country in connection with the steel flooring of the Williamsburg Bridge in New York City, which was briefly described last week. The specifications for the 12-inch channels on which the paving blocks are carried required them to be cleaned and painted with pure linseed oil while still hot from the rolls. When it came time to execute the work, these specifications were changed so as to permit the metal to be cleaned in pickling baths, which has long been done to a considerable extent in Europe. In the case of the channels for the Williamsburg Bridge the shapes were first boiled in a 10 per cent. solution of caustic soda to take off grease and were then rinsed in boiling water. Afterward they were dipped in a boiling 10 per cent. solution of sulphuric acid until all the oxide was removed. After being rinsed in boiling water, they were dipped in a boiling 10 per cent. solution of carbonate of soda to free them from any trace of acid. Finally they were rinsed in boiling water, dried over steam pipes and then treated by the Sabin process of enameling. The contractors for the steel work, the R. H. Hood Company, made a sub-contract for this pickling and japaning with the American Circular Loom Company in New Jersey, and the work was done at the plant of the latter company for some time. Eventually the R. H. Hood Company built a plant of its own for the purpose near the bridge; this plant was inexpensive and the total cost of the work was probably very low. This successful use of the process deserves particular attention, not only because it is probably the first instance in which structural metal was pickled in the United States, but also from the fact that the coating on the channels proved extraordinarily tenacious. During the construction of the wooden pavement on these channels by the United States Wood Preserving Company, large quantities of material were wheeled over the enameled surface of the metal without injuring it in any appreciable manner. The result of this experiment, technically and financially, indicates that the time may be drawing near when the members of important bridges will be thoroughly cleaned and enameled before they are put in place. The painting of a bridge of large size is a tedious and costly operation and the possibility of protecting the metal by more durable enamel opens an interesting field of speculation. In the same way the success of this initial trial of the process opens a new field in respect to the steel work of buildings. From time to time criticisms are made concerning the durability of the steel work of office structures, particularly that portion of the metal embedded in concrete below the ground water level. The use of japan coatings for riveted steel pipe is such an old story to the readers of The Engineering Record that it is unnecessary to more than mention the fact that steel work treated in this way before it is bedded in concrete probably is protected against corrosion as thoroughly as it is reasonable to expect such work to be done. Now that the work on the Williamsburg Bridge has been executed at a very low figure, there seems to be no reason for objection to the use of this process on the ground of its cost, which has hitherto been the great argument against it.

Extensions of Brooklyn Sewerage System: Avenue G Trunk Sewer.—I.

Large areas in the southerly and southeasterly parts of the borough of Brooklyn, New York City, are being rapidly developed and built up. Miles of streets are being laid out and improved and hundreds of houses are being erected from year to year. This process has been going on for several years and, of course, has created a demand for sewers. As large parts of these districts could not be drained into any existing main sewer, it became imperative to build as soon and as rapidly as feasible several large trunk sewers, as well as the street laterals, to collect and convey to the sea not only the house sewage but large quantities of storm water also.

Brooklyn Sewers: Long Island Railroad Crossing; Curve at Forty-sixth Street; Setting Frame for Sheeting; Crossing the Marsh.

Furthermore, some of the main sewers in the older parts of the borough have become overtaxed owing to the laying of asphalt and other impervious pavements on many streets and the covering of large areas with business and dwelling blocks, thus greatly accelerating the run-off from the watersheds of a number of sewers and necessitating the construction of several large relief sewers.

Consequent upon the changes just mentioned, the sewer department has on hand an unusual amount of large work, in various stages of beginning or completion, the cost of which foots up approximately $7,000,000. A few of the larger pieces of this work have been described in recent volumes of this journal. An article printed September 1, 1900, dealt with the Greene Avenue relief sewer, a 180-inch diameter circular brick sewer 35 to 40 feet below the street surface; this article describes some very deep trench work. October 26, 1901, mention was made of the application of concrete-steel construction to a portion of the triple outfall sewer projecting into New York Bay at the end of Sixty-fourth Street; this outfall has been modified somewhat during the construction. The Sixty-fourth Street sewer, 14 and 15 feet in diameter inside, is mostly in deep tunnel, and the interesting and ingenious methods employed in its construction were described and illustrated November 21 and 28 and December 5, 1903. Some difficult reconstruction and complicated connections with intercepting sewers were shown and described in the issue of May 31, 1902.

The most important main trunk sewers are designated as the Avenue G sewer, the Ninety-second Street sewer, the sewer in the proposed street through the northern part of Dyker Beach park, the Bath Avenue, the Flatlands Avenue, the Foster Avenue, the Sixtieth Street, the Sixty-fourth Street and the Dyker Heights sewers. The principal new relief sewers are known as the Dean Street relief sewer and the Degraw Street relief sewer, both of which relieve the Greene Avenue relief sewer, the Evergreen Avenue relief sewer, the Morgan Avenue relief sewer, the Vanderwoort Avenue sewer, and the remodeling of the Knickerbocker Avenue and the Johnson Avenue sewers. The construction of the Atlantic Avenue subway, parts of which have been described in this journal, has necessitated many changes in sewers.

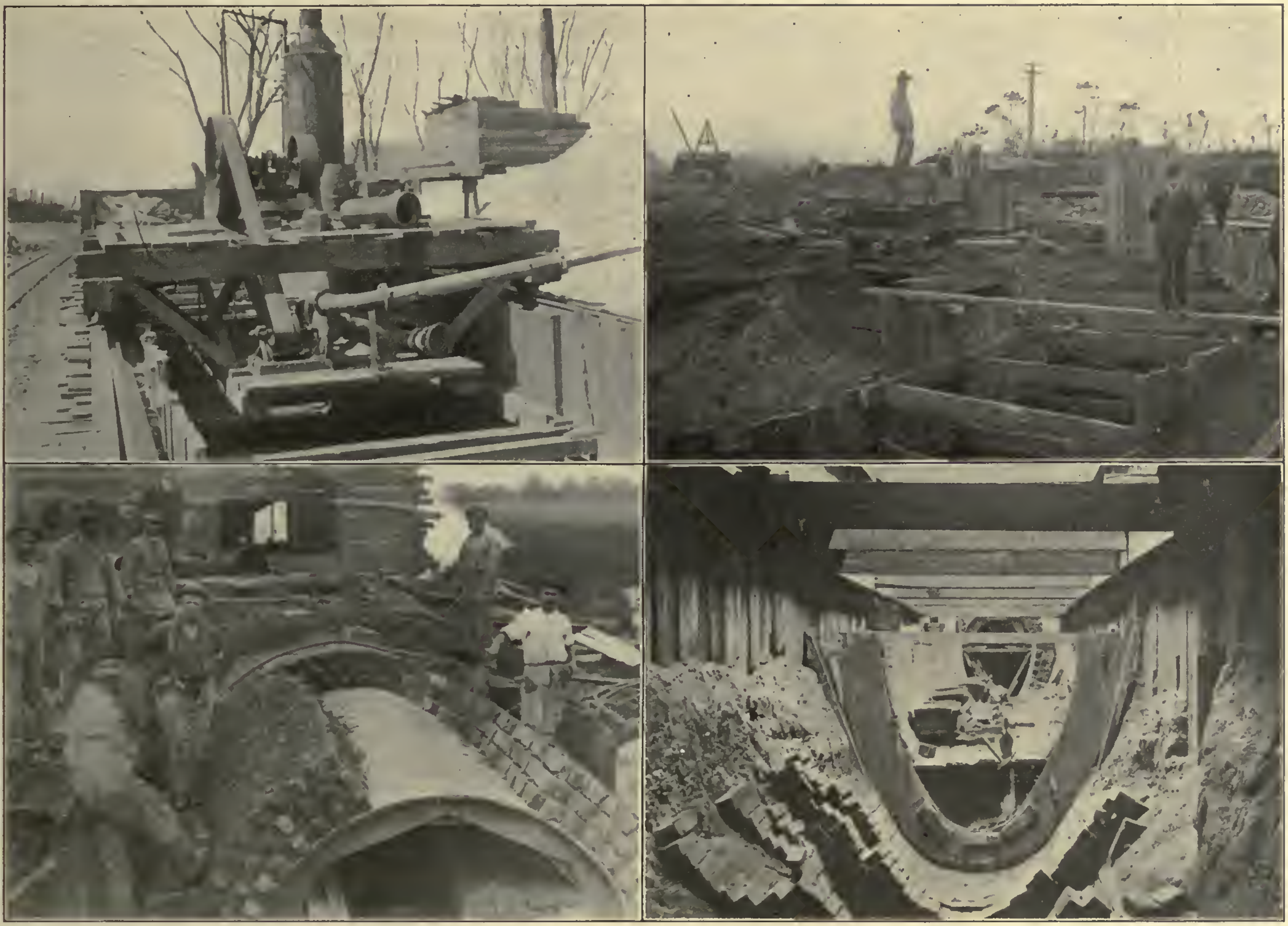
Avenue G trunk sewer was put under construction in September, 1902, and is to be completed by the latter part of the coming summer. It will drain an area of about 650 acres situated easterly of the district served by the Sixty-fourth Street sewer. This sewer will have a total length of 16,540 feet, or slightly more than 3 miles, extending from Coney Island Avenue through Avenue G, Flatbush Avenue, Nostrand Avenue, Avenue F, Paerdegat Avenue, Avenue G and Paerdegat Avenue to Paerdegat Creek at Flatlands Avenue. Beyond the intersection of Avenue F with Paerdegat Avenue the line passes through undeveloped territory, largely marsh land.

The size of the sewer increases as needed from 15 inches to 90 inches. Beginning at the upper end, the diameters and the lengths of sewer of each diameter are as follows: Vitrified pipe laid in concrete, 15-inch, 350 feet; 18-inch, 780 feet; 24-inch, 260 feet; circular brick, 36-inch, 140 feet; egg-shape brick, equivalent to 36-inch circular, 805 feet; egg-shape brick, 42-inch, 1,135 feet; circular brick, 48-inch, 5 feet; egg-shape brick equivalent to 48-inch circular, 630 feet; egg-shape brick, 54-inch, 1,320 feet; 60-inch, 1,380 feet; 66-inch, 815 feet; circular brick, 84-inch, 5,660 feet; 90-inch, 3,260 feet. The egg-shaped sections and the circular sections mentioned have great advantage, according to Brooklyn experience, over other sections in that they are self-cleaning when laid at the minimum grades adopted on this work.

The portion of the trunk sewer laid with vitrified pipes has grades varying from a rate of .00431 to .0143. The pipes are laid in a bed of Portland cement concrete reaching up to the horizontal diameter and placed in a trough made of 1¼-inch boards. The concrete is 6 inches thick beneath the bottom of the pipes and 6 inches wide at each side. For the

36-inch to 66-inch brick sewers the grades are .002, .001578 and .002182; for the 84-inch and 90-inch sewer the grade is uniformly .001111 to the silt basin at the terminus. The sewers are designed to flow two-thirds full when carrying the maximum estimated run-off, and the velocities in the large sewers are computed to be not less than 3 feet nor more than 12 feet per second.

The 66, 84 and 90-inch portions of the sewer are built with three rings of brick, and wherever the foundation is upon quicksand a timber grillage foundation and haunch walls built of brick or concrete are provided for in the contract. The other sizes of brick sewer have two rings of brick. Cradles of 1¼-inch plank have been used under the smaller egg-shaped sections wherever the work was constructed on firm sand or gravel, in which cases the lower portion of the ditch was shaped to fit the lower half of the egg-shaped section. The cross-section of the 66-inch egg-shaped sewer is shown by an accompanying drawing and is typical of all the egg-shaped sewers, in general form. The egg-shaped sections used are always of the well-known John Phillips type, in which the long or vertical diameter is one and one-half times the short or horizontal diameter, and the radius of the small end of the egg is one-half that of the large end. The method of laying the 66-inch sewer in a wooden cradle and the centering and profile used are shown by an accompanying photograph.



Brooklyn Sewers: Auxiliary Pumping Outfit; Bracing, Forty-sixth Street Curve; Closing Arch on Curve; Sixty-six-Inch Sewer in Cradle.

The depth of trench, measured from the surface as it existed when work was begun, varies from about 8 feet to 27, the excavation, excepting through the marsh, being almost wholly in sand of various grades and fine gravel. Across the marshes there were from 3 to 12 feet of muck and peat on top of the sand, but the digging was easy everywhere, no rock nor hardpan being found in this part of Long Island. The unstable nature of the sand, however, required close sheeting and heavy bracing practically throughout the length of the trench, and a total of about 1,500,000 feet, board measure, of sheeting was left in the trench at various places. One of the pictures shows plainly the method of setting the frame and starting the sheeting in the trench for the 66-inch sewer alongside a street railway track.

Water has caused the most serious difficulty in the execution of this contract. The sands and gravels of this part of Long Island carry large quantities of water and in several cases have yielded abundant supplies when drawn upon for water-works purposes. Furthermore, for 3,600 feet of its length the bottom of the 90-inch sewer trench is below tide level. To handle the large quantities of water flowing into the trench centrifugal pumps were used. While crossing the marsh, sometimes three 8-inch delivery and two 6-inch delivery pumps, designed by Mr. Richard Bush and made by Mr. Jesse Craft, of Water Street, New York City, were installed to keep the water out of the portion of the trench that was open. The 8-inch pumps are rated at 3,000 gallons per minute and the 6-inch at 1,200 gallons per minute. This water was discharged into Paerdegat Creek. The pumps were driven by Nagle engines with portable boilers. Of course, as the work progressed, the pumping plants were moved.

An underdrain 12 inches in diameter was laid beneath the center of the foundation of the sewer from Nostrand Avenue to Avenue G, from which point (Avenue G and Forty-sixth Street) two lines of 12-inch drain pipe became necessary. For the 90-inch portion of the sewer the quantity of water to be cared for has been so great that two 12-inch pipes are being laid, one under each side of the sewer, the center of each pipe being 24 inches from the center line. In some places on the lowland pockets or hollows have been formed between the sewer embankment and the nearby higher land. Most of these depressions will be filled soon, and all of them will be filled when the streets are graded, so that no permanent culverts will be needed. One large hollow of this sort in the marsh, at Avenue G and Forty-fifth Street, is drained by a wooden trough leading to an 18-inch lateral sewer connection at Troy Avenue, left in the south side of the sewer near the springing line. This water flows in the sewer for a short distance, to East Forty-seventh Street, and is then let out through another lateral sewer connection on the opposite side of the sewer and led through a short trough and ditch to the creek. A temporary bulkhead was built across the sewer above the upper opening and another below the lower opening to prevent the water flowing to parts of the sewer under construction. These low places will be filled before the sewer contract is completed, and the expedient described is, of course, for temporary relief only.

West of Flatbush Avenue the streets through which the sewer passes have been at least approximately graded, although little, if any, paving has been done, and many houses have been built along the line. East of Flatbush Avenue material changes are contemplated in the grade of Avenue F, and beyond the intersection of

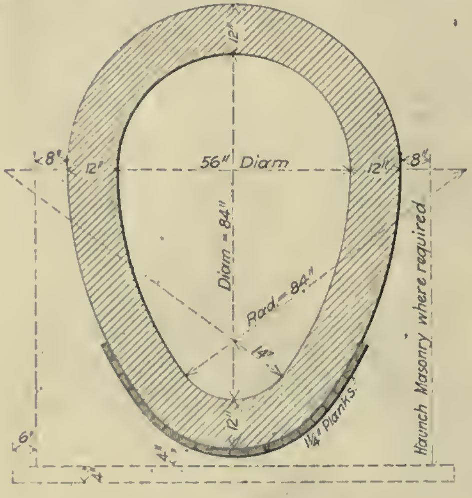
Avenue F and Paerdegat Avenue the location is almost wholly through a marsh only a few feet, at most, above high-tide level. For this section the streets existed only on paper and it was necessary for the sewer department to make extensive and accurate surveys, which, owing to the nature of the country, were somewhat difficult. Trouble has naturally been experienced in maintaining the line stakes and bench marks across the marshes, and the conditions have necessitated running the lines on offsets, frequently at distances of 50 to 200 feet from the center line. The general topography of this marshy territory is indicated by one of the accompanying views, taken on the line of the 90-inch sewer between Fifty-second Street and the Long Island Railroad, which also shows the sheeting and bracing of the trench and one of the pumping plants. At this place three 8-inch and two 6-inch centrifugal pumps were required to keep 300 feet of trench dry enough for masonry construction. The method pursued was to bulkhead off about 300 feet of trench, which was carried down to sub-grade and kept dry until the masonry was completed. In this vicinity the spring or ground-water level was about 3½ feet above the sewer invert.

Excavating machines of the kind shown in some of the accompanying views were built by the contractor for digging the larger trenches. Each machine consists of a heavy timber platform spanning the trench, supported on four car wheels traveling on two rails, one on either side, and an A-frame derrick with 30-foot boom mounted on the forward end of the platform and operated by a Lidgerwood engine and boiler in a small house on the rear of the platform. The excavated materials were shoveled into 1-cubic-yard steel buckets, which were hoisted by the derrick and swung over 2-yard dump cars on narrow-gauge tracks laid alongside. For a considerable part of the trench for the large sewer two of these machines were used together facing each other and about 60 to 150 feet apart, for greater convenience in handling the cars. The forward machine moved backwards, that is, with its derrick end toward the other machine, taking out the upper part of the material, and the second machine followed, removing the material down to the grade for the bottom of the sewer.

Machines of this type handled in this way are economical for work of this class. The presence of so much water renders the excavation extremely difficult, and a man is not able to shovel over 22 yards per day of 10 hours. There are seventeen men to each digger, or machine. On the trench for the 90-inch portion of the sewer, which is a very shallow cut (6 to 10 feet), one machine is being used and is passed over the line twice. On this part of the work one machine used in this way can open the trench as rapidly as the brickwork can be constructed. During the first movement over a given stretch of trench, the upper part of the material is taken out, and on the second trip of the machine the bottom is brought to grade ready for the sewer. On this part of the work, this spring, an additional platform has been attached to the rear of the machine to carry an auxiliary pumping outfit for removing the water from the trench bottom immediately in advance of the brickwork, supplementing the large stationary pumping plants along the trench. A 6-inch centrifugal pump mounted on a frame is suspended from the under side of the platform and the engine and boiler for driving it are mounted on the platform. This equipment is shown clearly by one of the views. As this pump travels with the machine, it is always near the point where it is most needed; the pump platform may, however, be detached from the excavating machine, if desired, as it is mounted independently on wheels. This arrangement, it is hoped, will to some extent avoid the frequent movement of the larger pumping plants at the side of the trench.

Where the 84-inch sewer turns from East Forty-fifth Street into Avenue G there is a 90-degree curve of 40 feet radius. To construct this piece of the sewer a machine of the type mentioned above was set up near the middle of the convex side of the curve, at the side of the trench, and fitted with a derrick having a boom 40 feet long so that it could command the whole curve. The method used at this place is indicated in one of the views. The centering and the method of closing the crown of the arch on the curve of the 84-inch brick sewer at Avenue F and Paerdegat Avenue is also shown by an accompanying illustration, in the background of which appears a shed containing two 8-inch centrifugal pumps.

In Avenue G near Forty-sixth Street the sewer crosses beneath the double tracks of the Long Island Railroad at an angle of about 45 degrees. To support the tracks across the trench a steel I-beam 24 inches deep and 36 feet long was placed by the employes of the railroad company beneath each rail, and the ends of these beams were supported on piles just outside, and close to, the lines of the sewer trench. As the excavation for the sewer was carried to the bottoms of these piles, it became necessary to support them by means of extra-heavy sheeting and bracing, the sheeting being placed against the piles. The arrangement of the two excavating machines at this place is shown in one of the photographs, which also indicates the method of splicing the telegraph poles so as to raise the line wires out of the way of the derricks on the two excavating machines. A 10x10-inch guard stick was laid outside each rail on top of the ties and bolted down. With these supports in place the sewer was successfully constructed without interruption to the heavy freight and passenger trains run at short intervals over this line.



Section of 66-inch Brick Sewer.

THE ENGINEERING RECORD.

Brooklyn Standard Egg-Shape Sewer

About 200 feet west from the railroad crossing just described, the 84-inch sewer is supported for 60 feet on a cribwork of 10x10-inch timbers laid up cobhouse fashion, 12 inches apart in the clear, filled with gravel and covered with a platform of 6x8-inch lumber. This form of support was adopted because at this place, near the edge of the marsh, the muck extended from 30 to 60 inches below the level of the bottom of the sewer, making necessary a low foundation embankment, and because the material under the muck was sharp sand and gravel so hard that piles could not readily be driven. The top of the cribwork is about 4 feet below the spring-water line and the wood will always be wet, so there is no danger of its rotting.

The Avenue G trunk sewer was designed and is being constructed under the direction of Mr. Henry R. Asserson, M. Am., Soc. C. E., chief engineer of sewers, Borough of Brooklyn. Mr. George T. Hammond is the division engineer in immediate charge. Mr. John McNamee, of Brooklyn, is the contractor.

(To be continued.)

The Mechanical Plant of the Minnesota State Capitol.

A new State Capitol has been in process of construction for the last few years in St. Paul, Minn., and is now approaching completion. It is a building of some 4,000,000 cubic feet of contents, heated almost entirely by the plenum system of forced hot-air distribution, lighted by electricity, provided with hydraulic elevators, furnished with the system of water distribution common to buildings of considerable size and has an extensive call-bell and telephone system. The heating and ventilating apparatus includes some 19,000 square feet of pipe coil heating surface, grouped at five points, each with a blast fan, and these blowers have a combined capacity for delivering under normal conditions 225,000 cubic feet of air per minute. They are operated in conjunction with five ventilating fans, which exhaust air from rooms subject to more or less vitiation. There are an equivalent of 7,000 16-candle-power electric lamps to be supplied for illumination, and the total connected motor load for driving fans and pumps amounts to 275 horse-power. A separate building has been constructed for generating the power required in the main building and this is some 367 feet distant and is connected to the main building by means of an underground tunnel. In both the power plant and in the equipment of the building itself a design of considerable interest has been developed, characterized by a number of specially instructive details. It is the intention to describe the power plant and the tunnel in the present article and to follow this by a discussion of the mechanical engineeering work in the Capitol in a subsequent issue.

Power House.—The power plant is noteworthy from the fact that its boiler plant is served by a mechanical draft equipment and is provided with economizers. The steam engines are, of course, direct-connected to the electric generators, and are run non-condensing, as there is use for the exhaust steam in heating. Only the exhaust steam, that is, steam at low pressure, is conducted to the building for heating work, and no high-pressure steam is led from it, except a small quantity for hot-water heaters of the plumbing system. It was felt that for such pumps as would have to be installed in the main building, it would be better to employ electric motors, and carry the power in the shape of electric current. This arrangement has been carried to the extent of using motors for driving the boiler feed pumps in the power-house itself, but the unusual departure in the provision of electric driving has been the installation of electrically-driven pumps for the hydraulic elevators in the Capitol.

The power-house building, while somewhat distant from the main structure, has been designed with a notable degree of attention to its architectural appearance. It is built on the side of a hill, and at one end of the building considerable excavation had to be made, so that it appears partly set into the ground. The plot has general dimensions of 60x165 feet, but one end is cut off at an angle by one of the streets of the city, and its ground area is about 8,350 square feet. It consists of an engine room and a boiler room, end to end, as shown in the accompanying drawings, and beyond the engine room the ground area is utilized for the firing space and the storage of coal. The total generating equipment of the station is 575 kilowatts and the engine room occupies in plan about 6 square feet per kilowatt, and the boiler room, including the firing space, about 5.85 square feet per kilowatt. These two rooms, excluding the firing space, form the building proper, and the rest is covered by a yard, into which coal wagons are hauled and the coal dumped directly through coal holes into the coal storage.

The power-house building is a one-story and basement structure built of St. Louis pressed brick with terra-cotta trimmings. An idea of the character of the exterior design of the building may be obtained from one of the accompanying illustrations. One of the noteworthy points in this design is the rounded outside corners. A consideration leading to the selection of mechanical draft was the proximity of the power station to the Capitol building, as the chimney required for the boiler plant could be kept short. As a matter of interest, it may be stated that it rises but 15 feet above the ridge of the roof and is enclosed in brick with the terra-cotta cap, conforming to the general design of the exterior. The stack itself is separated from the enclosing chimney by about 2 inches air space and the chimney brickwork consists of 8 inches of hollow brick enclosed by an outer facing of 4 inches of brick. The metal flue extends a few inches above the terra cotta cap. The engine room is lofty and well lighted, as indicated in the accompanying drawings. The distance from the floor, which is of 1 inch of cement on a concrete and brick-arch flooring, to the under side of the roof trusses, is 25 feet. Underneath the engine room, excavation has been made between the rows of engine foundations and wherever else space could be utilized, and a basement tunnel formed for the carriage of pipes. Both the high-pressure steam and the exhaust piping, as well as auxiliary piping, is all run in this tunnel space and there are no pipes overhead in the engine room. The headroom of the engine room tunnel is 9½ feet, except where the connection to the tunnel running to the Capitol building is made, at which the headroom is 4 feet greater.

Power Plant for the Minnesota State Capitol, St. Paul.

A further word may be said about the building construction. The roof trusses are supported by the walls, which have pilasters at the bearing of each truss. The foundations under grade are concrete. The trusses in the engine-room are exposed. There is no traveling crane in the engine-room, but, instead, a 15-inch I-beam runs along the ceiling on each side of the engine-room, 6 feet or so from the outside wall. This is, of course, riveted to the roof trusses and carries a trolley hand hoist of 10 tons lifting capacity. It provides facilities for handling the generators. The partition wall between the rooms is 16 inches thick. It has one opening fitted with doors, allowing for the central passageway through the station.

Boilers, Economizers and Mechanical Draft.—The boiler-room floor is 2 feet below the level of the engine-room floor, leaving sufficient headroom to run the ridge of the power-house roof continuous over both the boiler and engine-rooms. The boilers face the end of the power-house, that is, the firing space, and their backs are 9 or 10 feet from the partition wall between the engine and boiler rooms. The smoke breeching extends across the top of the boilers at the rear, and there are four boilers, all told, placed in two batteries, leaving a gangway between them extending longitudinally from the firing space, through the partition wall and through the engine-room. The economizers, one for each battery, are supported on a line with the smoke breeching over the space at the rear of the boilers and the mechanical draft equipment is carried by a structural steel framework in the center of the boiler-room over the space between the two batteries. The flue connections from the smoke passages direct and from the economizers are made at this central point.

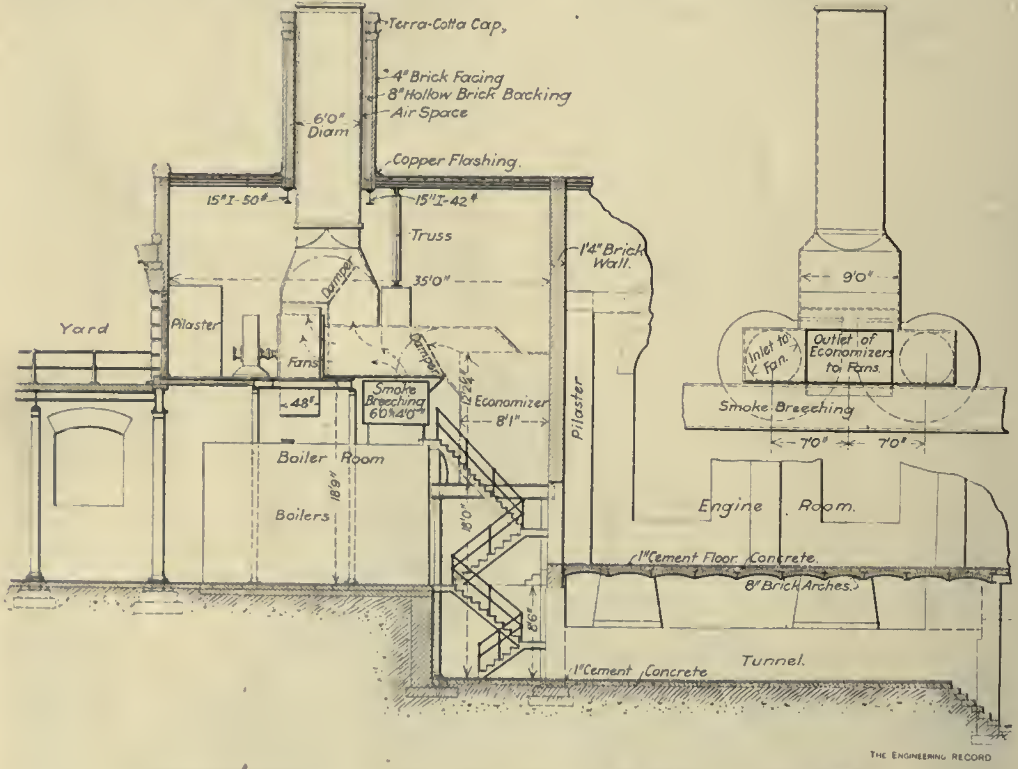
Under one of the economizer settings are located the boiler feed pumps and opposite the end of the tunnel the boiler-room is depressed in the form of a pit, in which the steam and other piping is dropped to the level of the lines in the tunnel. The floor of the coal store is on a level with the floor of the boiler-room, while its ceiling, built of brick arch concrete construction, supporting the yard above, is 16½ feet in clear height. There are five coal holes in the yard for the delivery of coal, and, in addition, a floating scale for weighing wagons when desired. An ash hoist at one end of the firing room also delivers to this yard, which is surrounded by a wall with a stone cap, partly with a cast-iron railing. The coal store can hold 500 tons. Its walls are plastered smooth with cement and it is provided with a system of narrow-gauge tracking in the floor with ½-ton open-side cars for conveying the coal to the boilers. The ash hoist is of the hydraulic type with direct-acting plunger, built by the St. Paul Foundry Company. Temporarily it is running on city pressure direct, but this will not be allowed when the plant is completed. Instead a pump and tank will be installed close to lift.

The boilers are of the water-tube type, built by the Erie City Iron Works, of Erie, Pa. Each was built to a specification requiring 2,250 square feet of actual heating surface, or, at 9 square feet per horse-power, of 250 horse-power capacity. The water tubes are 4 inches in diameter and about 23 feet 8 inches long and there are two steam drums in each boiler, each 36 inches in diameter and 21 feet long. The products of combustion pass backward over the bridge wall in contact with a lower group of tubes, then pass forward through the main nest of tubes and backward again around the under side of the steam drum, finally leaving the setting at the rear. They are fitted with the Hawley down-draft furnace, the upper grate of which comprises 27 tubes, 2 inches in diameter, disposed in the usual way on 2½-inch centers. These tubes are 5½ feet long between the headers. The lower, or front, header is connected with two 5-inch pipes extending forward at the bottom of the boiler from the rear header of the boiler tubes and the upper header of the Hawley tube grate is connected at each end with the corresponding boiler steam drum by a 6-inch pipe. The surface of the Hawley grate amounts to about 90 square feet for each boiler, or one-twenty-fifth of the total heating surface of the boiler. The settings are enclosed in a white enamel brick.

The smoke breeching for each pair of boilers is arranged to conduct the gases, either toward the center of the room, where the chimney and the mechanical draft plant is located, or toward the outer end of the room to the inlet of the economizer setting in each case. The breeching has a cross-sectional area of 24 square feet. Each economizer, which was built by the Green Fuel Economizer Company, contains 240 tubes, presenting, all told, 2,850 square feet of heating surface, or about 63 per cent. of the heating surface of the boilers served by it. The mechanical draft plant comprises two fans, each 7 feet in diameter by 34 inches peripheral width, one fan to serve as a relay in case of accident to the other. Each is designed to handle the products of combustion of the entire boiler plant at a maximum peripheral speed of 5,175 feet, the boilers burning 4,000 pounds per hour of Youghiogheny run-of-the-mine, or slack coal, giving 13,300 British thermal units per pound. The fans were built by the B. F. Sturtevant Company, and each is directly driven by a 25-horse-power engine, and the bearings are of the water-cooled type. Dampers are, of course, provided for directing the gases to either fan or around both, as the case may be, or to shut out the economizers when desired. The smoke passages as well as the chimney are formed of ⅜-inch boiler iron. An estimate would indicate that each fan to meet the specification requirements would have to pass 16,000 cubic feet of air at 60 degrees or 33,000 cubic feet if the gases of combustion are at 400 degrees per minute. This is allowing 18 pounds of air per pound of coal. The speed of the fan to meet the maximum requirement is 235 revolutions per minute. The top of the chimney is about 50 feet above the boiler grates.

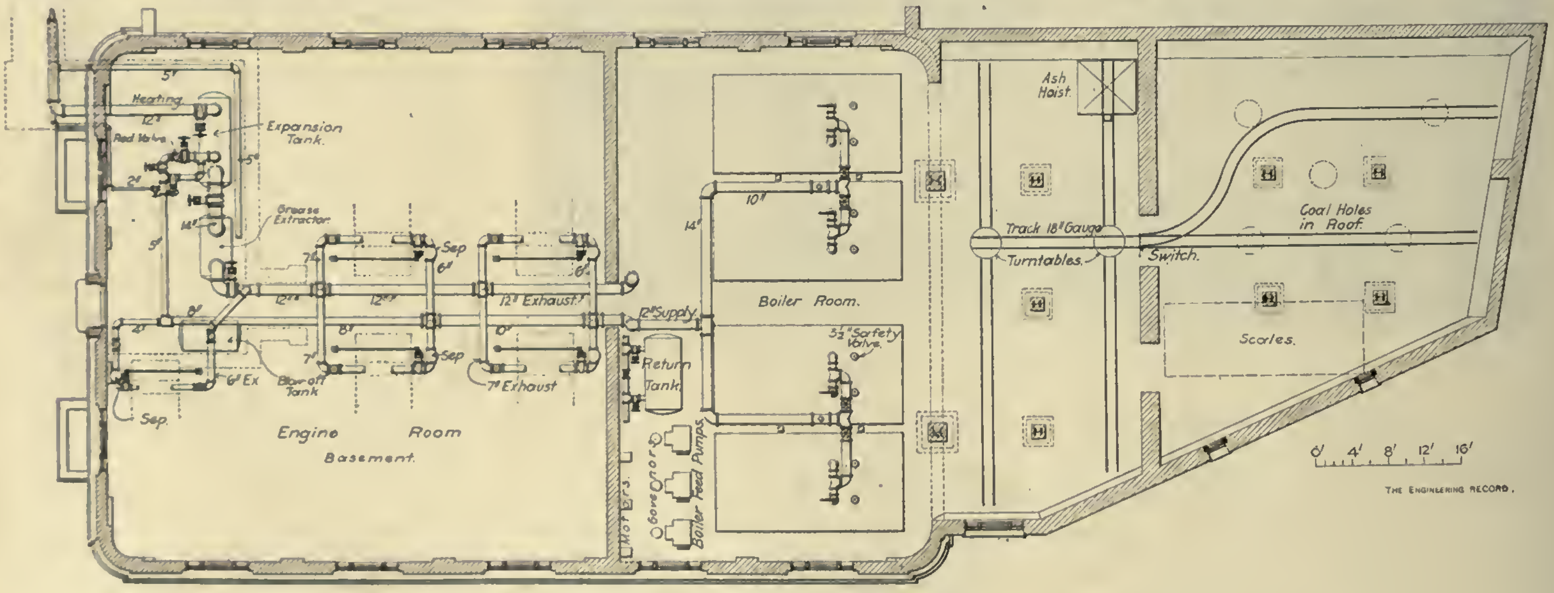
Steam Piping.—The boilers supply a 14-inch steam header, supported overhead immediately back of the boiler settings. The connections from the pair of steam drums of each boiler are joined together, and, as shown in an accompanying drawing, the steam supply from each battery is passed into a single 10-inch pipe passing backward to the header, one battery of boilers feeding into one end of the header and the other into the opposite end. The header itself measures 23½ feet long. A pop safety valve is fitted to each steam drum, a lever safety valve is provided for each boiler, and each boiler is connected into the steam system through a gate valve. At the center a 12-inch pipe is taken from the bottom of the header and carried to the basement tunnel under the engine-room, where the steam main is carried horizontally through the tunnel for the supply of the engines. At the bottom of the drop, where the tunnel main starts, a tee was used for the connection and the bottom of the tee is closed, as is often done, by a blank flange through which a drip connection is made, returning the condensation by means of a trap to the return tank for delivery to the boilers through the feed pumps. The tee is supported by means of a pipe stanchion. The piping throughout is extra heavy wrought-iron lap, welded with Van Stone joints.

The generating equipment comprises five units, four of 125-kilowatts capacity each, and the fifth of 75 kilowatts. The larger units are set in pairs across the room, with their steam ends at the central passageway through the room and their generator toward the outside walls. This arrangement minimizes the length of steam piping necessary, and, as shown in the accompanying illustrations, the steam connections for each pair of engines is taken from the main at a single point. Steam is drawn from the top of the main and run under the engine-room floor to a gate valve at the engine cylinder. Although each branch for steam supply is short, a steam separator is inserted outside the gate valve. These are of the type made by the Direct Separator Company, of Syracuse. The steam main decreases in size as the connections are taken from it and at the end of the engine-house tunnel it ends in a 4-inch pipe leading to the small unit beyond a 5-inch connection for the supply of live steam to the heating system when the amount of exhaust is insufficient.



THE ENGINEERING RECORD

Longitudinal Section of Boiler Room, Showing Mechanical Draft Plant.



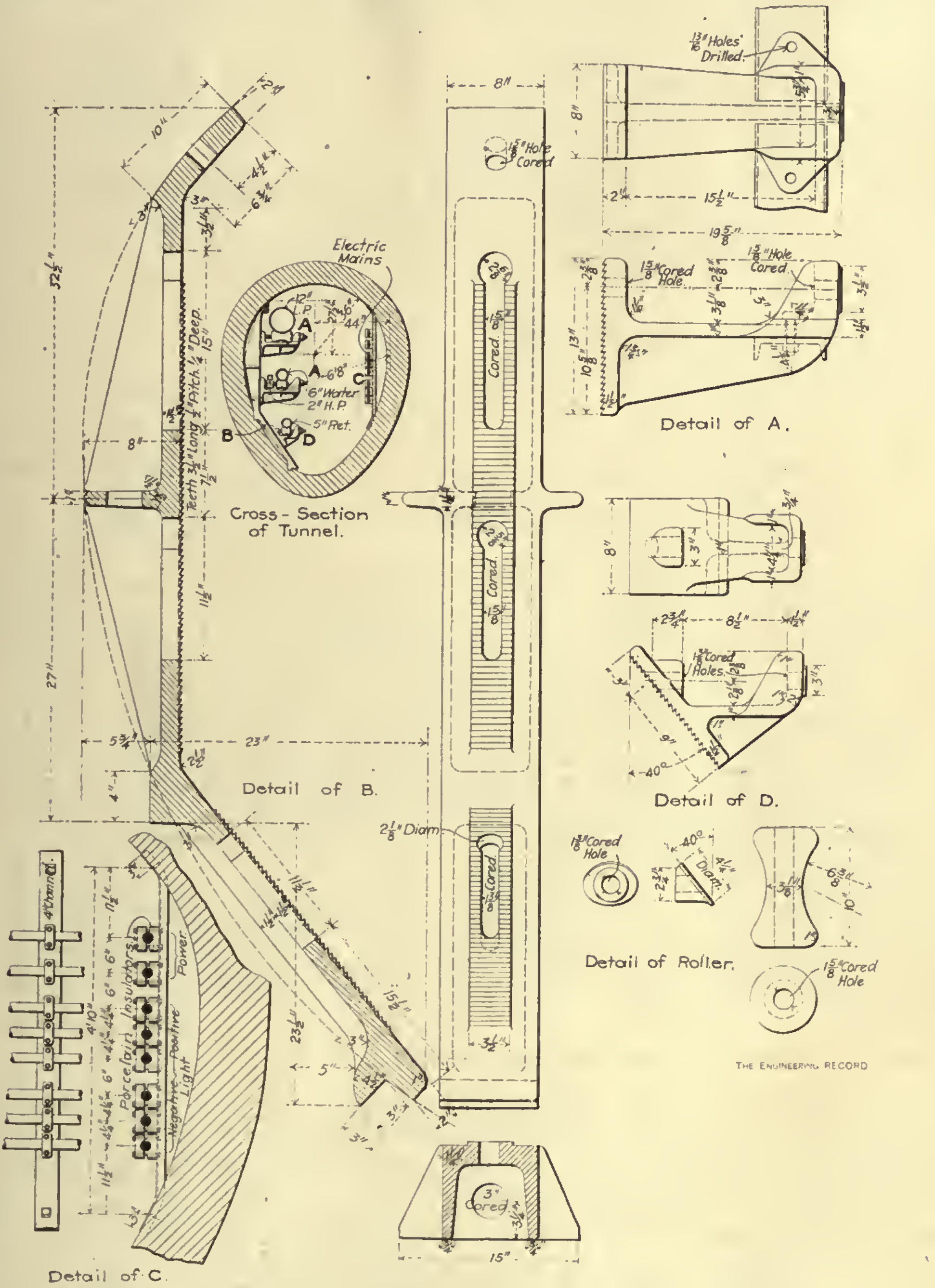
THE ENGINEERING RECORD.

Minnesota State Capitol: Plan of the Power Plant, Showing Live and Exhaust Steam Piping.

The exhaust steam connections are arranged similarly to the live-steam pipes, as indicated in the illustration. The valves to both the live and exhaust pipes at each engine are controlled from floor stands in the engine-room, and these stands are side by side, the exhaust valve stem being continued directly upward from the valve, while the valve on the live-steam connection is reached from a short line of shafting and bevel gearing. The exhaust main is 12 inches in diameter at the boiler-room, where it is turned upward to discharge into the atmosphere through the usual back-pressure valve, in order that the exhaust may be utilized during the heating season in the ordinary way.

At the other end the header is 14 inches in diameter and is connected into the heating system through a Utility grease extractor, supplied by the Standard Steam Specialty Company, and also through an expansion tank connected in series with the grease extractor. While the grease extractor can serve as a muffler, owing to its large volume as compared with the steam pipe connecting to it, it was decided to install the expansion tank in addition. As has already been stated in these columns, the so-called expansion tank is a usual adjunct of the mechanical plant of the Middle West, especially where it is necessary to run a number of different mains for heating purposes. Into the expansion tank is brought the live-steam auxiliary supply, with the reducing valve near the tank and a by-pass around the reducing valve. According to the experience thus far, only five of the eight sets of chains in the grease extractor show any oil, which fact is taken to indicate the efficacy of the Utility apparatus. The extractor and expansion tank are located near the entrance to the tunnel and the heating main, 12 inches in diameter, is run from the top of the expansion tank into the tunnel, with the valve at the tank. A high-pressure line, 2 inches in diameter (this, as explained, for hot-water heaters in the Capitol) is run from the 5-inch live-steam pipe employed for the delivery of live-steam to the expansion tank. Both the live-steam and exhaust mains are suspended from the beams of the engine-room floor by wrought-iron hangers. The expansion tank is 4 feet in diameter and 10 feet long.

Feed-Water System.—Feed-water is, of course, obtained during the heating season largely from water of condensation from the heating apparatus. Generally speaking, the water is drained by gravity from the Capitol building to a return tank in the boiler house alongside the boiler feed pumps. In summer, however, when there is little or no water returned, as the exhaust is discharged to the atmosphere, the feed-water is mainly made up of fresh water, taken from the city mains. No feed-water heater was provided, but economizers were installed instead. All the water, from whatever source, is delivered to the return tank, the fresh water supply, however, controlled in the usual way by a float valve, to make up deficiencies automatically.



Minnesota State Capitol: Detail of Pipe and Wire Supports in Tunnel.

The fresh water for the boilers is metered and is first passed through a brass-pipe cooling coil in the blow-off tank, this arrangement being that frequently employed in places where it is necessary to cool down the contents of the blow-off tank before delivering into the sewer. The return tank is 4 feet in diameter and 8 feet long and is built of ⅜-inch shell and 7/16-inch heads. Besides the return main from the heating system, which is 5 inches in diameter, and the 2-inch water pipe from the city mains, there is brought to it a drip line from the engine steam separators, discharged into the tank through a trap. The return tank has, of course, a discharge connection to the blow-off main, and a vapor pipe run from it to the main exhaust riser above the back-pressure valve.

Three feed pumps were installed, each of the capacity of 40 gallons per minute, against 150 pounds pressure. Two are equal to the requirements of the plant, leaving the third as a reserve. Three pumps of the present size were thought better than two of twice the capacity of any one, as there is one chance in three for failure, as against one in two. They are of the Dean triplex pattern. Each is separately driven by belt from a 7-horse-power motor, of Electric Machinery Company, of Minneapolis, make, under automatic control of a Kieley pump governor of the type usual with steam-actuated pumps. The balanced float lever of the Kieley governor actuates an automatic switch for stopping and starting the motor, according to the level of the water in the return tank. A feature of the use of the three pumps, that is, of two in regular operation, is that one governor is set to act ahead of the other, so that one pump is sufficient for say three-quarters of the time, and two together are only required for about one-eighth of the time, due, for example, to a sudden inrush of water to the return tank. In other words, both pumps are idle about one-eighth the time, and both working together only about one-eighth the time. Each pump has three plungers, 4x4 inches in size, and has a 3-inch suction and a 2½-inch discharge. They draw from a suction main continued from the return tank.

Over the boilers the feed main bifurcates into two lines, one leading to the economizer inlets and the other to the main for feeding directly into the boilers. The feed connections are located toward the rear of the boilers and the valve to each boiler is controlled by a stem extending forward to the front part of the boiler, where a sprocket wheel is attached, carrying a chain dropping within reach of the fireman. In other words, by means of the pendant chain, which is nickel-plated, the more or less inaccessible feed valve is under immediate control.

Generating Equipment.—The generating equipment consists of simple engines of Corliss pattern, direct-connected to continuous-current 250-volt generators, built by the Electric Machinery Company, of Minneapolis. The generating engines are of the Minneapolis Corliss manufacture, and the four for the 125-kilowatt dynamos have cylinders 16x42 inches in size, and operate at 80 revolutions per minute, and the fifth engine has a 14x36-inch cylinder and runs at 90 revolutions. The current is all controlled from a switchboard at the far end of the engine-room. This is of marble, 2 inches thick, and comprises nine panels, five of which are devoted to the generator connections. The sixth is an equalizing panel with meters, providing for recording the total output of the plant, and the remainder for the feeder control. There are two sets of bus bars, one for power and one for light, and each generator switch is of the double-throw pattern, with three poles, the third for equalizer connections. Each generator panel carries an ammeter at the top and a circuit breaker at the bottom. The two sets of busses may be thrown together, and both light and power supplied from the same generators in the power-house. The connected load has already been referred to and it may be stated that the wiring from the switchboard to the point of use is designed so that the drop in voltage will not exceed 6 per cent. under full load.

Pipe and Wire Tunnel.—Both the piping and wiring is carried in the same tunnel to the Capitol building. This is of the egg-shape form of construction, 8 feet high, 6 feet wide and 367 feet long. On one side are carried all the piping and on the other the electric cables, the latter being eight in number. The walls of the tunnel are of brick, 12 inches thick.

The method of carrying the piping is a very interesting one, as shown in an accompanying drawing. The various pipes (which comprise the 12-inch low-pressure pipe for heating purposes, the 5-inch return, a 6-inch water pipe for domestic or house purposes, and a 2-inch high-pressure pipe) are all supported on expansion rollers in the usual fashion. These are fixed in brackets, which may be adjusted in position to bring about the desired alignment or pitch of the pipe, but it is the scheme by which this effected that is the instructive feature of the present design. Each bracket has a saw-tooth surface meshed with a similar surface, fastened to the tunnel wall. This is a casting, and, as shown in the detail sketches, carries two projections fitted into the brickwork in such a position that the main stresses due to the weight of the pipes are taken up at these two points. In addition to this, the only other fastening to the tunnel wall is a 1½-inch anchor bolt in the top of the casting. The casting is ribbed, as indicated, and the teeth are cast with it and not finished, but left with the original surface. The toothed surface of each bracket is likewise unfinished, and it has been found that the sets of teeth can be brought together quite closely, even where there has been some shrinking or slight curvature of the two surfaces. The brackets are, of course, attached to the casting by through bolts and can be placed at any height by means of cored openings in the casting face. The bracket supports are spaced at intervals of 16 feet along the tunnel. The larger brackets are shown braced to prevent lateral movements, by longitudinal channel irons, bolted to the under side of the brackets, one channel bar extending from one bracket to the next, and so on. They were found unnecessary, however, and were omitted, although shown in the engravings. The expansion rollers are all made to conform to the outside diameter of the pipes, which they support.

The method of supporting the electric cables is also shown in the drawings. They are held in porcelain clamps, fastened to a channel bar, as indicated. Two of the cables are for power and the remaining six for lighting, three for the positive legs of the system and three for the negative, the generator voltage being 250 volts.

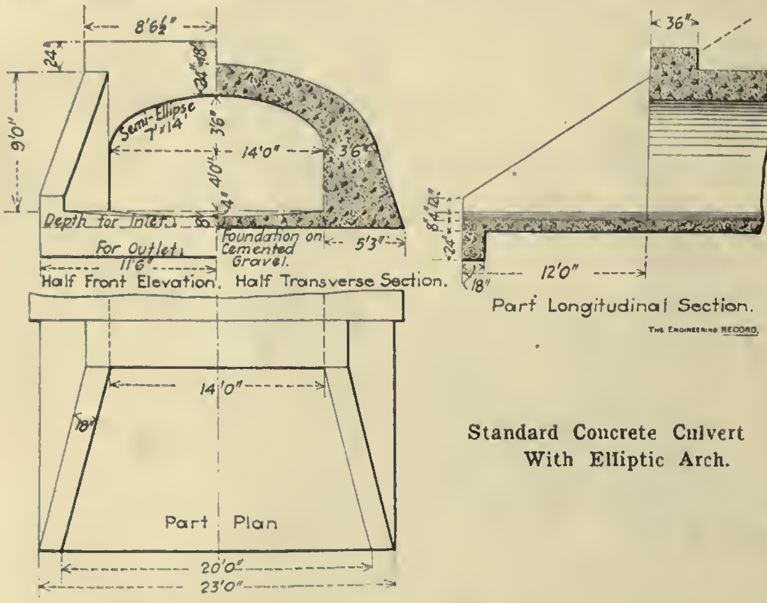
The Minnesota State Capitol was designed by Mr. Cass Gilbert, largely at his St. Paul office. The mechanical equipment was entrusted to Mr. Burt S. Harrison, M. Am. Soc. M. E., A. I. E. E., A. S. H. & V. E., consulting engineer, of New York, who laid out the work and designed the system of pipe supports installed in the tunnel. Messrs. W. I. Gray & Company, of Minneapolis, were the contracting engineers for the installation described.

Fire-Resisting Wooden Partitions in Bangor, Me., have been designed and used satisfactorily for some years by Mr. W. E. Mansur, architect of the new Court House and other buildings in that city. In the few steel-frame buildings which have been constructed in Bangor, it was found that the necessity of importing special tools and workmen from Boston or New York made the cost of wire lath, expanded metal and hollow-tile partitions prohibitive. In order to provide an economical substitute which would occupy little space, would be a non-conductor of sound and heat and would resist moderate fires, a simple type has been built, which is considered very satisfactory. These partitions have a core of 2-inch vertical hemlock boards well secured to the floor and ceiling, and covered on both sides with crossed diagonals of ⅞-inch hemlock, well nailed, so as to form a solid timber web 3¾ inches thick, which develops abundant strength. Each surface is then furred, lathed and plastered with a ¾-inch coat of lime mortar. The mortar keys between the lath and furring and makes a durable and satisfactory finish. The cost of the lumber is so moderate in this region that the construction is cheap and popular. By substituting cement for lime mortar, this work could be made still more fire-resisting. An example of its use can be seen in the Morse-Oliver building, where all the partitions are made of it, and are fitted with double doors between adjacent offices.

The Southern Missouri Railway.

By Charles A. Sheppard, Resident Engineer, Edwardsville, Ill.

One of the important pieces of railroad construction done lately by a road outside of the large systems is the Southern Missouri Railway, now known as the Missouri Division of the Illinois Southern Railway. Simultaneously with this work a branch six miles long was built in Illinois from Missouri Junction, on the Illinois Southern Railway ten miles northwest of Chester, to Bogy Landing opposite Ste. Genevieve. Inclines have been built at Bogy Landing in Missouri near Ste. Genevieve and a transfer boat of ten cars' capacity makes the crossing of the Mississippi River. From Little Rock Landing the Southern Missouri Railway extends southwest to Bismarck, 43.2 miles, passing through Ste. Genevieve near its eastern terminus and through the Flat River lead fields near the Bismarck end. Mr. Robert Moore, of St. Louis, was chief engineer of the new work in both States and the writer was locating engineer of the above work and resident engineer on the work in Missouri.



Standard Concrete Culvert With Elliptic Arch.

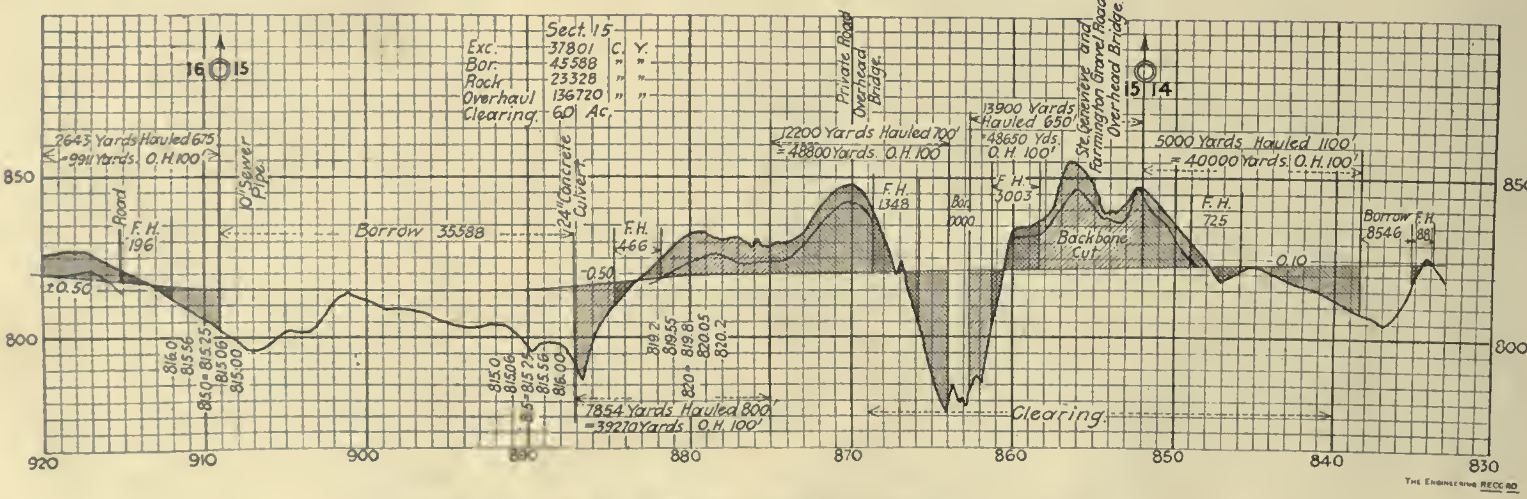


Diagram Showing Method of Making Preliminary Estimates of Cuts and Fills.

The Illinois Southern Railway, the parent road, runs from Salem to Chester through the coal fields, and it is expected that the principal business will be to haul coal to the lead mines of the Flat River or St. Francois County District, where more lead is produced than in any other locality in the world, making the consumption of coal there very large.

The idea of building a railway from the Mississippi River to the mineral fields of Missouri is quite old and when Iron Mountain was thought to be inexhaustible a road was surveyed and partly graded and bridged extending from West Chester to Iron Mountain. The panic of 1873 caused the shutting down of work and though many efforts have since been made to finish the road none has been successful.

Of late years the western end of the route was surveyed to Flat River, using the old location over the "Ozark Ridge" and to the east where the difficult work had been partly done. Efforts were made to build this line but none got beyond the paper stage.

As the first idea of the Illinois Southern Company was to build from West Chester to Flat River it was thought that the Saline Creek route could be utilized, and a preliminary was run over this line. The grades were steeper than were wanted and there was no chance to improve them, so when Flat River was reached a preliminary line was run from there to Ste. Genevieve. Though the country is much rougher looking along this route it proved to be much the better line and location followed the preliminary. To build a road from any point on the Mississippi River near Ste. Genevieve to Flat River and Bismarck, the "Ozark Ridge" must be crossed, its general elevation being 700 feet above the Mississippi Valley. It is too broad and flat on top to permit cutting to much extent or tunneling.

The two longest streams in this neighborhood reaching from the Ozark Ridge to the Mississippi Valley are the River Aux Vases emptying five miles south of Ste. Genevieve and Establishment Creek, which empties five miles north of Ste. Genevieve. These creeks have good valleys for railroad building for some distance, but head up very suddenly and the slopes are extremely rough when they get within five miles of the summit.

Emptying at Ste. Genevieve is the South Gabouri Creek, six miles long and heading up in the proper direction. The ridge at its head is joined by the divide between Establishment Creek and Jonca Creek, a branch of the River Aux Vases. The line was located up Gabouri Creek and then along this ridge which extends in the required direction and joins the main summit twenty miles from Ste. Genevieve. For five miles more the line is on or near the divide between the St. Francois River and Big River tributaries and then it enters a valley leading to Flat River and when reached follows Flat River to its headwaters at Bismarck. The heavy work lies east of the summit and consists mostly of cutting through the divide when it is too crooked to be followed and cutting through spurs of the divide. Cuts are mostly rock and two of them are over 58 feet deep and one of them 65 feet. About sixteen miles from Ste. Genevieve the divide sags about thirty feet below grade for 9,000 feet and bends badly out of direction. Lying in a direct line and joined on to the divide at its west end is a very narrow and straight spur whose top fits very closely to the required grade. The line was located on this spur and about a mile of tangent secured crossing a gorge called Rough Creek with a bridge 105 feet high. The steel work in this bridge is 615 feet long and the wooden trestle approaches bring the total length of the bridge up to 1,425 feet.

A about half of the line is a ridge location, there is considerable curvature, about 30 per cent. of the line being curved. Five degrees is the maximum and there are only three of these outside of yard limits. One per cent. is the maximum grade, which is used on about fifteen miles in all; about seventeen miles range from 0.5 to 0.8 per cent. and twelve miles are practically level. Ascending to the main summit there are only 25 feet of adverse grade though a total climb of 670 feet is made.

All grades of a contrary direction have a minimum of 1,000 feet of level grade between them.

As soon as location was completed a sounding party of four men was sent over the line to make soundings in the cuts containing rock. An ordinary 2-inch auger with a stem of 1-inch gas pipe in 4-foot sections was used and gave good results. In cemented gravel overlaying solid rock there was considerable uncertainty and in some cuts the material bored through and thought to be earth was too hard to plow with six-horse plows and had to be classified as loose rock. Outside of these cases, the rock profile plotted from sounding notes, and the cross-sections taken during progress of work corresponded very closely.

Transition spiral curves were used on the ends of all curves sharper than two degrees. Length of spiral was 250 feet. The method used was to run in the simple curve and make the transition curve by offsets from the simple curve. This kept all tangents in their original location and shifted the curves inwards a regular distance after a point 125 feet beyond the P. C. had been passed and up to within 125 feet of the P. T. Calculations of these offsets were made in the office for every station and half station within the limits of the transition curve, and the division engineers were furnished copies. This method reduced the work, so that it was very little more trouble to run in the curves than simple curves would have been.

Profiles for letting contracts were prepared giving as much information as possible concerning the character of work and the proposed distribution of material. Distribution was shown by a system of cross hatching which is illustrated on the accompanying diagram, the aim being to give the number of yards in each cut and where a cut was hauled to several different places, to show the number of yards hauled and the average distance hauled for each place or part of the cut, and the result was reduced to yards overhauled for 100 feet. This is more work than is usually put in on a preliminary profile but in the writer's opinion it is time well spent and saves money for the company and lots of worry for the engineers later.

The swell of material in the rock cuts and its effect on overhaul was provided for in the following clause of the specifications: "Solid rock and loose rock will be measured in excavation and in computing overhaul, the number of yards hauled will be determined by the measurement in excavation and the distance hauled will be determined by the volume of embankment made from it."

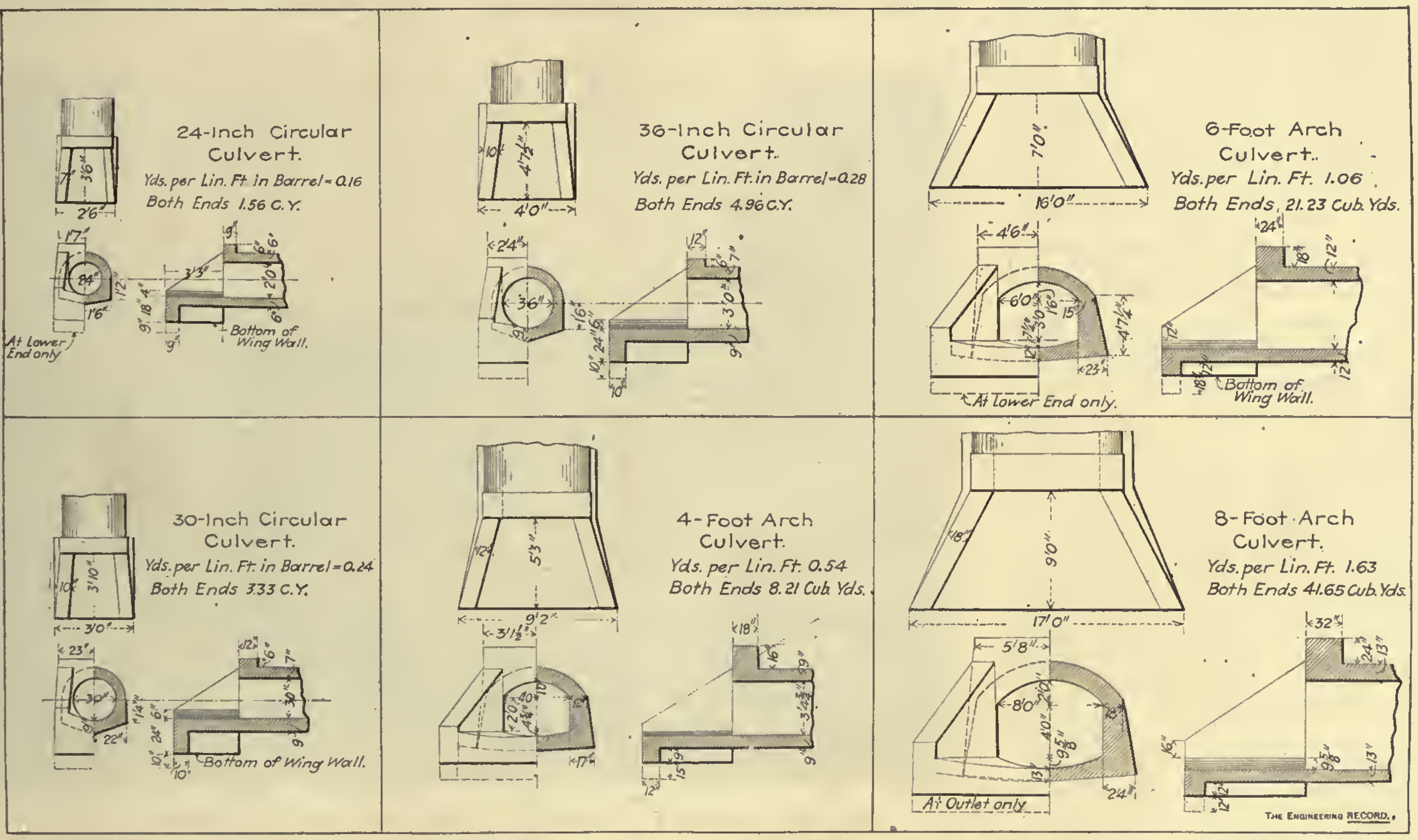
There is very little bridge work on the line except at Rough Creek, and though there are a few frame trestles over streams too large for arch culverts, none of these places will require a permanent opening of more than 80 feet. One stretch of 14 miles is without a bridge, and another one of 11 miles and another of 5 are the same, all drainage being taken care of by concrete culverts.

Three types of culverts were used. The 18, 24, 30 and 36-inch culverts are circular in form. For 4, 5, 6, 7 and 8-foot openings, a segmental arch designed according to a formula by Mr. Robert Moore were used, the inside dimensions being as follows: S = span. Middle ordinate of lower segment = 0.1 S. Vertical height of side walls = 0.5 S. Middle ordinate of upper segment = 0.25 S.

Area is as follows:

Upper segment or arch = 0.1742 S^4.
Lower segment = 0.0676 S^2.
Rectangle = 0.5000 S^2.
Total area = 0.7418 S^2.

Two elliptical arch culverts of 14 feet span were built as shown in one of the illustrations.



Standard Concrete Culverts, Southern Missouri Railway.

Drainage areas were traversed and acreage determined and slope and shape of basin taken into account to ascertain the proper size of culvert to be used at each place.

On a good part of the line gravel was used in the concrete, and seemed just as good if not better than broken stone and sand. Proportions were determined by tests and were usually 1 of cement, 2 sand, 5½ broken stone. In gravel the general proportion was one to seven. Only Portland cement was used. The heaviest concrete works are the Rough Creek bridge piers, one of them being about fifty feet high. Pedestals for foundation of steel work at Rough Creek are of concrete.

The concrete culverts have proved very satisfactory during two seasons of heavy rain and no washout has occurred and none have failed.

The McArthur Brothers Company, of Chicago, contracted for the whole line, for the grading and masonry. Work was begun in June, 1901, and was more difficult than it was first expected to be. A great deal of the solid rock was in large masses without any stratification so that blasting was expensive and the breakage extended beyond the proposed cross-section in nearly all the cuts. The largest cut of all, 65 feet deep, had to be taken out on a half to one slope on account of bad ledges of sandstone near the top. Another rock cut had to be taken out to a full earth cross-section to secure safety from slides.

A great deal of red waxy clay was encountered in many of the cuts which rapidly disintegrated on exposure to the weather and settled badly in the fills.

Material on a five-mile section of the work was very much mixed; one cut having porous sandstone nearly light enough to float, while close at hand was a cut with the heaviest limestone in the country in it. The "backbone" cut was of limestone full of seams running in all directions, and when shaken up by powder it went to pieces, making a first-class quality of ballast. A steam shovel was put to work there after tracklaying passed this cut and the track was given its first lift of ballast for over ten miles out of it. The nature of the soil and material from excavations put into the banks make it absolutely necessary to use ballast or the track would soon be buried and the rails bent.

After Flat River was reached in January, 1903, "chatts" from the lead mills were used for ballast. In addition to the output of two mills, having a combined capacity of 600 yards a day, two dumps or waste heaps of chatts were secured, and a steam shovel put to work loading this material. About 120,000 yards were secured in this manner between May and September, half of it being shipped to the Illinois side. Chatts make a good ballast for several reasons. In the lead country and nearby, they are cheap. The cost of surfacing track and renewing ties is very small as compared to this work in broken stone or slag. They keep all vegetation from growing and ties last well in chatts ballast. They wash easily and should be faced with rip rap of some sort in cuts.

Grading was completed in June, 1903, and track laid to Bismarck during the same month.

The regular location party consisted of fifteen men including the cook and teamster. Construction parties, three in number, consisted of the division engineer, rodman, tapeman, axman and teamster. Surveys were begun in October, 1900, and finished in February, 1901, except the 7½ miles between Elvins and Bismarck, which were not decided on until in the fall of 1901. This location was made by one of the construction parties in February, 1902.

The Southern Missouri Railway construction standards are as follows:

Width of roadbed on fills of 6 feet and less = 16 feet.

Width of roadbed on fills of less than 16 feet and over 6 feet = 18 feet.

Width of roadbed on fills of 16 feet and more = 20 feet.

Width of roadbed in earth cuts, 22 feet, slope 1 to 1.

Width of roadbed in solid rock, 18 feet, slope ¼ to 1.

Seventy-pound rails; No. 10 frogs on main line turnouts, and No. 7 in yards. Ties per mile, 2,992.

The work averaged about 3,400 yards per mile and the total amount of excavation added to the total amount of borrow came on final estimate within about 1 per cent. of the preliminary figures. Excavation was increased considerably and borrow reduced.

The Bridge of Ayr, built in 1232 and made famous by one of the poems of Robert Burns, has recently been closed to traffic, on the recommendation of an Edinburgh engineer. The bridge is a stone arch structure.

The Weston Aqueduct Pipe Arch over the Sudbury River, Massachusetts.

Until December 29, 1903, the water supplied to Boston and the other municipalities of the Metropolitan water district was conveyed from the impounding reservoirs to the distributing reservoirs within the district through the Cochituate and Sudbury aqueducts. On the date given, however, the new Weston aqueduct was put into commission, as stated in this paper January 2, and now supplements the older aqueduct. Articles printed in this journal May 4, 1901, and October 18 and 25, 1902, described and illustrated the design and construction of the new aqueduct, and in the issue of October 25, 1902, mention was made of the two 7½-foot riveted steel pipe inverted siphons which convey the water across two valleys that interrupt the contour location of the aqueduct.

The longer of the these siphons crosses the valley of the Sudbury River, has a length of 3,617 feet and, at its lowest point, is about 75 feet below the hydraulic grade line. Only one pipe-line has been laid, sufficient to meet the demands for water for several years to come, but with a capacity much less than that of the masonry portions of the aqueduct. Two other pipes, which will probably be of the same size, are to be laid as required in the future. Where the line crosses the Sudbury River, instead of laying the pipe in a trench beneath the water or building a bridge to carry it above the stream, the pipe itself was designed to span the river as a tubular arch between two substantial abutments of concrete faced with granite ashlar masonry. The pipe-line was constructed with alternate inside and outside courses, each course being made of a single 7/16 inch basic open-hearth steel plate, about 7½ feet long, excepting that the arch was made of plates ⅝-inch in thickness.

The arch is circular and has a radius of about 155 feet at its center line, a span of 80 feet between abutments and a rise of 5½ feet. An elevation of this arch was reproduced with the article of October 25, 1902, and accompanying illustrations show some of the details, together with views of the structure taken during its erection and after completion. In order to insure accuracy of alignment and rapidity of erection, the pipe sections forming the arch were assembled on falsework at the contractors' shops and the rivet holes for the circular seams drilled in place. This falsework was carefully marked and later was re-erected on a wooden trestle at the bridge site with its various members in the same relative positions. The arch was riveted at the shops in sections about 20 feet long, using a hydraulic riveter which exerted a pressure of approximately 80 tons on each rivet. The rivets are 1 inch in diameter, and the circular as well as the longitudinal seams are double riveted. The pitch of the rivets is 3⅝ inches and the distance between rows is 1¾ inch. The plates are lapped 4⅞ inches.

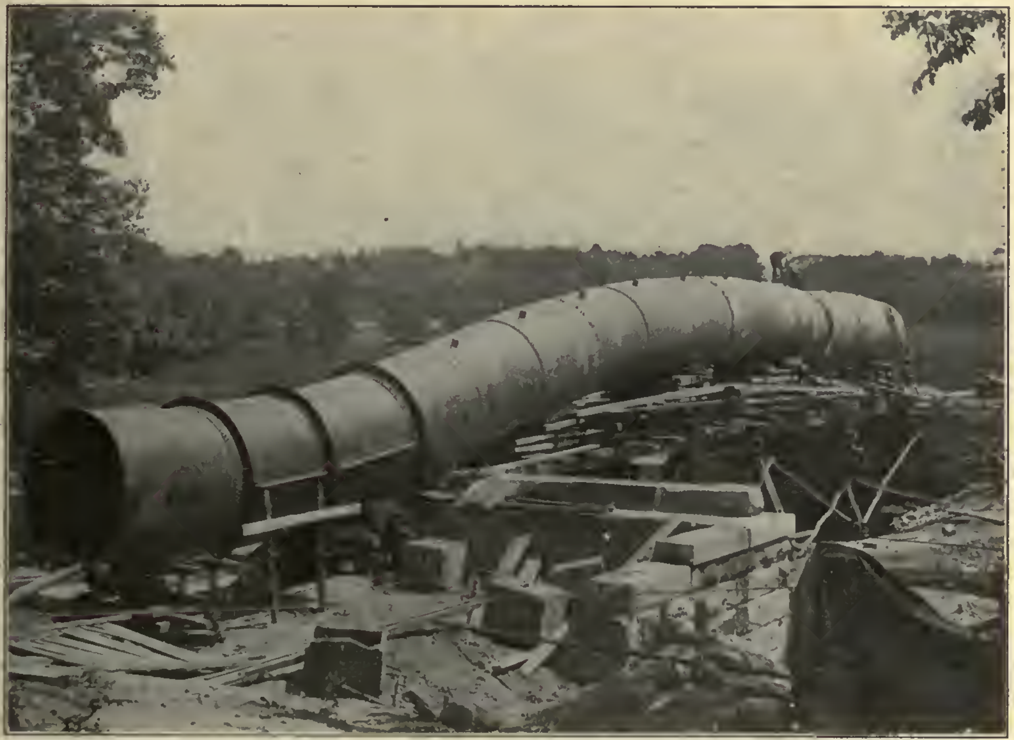
Each section, consisting of three courses, after being calked and tested, was dipped into a hot bath of mineral rubber pipe coating made by the Commercial Asphalt Company, of New York. The vertical dipping tank used for all these steel pipes was illustrated in the article previously referred to. The steel plates were rolled by the Central Iron & Steel Company, of Harrisburg, Pa., and inspected by the Pittsburg Testing Laboratory, of Pittsburg, Pa. All the rivets were furnished by the Champion Rivet Company, of Cleveland, O. Field joints were riveted with Boyer pneumatic riveting machines of 4½-inch stroke, making 800 strokes per minute. These machines were set up and firmly braced inside the pipe at the joint to be riveted, and pneumatic holding-on tools were fastened by chains around the outside of the pipe. The field joints were calked with Boyer pneumatic calkers of 1¾-inch stroke, making 1,500 strokes per minute.

The portion of the pipe forming the arch across the river is connected to the adjacent portions on either side by reverse curves having a radius of about 67 feet at the convex, or lower side of the curve. The greater part of each of these curves is embedded in the masonry abutment, as indicated by the illustrations. The shape of the portions of the pipe buried in the abutment, together with the adhesion of the concrete, offers considerable resistance to any tendency to slip or overturn, but to provide still greater resistance to any possible movement of the pipe in the masonry, three collars of 6x6-inch steel angles and four longitudinal pieces of angle of the same size were riveted to the portion of the pipe in each abutment, as is shown in one of the photographs.

Weston Aqueduct: Ninety-Inch Pipe Arch over the Sudbury River.

In order to drain portions of the aqueduct on each side of the river, a 24-inch blow-off pipe ending in a 24 to 36-inch increaser, was laid close to each abutment, with head walls of concrete, as shown in the views. A 16-inch connection was made from the 24-inch pipe to the steel pipe, and by means of a Y-branch blow-off connections to the steel pipes to be laid at later dates, were provided for. The arrangement at the west abutment is shown in an accompanying drawing; the other is similar. To remove air from the pipe arch a 2-inch Chapman corner valve was attached to a short pipe which was flange-connected to the steel pipe at the crown of the arch. On the few occasions when the air valve has been opened, there has never been any air found in the pipe. For the convenience of the employes of the waterworks a wooden foot-bridge, with 1-inch iron pipe railings was attached to the arch by means of pairs of short 6x6-inch angles riveted to the pipe, as shown in the views and a detail drawing.

Wash borings were made on the sites of the abutments to a depth of about 25 feet below the surface. Aside from small deposits of silt on the easterly side of the river, the materials encountered afforded a satisfactory foundation for the masonry. The silt at the site of the easterly abutment was removed and the lower part of the excavation refilled with coarse gravel. Each abutment extends about 25 feet along the pipe line and the portion below the belt course is wide enough to accommodate the two additional pipes. The earth slopes at the ends of the abutments are protected by substantial slope paving and a deep layer of riprap was deposited on the river bottom in front of each abutment. At times of low water the river is not very deep at this place and so no particular difficulty was experienced in enclosing the site first of one abutment and then of the other in a low cofferdam. The longer side of the cofferdam was built approximately along the axis of the river and served for the excavations for both abutments, short wings being built from the ends of this portion, first to one shore and then to the other. The abutments were built some time in advance of the laying of the pipe.



Sudbury River Pipe Arch: Method of Connecting Pipe Sections; Anchors in Masonry.

For laying the pipe across the river wooden falseworks were erected between the abutments, as shown in the views, and then a narrow-gauge track was laid along the center line of the bottom of the trench and over the falseworks. Each section of pipe was rolled from the ground alongside the trench on to a small car running on the track just mentioned. This car was provided with rollers, so that the section of pipe could be rotated into exactly the position desired. The section of pipe having been adjusted on the car, the car was then hauled into position by a cable attached to the drum of a hoisting engine. This method is similar to that used for laying the pipes in the other siphon, known as the Happy Hollow siphon, described and illustrated in the issue of October 25, 1902. One of the photographs shows a section of pipe being connected to the portion of the arch already in place. The men on top of the pipe are in the act of placing a drift pin in the upper rivet hole of the joint. After the pin had been inserted the farther end of the section was raised by means of two jacks until the car and rails could be removed from beneath it, and then lowered, so as to bring the rivet holes of the seam to match. Adjustment was accomplished by means of the jacks at one end and pinch bars at the other, until drift pins were driven into every third or fourth hole around the joint. The arch was successfully constructed and has passed through the severe winter without the slightest visible signs of injury, the joints showing no signs of distress by even the smallest leak or in any other way.

Several pipe arches have been constructed in various places, but the practice is more common in Europe than in this country. An arch of 164 feet span and 11½ feet rise, of pipe of about the same diameter as the Sudbury arch, was built across the Arc River in France, in 1897, and was described in "Le Genie Civil," June 23, 1900. There are some arches of cast-iron pipes which were built a generation or more ago as a part of the Washington Aqueduct. These were described by Mr. William R. Hutton in an article printed in The Engineering Record, July 29, 1899. Two pipe lines were carried over a canal by being built in the form of an arch of 120 feet span and 12 feet rise, with simple blocks of masonry to serve as abutments. The pipes were straight, the flanges on the ends were cast with a proper bevel, planed, washed with a solution of sal ammoniac, put together and bolted up. When water was let on, it flowed in radial jets from every joint. A workman with a light hammer went over them and battered them close. It is reported that they have not lost a drop of water since. The pipes were carried over Rock Creek, separating Georgetown from Washington, by a more important arch, 200 feet in span, of pipes 4 feet in diameter. As these pipes were laid in the line of Pennsylvania Avenue a roadway was built on them, carried by an iron spandrel bracing from the arch, with a floor of wood. These pipes also were straight, with beveled flanges, planed and put together with paper and red lead. In the article quoted a stress diagram for this arch is given.

For the steel pipe-lines of the Weston aqueduct, including the Sudbury River arch, Messrs. Edward Kendall & Sons, of Cambridgeport, were the contractors; Messrs. Winston & Company, of Clinton, Mass., were the sub-contractors for the earthwork and masonry. The work was done under the general supervision of Mr. Frederic P. Stearns, chief engineer of the Metropolitan Water and Sewerage Board. Mr. Horace Ropes is the engineer of the Weston Aqueduct department. Mr. Frank E. Winsor was the division engineer in immediate charge of the pipe-lines and adjacent portions of the aqueduct until he resigned in February, 1903, to accept another position; he was succeeded by his brother, Mr. George A. Winsor, under whose supervision this interesting pipe arch was erected.

Development of an Underground Water Supply for Penzance, England.

The problem of procuring additional supplies of water for communities which are outgrowing the works that have supplied them for years is one of growing frequency and importance in England. In dealing with such a problem for the town of Penzance, in the Cornwall district, at the southwestern extremity of England, Mr. Frank Latham, the borough surveyor and water works engineer, had some interesting experiences, which he described recently in a paper before the Society of Engineers. Until the new works were put into service, the whole supply of the town was obtained from two reservoirs, 220 feet above ordnance datum, having a combined capacity of nearly fourteen million gallons.

The existing reservoirs were supplied from a stream flowing from an old mine adit at Lanyon, a distance of about 4 miles, which in the winter months was considerably augmented by surface water from the moorlands. There was ample water running during the winter months to supply four times the requirements of Penzance, but during the remaining months of the year the flow was scarcely sufficient to meet one-third the demand, and the water in the reservoirs rapidly lowered in consequence of being insufficiently replenished.

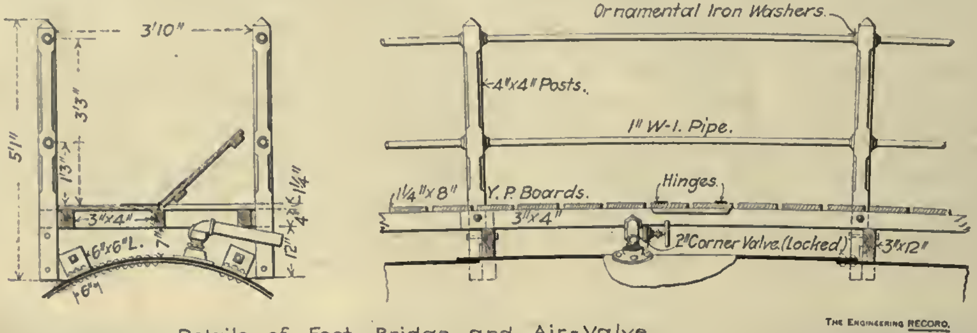
After a considerable amount had been previously expended in an experimental well, without the success anticipated, together with the natural tendency of a granite country being the reverse of producing a plentiful and reliable underground supply, any suggestion to make another attempt in that direction would quickly be negatived, unless very conclusive evidence was forthcoming in its favor. In taking soundings for a reservoir site, the author found that in some places a tube could be driven to a considerable depth with little difficulty. The author continued his observations, and finally located the subsoil water level over a considerable area of land; thirty-two wells were driven, varying in depth from 18 to 45 feet. Water was found in abundance at several points, and in one instance an under pressure caused the water to rise 20 inches over the top of the well. This water was allowed to flow for some weeks, and did not diminish in volume. The author concluded that some geological condition was responsible for the abundance of water and the similarity of the tests in one particular locality. He investigated this matter, and, as has since been proved, rightly attributed the cause to the following interesting geological formations.

The contour of the country to the north of Penzance is a gradual rise for a distance of some 4 miles, ranging from 86 to 650 feet above ordnance datum. Proceeding from Penzance in a northerly direction for three-quarters of a mile the formation is greenstone, a hard granular crystalline trap rock. At this distance the trap formation changes, and for nearly half a mile there is an alluvial formation, the area of which the author has traced to half a square mile. This alluvium evidently occupies the site of some lake or natural reservoir, which by the gradual deposit of silt and drift has become converted into land. Bordering the upper part of this alluvium there is an extensive elvan course or dyke of vertical construction, about 30 feet in thickness, running for a distance of 5 miles east and west to an altitude of 280 feet above ordnance datum east and 300 feet above ordnance datum west, while the alluvium valley referred to is but 220 feet above ordnance datum.

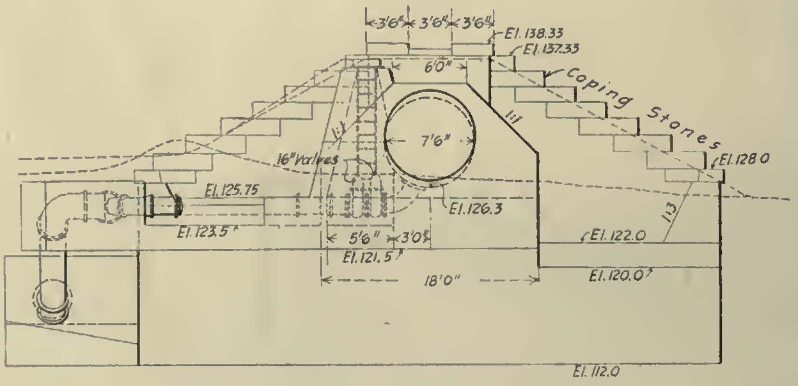
Continuing north, above the elvan dyke, there is a course or considerable formation, of white spar rock (important evidence of water), which meets the Cornish granite country on its upper side. The granite formation extends for 3 miles north, with an average fall towards the elvan dyke of 1 in 35. The granite as it leaves the elvan dyke and spar is covered with an upper stratum of clay, with an intermediate stratum of decomposed granite of gravelly nature, known as "rab," ranging from 5 to 15 feet in depth. The surfacing stratum of clay runs out in many places about a mile up the incline, where the "rab," covered with earth and grass, or entirely exposed, forms the upper stratum. The district referred to is extensive moorland country, and a good deal of the water that falls thereon must percolate the "rab," find its way down the incline on the granite surface, pass under the clay, to be finally checked in its downward course by the intervening vertical elvan dyke and spar rock. On further investigation and inquiry the author located an extensive cross-course, many feet in width, running through the country from north to south, which, being filled with "rab" and drift, in its turn was an important factor in conveying water from the heights.

Convinced of the soundness of his investigations and theory, the author prepared a plan for constructing a well on the lower side of the elvan dyke, in the schistose and gravelly formation below, within reasonable driving distance of the cross-course. The plan included an adit driven parallel to the dyke, cutting through numerous spar leads as they left the elvan, and passing through the cross-course. On October 12, 1901, after a severe drought, the quantity pumped, when the shaft was but 56 feet deep, was 140,000 gallons per day; which quantity rapidly increased with the depth, until at the completion of 100 feet, after continuous pumping night and day without cessation for twelve weeks, the daily quantity had reached 327,000 gallons. The quantity required from these new works was but 350,000 gallons a day, and this was obtained with only 18 feet of adits completed, the quantity steadily increasing as the adits were extended towards the cross-course.

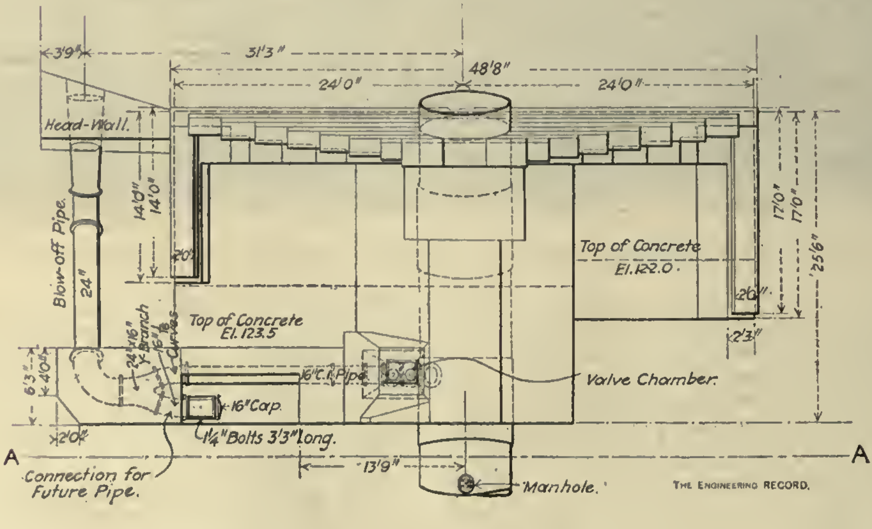
The formation through which the shaft was sunk was of loose schistose and gravelly nature for a depth of 80 feet, the excavation to which depth was naturally most dangerous work. The chief danger to be guarded against was the collapse of the walls during sinking and pumping operations. Careful consideration had further to be given to the adoption of the best facilities for substituting permanent steining stone in the place of the temporary timbering should the undertaking prove successful. The direction in which the timbering was constructed—viz., from the surface downwards—would have to be reversed in executing the permanent steining, which would be built from the base or foundation, and carried up to the surface level. The method adopted may appear, at first sight, to be rather costly, but bearing in mind the nature of the ground, and the weight that would eventually have to be resisted by it—by the settling of the walls and constant vibration of the pumping machinery—it will be clear that a good and safe course was pursued.



Details of Foot Bridge and Air-Valve.



Rear Elevation.
Section A-A.



Plan.
West Abutment and Blow-off.

Sudbury River Pipe Arch: Abutment, Railing and Air Valve.

At the surface level much importance was attached to strength, there being two curbs of timber, each measuring 12 by 12 inches. These curbs were each extended at the angles well over the surface on a bed of cement concrete. It was from this double curb that all the timbers in the well were suspended, and to which the pumping gear was fixed. The timbers were prepared on the surface, and were rapidly placed in position in the well as the work proceeded. The sets were placed 5 feet 6 inches apart for a depth of 50 feet, after which the distance was increased. Each set is a complete construction in itself, and was easily handled. The sets were secured one to the other by means of crook bolts at the corners. The crook bolts were extended to half the depth of each set, into which the corresponding ones of the set next following were linked. Upon this being effected, any slackness between one set and another was readily adjusted by the screw nuts. This method was adopted throughout the shaft, and two years subsequently, upon stone being substituted, the advantage of the system was again very evident.

The danger of a run in the ground on removing the timbers was perfectly guarded against. The sets offered such facilities, that a foot or less could be raised at a time. In order to raise a set of timbers ahead of the masons, the vertical derns of the under set were removed, and by the use of the screw-bolts which suspended the set, the lower curb was raised as slowly as desired, and to whatever height was needed. The lagging behind the sets was in most cases built in behind the steining, but was usually drawn out again on the completion of a few feet, and the space was filled up with spalls or concrete.

The shaft was steined elliptical in plan to afford strength in resisting pressure. The internal length is 10 feet and width 5 feet 3 inches. The stone was local granite, and each stone was roughly arch-shaped. The stones were set in fine concrete, and occasional horizontal joints were left open as weep holes. The whole of the joints, however, within 30 feet of the surface had to be completely closed, owing to the soft formation being forced through from behind, discoloring the walls and possibly at times the water also. The work now finished forms a very permanent construction, sufficient to support pump girders and other machinery.

Sudbury River Pipe Arch: Cofferdam for Abutments; Falsework for Arch.

In order to supply the upper district of Penzance with water it was found essential to adopt some source of higher altitude than the existing reservoirs. To meet this requirement the author advised that the mains coursing the town be divided, so that the higher district might be supplied by a main independent of the lower part of the town, which would be connected with an elevated tank to be fed from the well, while the latter district would continue to be supplied from the present reservoirs. The site for this tank afforded a precarious foundation, in that it was made ground on a side-long formation, which also necessitated the greater part of one side of the tank being out of the ground altogether, while the back would have to resist the thrust of the land. An iron-covered tank, of 150,000 gallons capacity, was at first considered best, but finally it was decided that a tank constructed on the Hennebique ferro-concrete system would be perfectly adaptable to the conditions of the case. The tank, which is of light steel and concrete construction, and roofed with the same materials, was the first of its kind to receive the approval of the Local Government Board, after the holding of an inquiry on the subject, and since its completion it has proved itself highly satisfactory.

Great care was exercised that the steel at all corners and at the head of the columns should give the greatest strength possible. The concrete, which forms an essential part of the construction, must naturally be of excellent quality and suitable for the duty it has to perform. In some cases resistance would be the essential aim, but in this instance impermeability was the chief consideration. The proportions in which the concrete was mixed were as follows: Gravel, of all mixed sizes, varying from 1/3 to ¾ inch, but free of sand, 24 cubic feet; sand, clean and gritty, 13½ cubic feet; Portland cement, of highest class, 6 hundredweight. This mixture when in place and rammed was equal in volume to 31 cubic feet of concrete. The cement used was required to pass through a sieve of 5,767 meshes to the square inch, leaving not more than 10 per cent. residue. The whole of the larger material used in the concrete was quarried, machine broken, and proportioned by the author's workmen at the corporation quarry. The difficulty of obtaining a good specimen of sand in the neighborhood was known to the author; the removal of such from the sea-shore being strictly prohibited. The sand on the site, which had been brought in from distant beaches, ranged from a coarse gritty beach sand to a fine drifting sand, common to different beaches in this district. The concrete obtained from these materials was almost as close and hard as granite itself.

The tank, on examination three months after completion, did not show a trace of a single crack or settlement, and the walls themselves were of a very impermeable nature. The internal surfaces of the walls were rendered absolutely watertight by a coating of cement and sand, in proportion of one of the former to two of the latter, ¾ inch thick, troweled to a smooth surface, and all angles were rounded and rendered smooth, most important desiderata to be observed in successfully producing a watertight tank.

With reference to the rendering of concrete reservoirs the author had an experience three years ago in connection with a work, with which he had been entrusted in supplying Tolcarne, a village in West Cornwall, with water. The reservoir was substantially constructed of concrete, and the author had specified that it was to be rendered with 2½ of sand to 1 of cement, absolutely watertight, to be proved so by testing on completion. The contractor appeared to exercise every care in rendering this reservoir, and to all appearances the work was everything desired. The result of the test, however, disclosed a leakage, and the author rejected the work until the leakage was stopped.

Upon the reservoir being emptied the author made a close examination of the walls and floor, and found that the floor rendering, which had been executed when the concrete was still plastic, before the walls were built, had a sandy and porous appearance, while the walls were smooth and close. The whole trouble was attributed to the use of coarse beach sand, with insufficient attention to filling the interstices in rendering the floor, which would be affected by the greatest pressure. The floor had in consequence to be broken up and again rendered with a sand which would enable the proportion of cement to completely fill all interstices and allow a thin coating of neat cement to rise to the surface in working, so making a hard and impervious face.

The author considers it of interest to refer to this failure, which, although soon rectified, is another proof of the care and knowledge that are required in selecting materials and putting them together, in order to obtain the best results from concrete. The too common practice of entrusting this kind of work to inexperienced persons, with the notion that concrete making is but a matter requiring ordinary intelligence, chiefly in that the proper quantity of cement is used, is most erroneous, and calculated to court disaster.

Here is an example among several tests made in connection with the Penzance sea wall, now in course of construction. The author made ten briquettes from material taken from these works. In some cases the materials were carefully measured in accordance with the stereotyped specification: 1 of cement to 4 of sand, etc.; and in others, care and judgment were used, placing a little finer sand to the mixture and a larger proportion of sand to fill up the voids in the gravel. These briquettes were proportioned 1 to 4, as in the case of the others, also 1 of cement to 7 of aggregate, and the result was that the 1 to 7 briquette stood 115 pounds tensile strain, and the other stereotype mixing in the proportion of 1 to 4 stood but 45 pounds, after twenty-one days' immersion in water in each case. On examining the careful gauging of 1 to 7 and comparing it with samples containing a higher percentage of cement, it will be observed there is the appearance of excess of cement showing on the top troweled surface of the former, and insufficient cement in the latter, although the proportions in which the cement was actually used were the reverse.

The foregoing paragraphs were extracted from Mr. Latham's paper as printed in a recent issue of "The Surveyor."

Tests of Two De Naeyer steam boilers of a new type showed an evaporation of 3.68 pounds per square foot of heating surface per hour, including a so-called reheater, but of 7.15 pounds when the reheater surface was not considered, according to "Revue Industrielle." Some 61.4 pounds of coal were burned per square foot of grate per hour.

The Description of the Power-House Foundations for the Pennsylvania, New York & Long Island Railroad's central station, which was printed last week, was given on the authority of men engaged on the work, but in some way a mistake occurred in mentioning the important feature of the concrete itself. As a matter of fact, the concrete employed is a 1:2½:5 mixture, for which, up to date, the Lawrence Cement Company has furnished over 22,000 barrels of Dragon Portland Cement. It should also be added that this company furnished several thousand barrels of the same cement for the covered reservoir of East Orange, described in The Engineering Record of March 26.

The Extension of the Imperial Hotel, New York.

Part I.—Design and Construction of Foundations, Steel-Cage Construction, Typical Columns, Grillages, Distributing Girders, Diagonal Sway Bracing and Portal Braces.

The Imperial Hotel, on Broadway, between Thirty-first and Thirty-second streets, New York, originally a ten-story building, has recently been enlarged by a seventeen-story addition, which occupies a 90x80-foot lot adjacent to the first structure and arranged so as to connect with it and make the lower stories continuous through both parts. The new portion has a trapezoidal E-shape plan with two 10-foot light courts about 51 and 55 feet long opening from the rear. The construction is fireproof throughout and the steel columns are seated just below the basement floor level on cantilever beams, distributing girders and grillages with concrete piers carried down to the rock in sheet-piled pits from 3 to 30 feet deep. The surface of the rock was found to be very irregular, dropping vertically several feet in a number of the pits. Many seams were encountered, which were filled with chlorite of the consistency of soft putty. This was excavated to a depth of 10 feet, and considerable difficulty was encountered in keeping it from being forced into the excavations by the pressure of the water in the seams. A large quantity of water was encountered and was drained out of the pits by special steam siphons, having a straightaway passage. Excavation was maintained continuously and the pits were sunk rapidly. As soon as they reached bed rock, its surface was cleaned and stepped where necessary and the concrete immediately filled in. Tongued and grooved sheet piles 3 to 6 inches thick, dressed on both sides and covered with thick grease, were driven by a pneumatic hammer, which was easily handled by two men without the use of tackle.

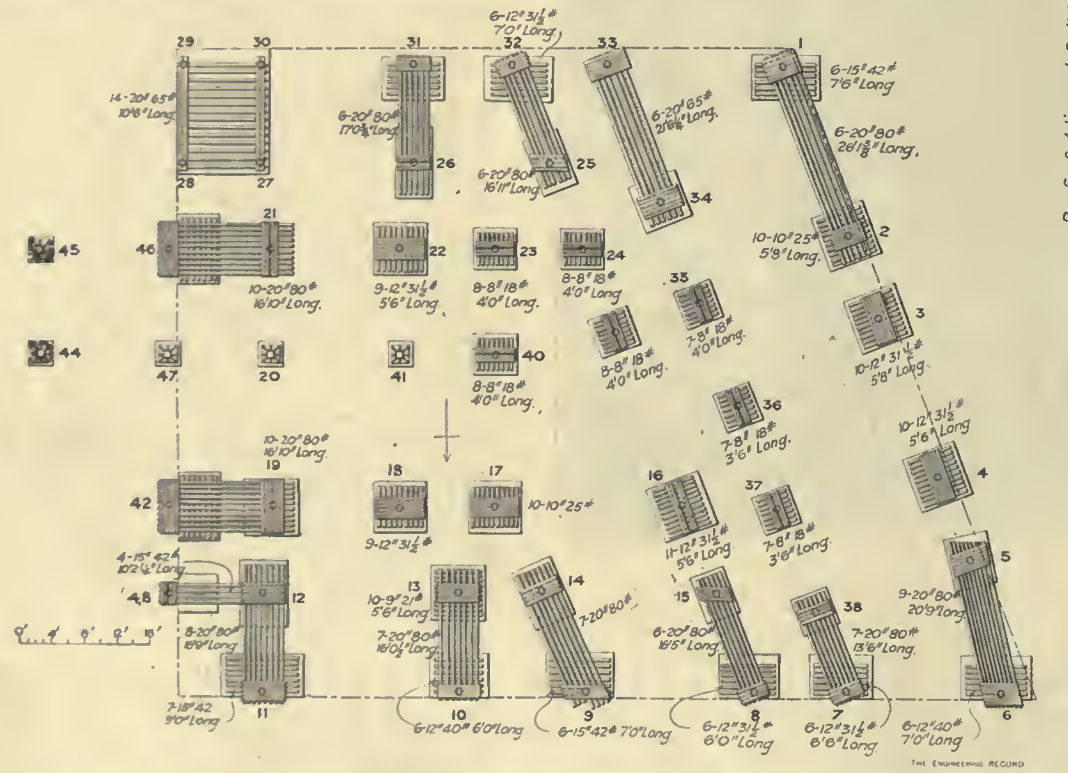
Although the excavations were carried down several feet lower than the footings of the foundations in the adjacent buildings, the latter were not underpinned nor shored. Photographs and levels were taken before the work was commenced and careful observations and records were made frequently during its progress, so that any material settlement would have been detected, but none was observed. Great care was taken to maintain the sheeting close to the face of the old walls and to keep it thoroughly braced as the excavation was continued. In some cases where the pits were deeper than the pile lengths, the sheeting was spliced, and, in other cases it was driven in two tiers, care being taken to have all of the waling pieces very carefully fitted and dimensioned.

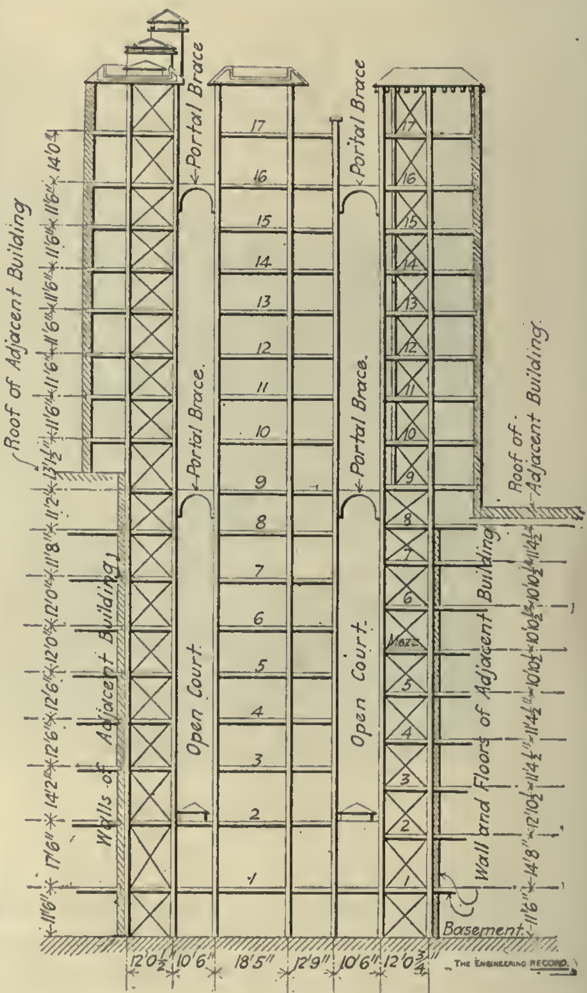
Important features of the work were the care with which the foundation pits were sheeted, which enabled them to be drained more easily than is usual under such circumstances, the rapidity with which they were sunk and the success which was attained in preventing much flow of the wet, fine soil. In this way it was possible to sink deep open pits very close to the old footings of heavy walls and far below them without undermining or disturbing them, and thus avoid the use of slower and more costly pneumatic caisson work. The sheet piles were made of first-class timber accurately tongued and grooved, planed on all sides and very rigidly inspected for straight and perfect edges. They were received in 13-foot lengths and were assembled together in vertical planes on the surface of the ground so as to make complete rectangular walls enclosing the pit before excavation was commenced. The piles were held in position by interior frames made of horizontal waling pieces with the ends cut square, the side being dapped 1 inch or 2 inches over the square ends of the end pieces, and the joints covered by horizontal planks spiked or bolted to the timbers. Outside of the sheet piles a rectangular frame was made with horizontal planks laid flatwise with their overlapping ends bolted together, thus forming clamps which held the piles securely in position against the inner frames. In some cases, where the piles were driven close to the faces of the old walls, the clamp planks were replaced by steel bolts.

The piles were bevelled at the lower ends so as to draw together and were driven, as before stated, by special pneumatic machines which could be lifted by one man, but were advantageously operated by two or three men. The lower part of the machine had jaws engaging the top of the pile and enclosing a cushion piece to receive the hammer blows and protect the head of the pile. This cushion had a small vertical spur which penetrated the timber and prevented it from slipping. The moving part weighed 15 or 20 pounds and struck from 400 to 600 blows per minute. The hammer guides were fitted with spiral springs at the top to relieve the impact in the handle. With this machine it was sometimes difficult to start a pile in bad ground, but once in motion, it was easily driven. The rapid action of the hammer seemed to produce waves of vibration, which sometimes were so strong as to cause the lower ends of the piles to jump out of the grooves of the adjacent piles. In such cases the hammer was replaced by ordinary mauls and rams.

The piles were driven sometimes as much as 3 feet in advance of the excavation and thus materially checked the bottom flow of water and being practically watertight prevented any flow of quicksand through the sides of the pits. The waling pieces were most of them 3 inches square and varied from 2 to 3 feet apart vertically on centers. They were made of planed timbers and were cut and fitted at the mills with great accuracy so that all pieces for the same size pits were interchangeable. In some cases heavy pieces were used for the bottom course which, in special instances, were made of 8 x 16-inch timber with the 16-inch side vertical, so as to occupy less space, and the lower edge bevelled to promote convenience in working under the bottoms of the piles to remove stones and other obstructions. The successive courses of waling pieces were separated by vertical posts at the corners of the pits and were driven down as the excavation proceeded. This novel method was found to be very satisfactory and to be quicker and more reliable than the usual method.

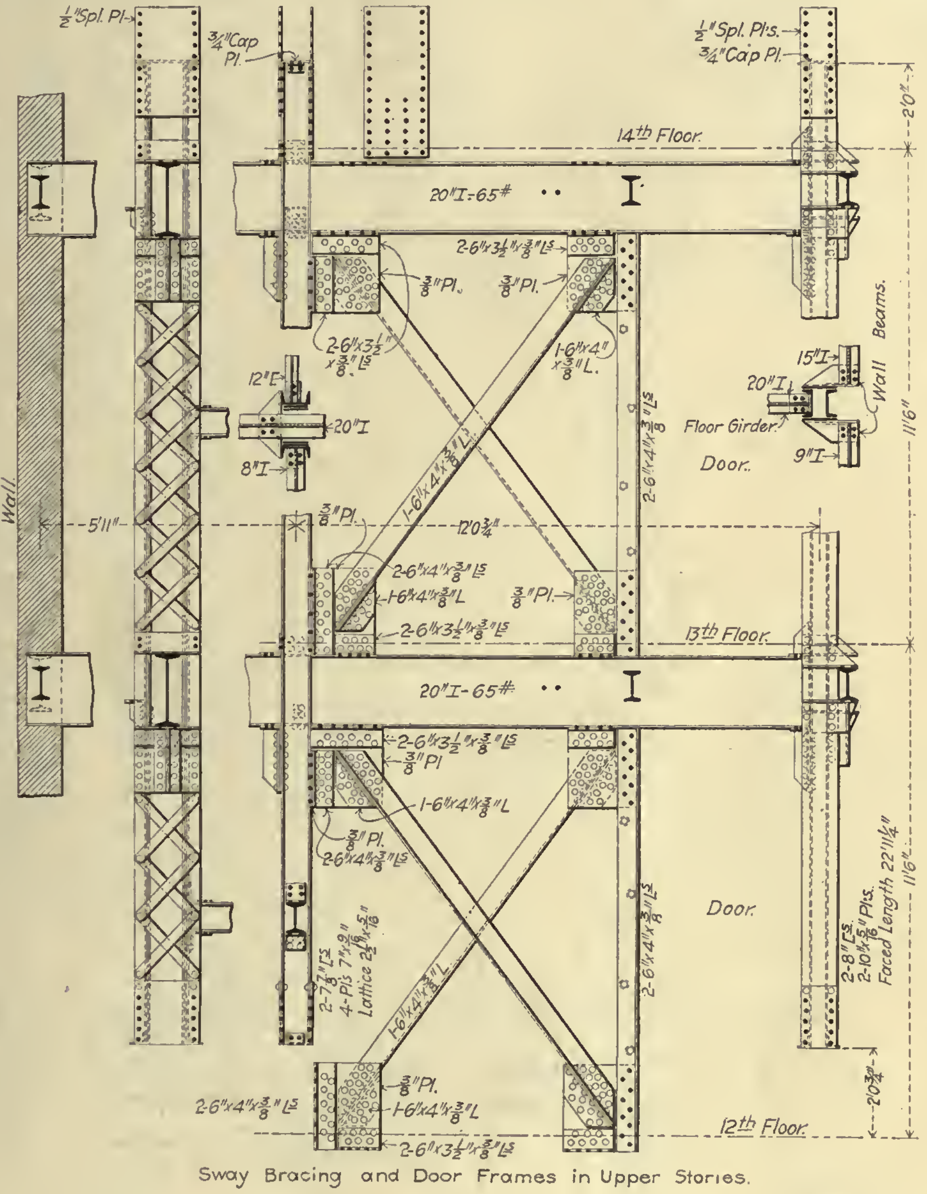
The lower set of waling pieces was framed together and put in position at the surface of the ground before excavation was commenced. Vertical posts were set on top of it at the corners and supported the second frame and so on.





Plan Showing Piers, Grillages, Distributing Girders, Cantilevers and Column Centers; Rear Elevation of Steel-Cage Showing Overhanging Stories.

As the excavation proceeded, the waling pieces were driven down, slipping easily on the well-greased surface of the piles, unless the pressure was very great. Men were stationed at each corner of each course of waling pieces and drove them down uniformly with simultaneous rows of 14-pound mauls. Ordinarily the entire series of waling pieces that had been placed from the bottom of the pit to a point above the surface of the ground were driven simultaneously, but under some conditions it was found desirable to remove the corner pieces and drive a single course separately. When the driving was unusually difficult, the mauls were replaced by vertical rams which consisted of 6 x 8-inch oak timbers about 10 feet long with several horizontal holes bored through them. Pipe handles being inserted in these holes, several men could grasp them at different heights and drive the pieces with great force.



Sway Bracing and Door Frames in Upper Stories.

THE ENGINEERING RECORD.

Imperial Hotel: Details of Bracing of Upper Stories.

After the pits were sunk to rock, horizontal transverse timbers were placed against the lower course of waling pieces; and powerful jacks being set against their ends and operated, forced the walls of the pit apart by compressing the solid earth and thus sometimes increased the width of the pit from 1 to 2 inches in a length of 4 or 5 feet. This, of course, exercised a powerful consolidation on the loose soil and tended to prevent any displacement of it under the adjacent old footings. When there was any reason to suspect the existence of cavities in the soil adjacent to the excavations, 2-inch vertical steel pipes 15 feet long were jetted down alongside and were filled with Portland cement grout poured into them through large funnels. A plunger made with a long steel rod and leather discs bolted to the end of it, like the piston of an old fashioned pump, was inserted in the upper end of the pipe and enabled moderate pressure to be exerted on the grout to force it out of the pipe.

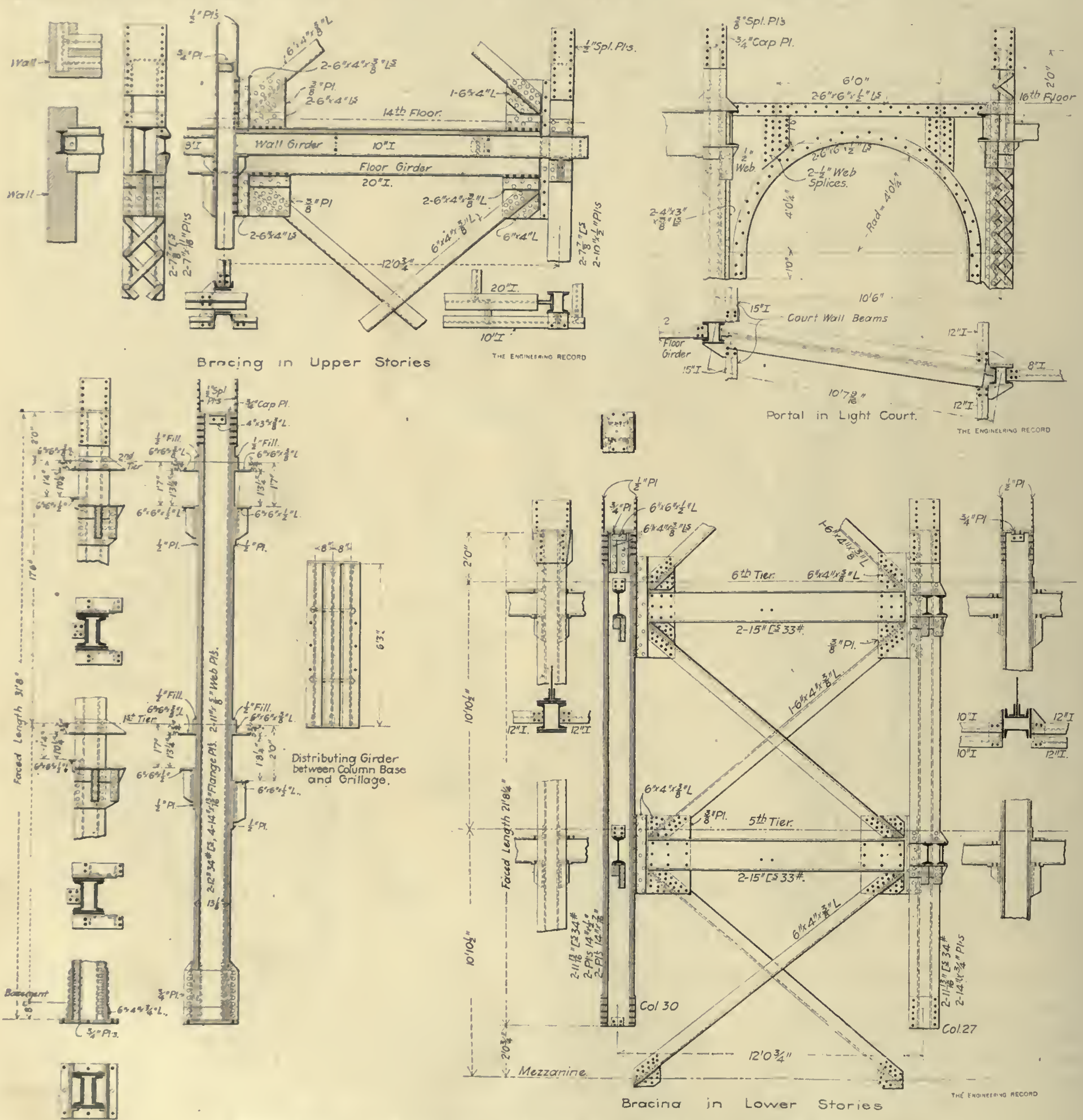
This apparatus sufficed for concreting on this work, but on other occasions where a larger amount of it was required, the same contractors have forced large quantities of grout into the soil outside the sheeting by pneumatic pressure. A closed horizontal cylindrical steel tank with a capacity of 300 or 400 gallons is fitted with an axial shaft which carries radial paddle arms and is operated by hand cranks on each projecting end. The cement and mortar is put in the tank and thoroughly mixed by revolving the shaft. Air pressure is applied to the upper part of the tank and the grout is driven through an outlet in the bottom. In rocky soil where the feet of the sheet piles are obstructed by boulders which cannot be easily removed by usual methods, a pipe is run down alongside the outer face of the pile and grout is injected through it until it is considered to have enveloped the boulder. After the grout has set, the boulder can be broken out from the inside and removed without admiting the water and the quicksand which is excluded by the concrete shell surrounding the former position of the boulder.

The pit for the pier supporting columns 27, 28, 29 and 30 was sunk in the extreme corner of the lot with the two outside faces in the building lines. This left no space between the sheet piles and the old footings, and the wall was so high and the soil was so bad that the excavation was considered hazardous and was made in two separate operations. In one of them a rectangular pit was carried down in the corner to the rock; the other excavation comprised the L-shape remainder of the pit. By this means about half of each wall face was exposed at one time and after the first pit had been excavated and the concrete built in it, the sheeting of the two sides which were common to both pits, was removed and the second pit was excavated and filled with concrete.

In several places the grillage beams and girders projected somewhat beyond the lot lines at a level below the footings of the old walls. Here the pits were excavated, as already described, and filled with concrete up to the level of the grillages. The site of the pit next to the old wall was still closed by the sheet piles in contact with the wall face at the upper end with the new concrete at the lower end. Intermediate there was a portion of the pile which served to retain the loose fine soil under heavy pressure below the footing of the old wall. This had to be removed in order to set the beams and girders, and the operation was a very delicate one. It was accomplished by cutting away one or two of the sheet piles at the required point on this wall and on the opposite wall of the pit. Then two or three of the grillage beams were inserted endwise through the hole in the outer wall and pushed into position with their ends projecting through under the old wall. This was done without disturbing the waling pieces and braces which were far enough above the top of the concrete pier to clear the beams. It was, of course, difficult to work on the beams in such narrow quarters so the ordinary tie rods and separators were dispensed with and the beams were conected by horizontal hooks engaging the flanges which could be slipped over the outer ends of the beams and successively pushed back to required positions. The first group of beams was carefully leveled, concreted and a second pair of sheet piles were cut off adjacent to them at each end, another group of beams inserted and so on until the grillage was put in position and concreted by successive operations. The foundation work was accomplished in 32 working days.

The building is of the steel-cage type, with thirty-eight main columns and nine minor collums arranged in seven transverse rows and seated on distributing girders and grillages, with their upper flanges about 9 inches below the surface of the basement floor concrete. The interior columns have separate piers, but those on three sides of the building are set so close to the line that it is necessary to carry them on cantilever girders, balanced by interior columns, so as to secure central reactions on the piers. In most of these cases the distributing girders receiving the extended bases of the columns are made with two or three pairs of 15-inch channels riveted together, back to back, to give thicker webs. The girders are of such a length as to extend across the top flanges of a group of 20-inch I-beams, which are supported on the regular pier grillages. Columns 27, 28, 29 and 30 are located on the corners of an 11x 13-foot rectangular grillage, through which their loads are distributed by a pair of plate girders, 61½ inches deep, which engage the ends of the grillage beams. Columns 48 and 11 are carried on the extremities of cantilever beams, intersecting each other at right angles under column 12, which has a computed weight sufficient for their combined reactions. All of the grillage beams were painted two coats of hot asphalt and surrounded with concrete 4 inches thick in every direction before the basement floor was laid above them.

A few of the interior columns, which support only the first two stories, have cast-iron pedestals seated on the concrete piers without grillages. The superstructure has a total height of about 240 feet from the basement floor to the top of the roof house and is braced by four arched portals across each of the light courts and by two sets of diagonal braces, reaching from roof to basement, between the wall columns in each of the outer wings of the building. The framework in general corresponds to standard practice for steel-cage construction, but is special in the provision made for wide spans in the lower stories and for carrying the upper tiers of the columns offset from the lower ones, and in that above the eighth and ninth floors the stories overhang the roofs of the adjacent buildings, and the floors and outer walls are carried on heavy girders, cantilevered several feet beyond the wall columns, as indicated in the elevation diagram.



Bracing in Upper Stories

Portal in Light Court.

Distributing Girder between Column Base and Grillage.

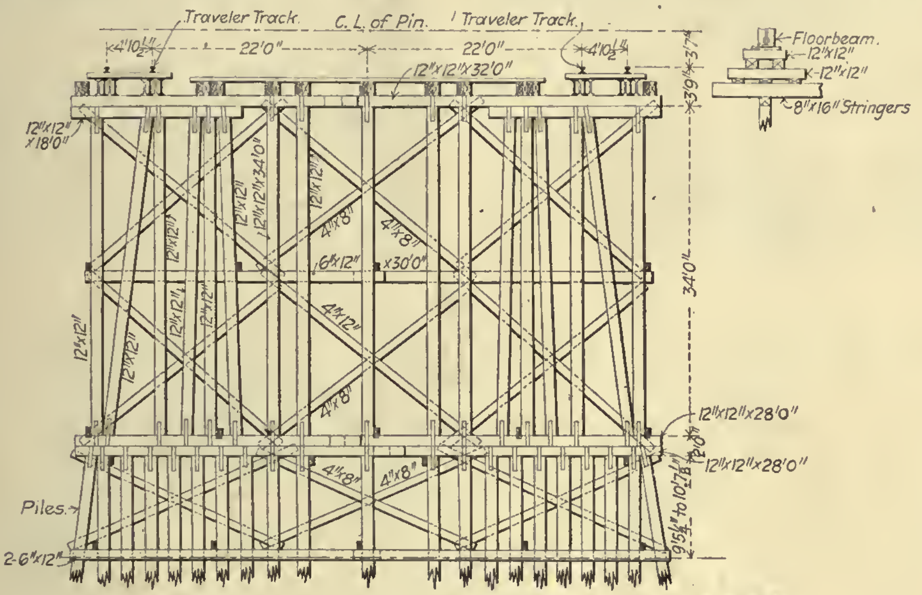
Bracing in Lower Stories

Imperial Hotel: Details of Bracing, Portal, Basement Columns and Distributing Girders.

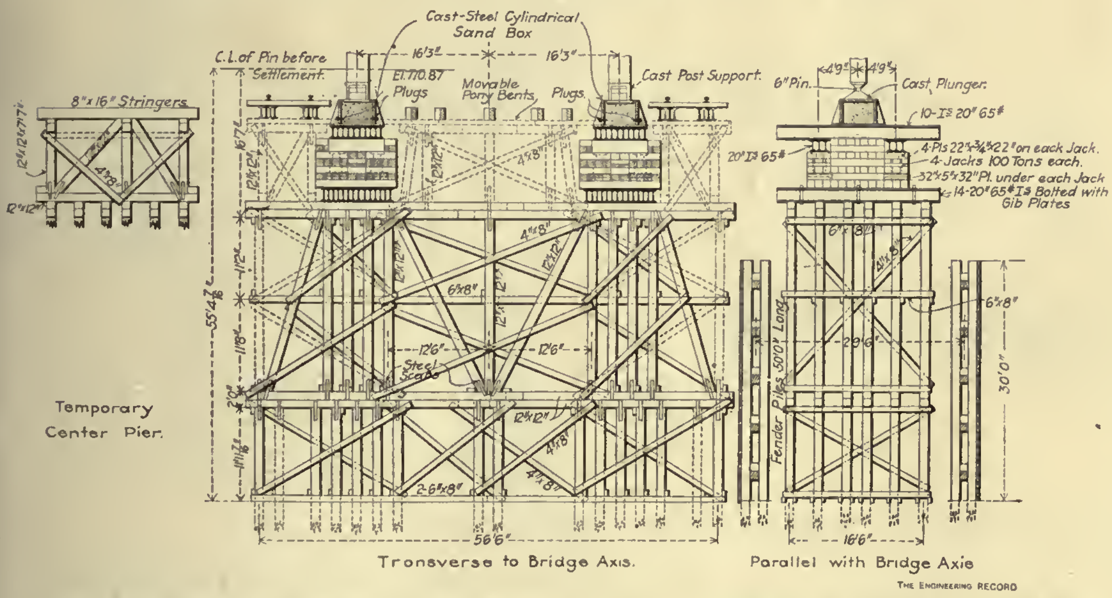
All of the columns are made in two-story lengths and have rectangular cross-sections built up of pairs of 12-inch channels, back to back, with their flanges turned outwards and latticed or connected by cover plates. In the lower stories the cross-sections of the columns are increased by using double cover plates and by riveting reinforcement plates to the backs of the channel webs. The beam and girder connections are made with horizontal angles riveted to their top and bottom flanges, the lower angles having their horizontal flanges supported by the upper ends of vertical reinforcement angles, milled to bearing. The horizontal angles are generally 6x6x½ inches, with two rows of holes in the beam connections. Where it is necessary for them to project beyond the face of the column to receive eccentric beams they are riveted to wide tie plates, which serve as brackets. Connections on the channel webs are made, as above described, but the horizontal angles are very short and their vertical flanges are riveted between the column webs and the vertical reinforcement angles, the latter being fillered below them. The basement sections of the columns have double ¾-inch base plates projecting 6 inches beyond the cover plates on both sides and stiffened there by vertical angles 2 feet long, riveted to the edges of the cover plates and having their ends milled to bearing on the base plates.

The outside flanges of the vertical angles are riveted to wide ¾-inch tie plates, which are carried down to bearing on the upper surfaces of the base plates, and receive the vertical flanges of the 6x4-inch angles which connect the base plates to the columns. The column splices are made with ½-inch cover plates, field-riveted to both upper and lower sections of the columns. Horizontal diaphragm plates are also inserted between the ends of the adjacent sections and are riveted to angle lugs on the webs of the column channels.

The three wings on the rear of the building are connected across the two light courts by eight plate-girder arched portals 6½ feet deep. The webs are made of ½-inch plates and three sections field-spliced together with double vertical cover plates. The upper and lower flanges are pairs of 6x6x½-inch angles, the former being horizontal and the latter being curved to a radius of about 4 feet. The ends of the struts have bent vertical flange angles shop riveted to them and field-riveted to the webs of the columns. All other rivets in the portals are field-driven, so that the different pieces could be shipped separately and assembled in position after the columns were erected.



Main Falsework Bent.



Temporary Center Pier.

Transverse to Bridge Axis.

Parallel with Bridge Axie

Clairton Bridge: Main Falsework, and Temporary Center Pier Supporting Ends of Semi-Spans.

The end panels between wall columns in the rear of the building are x-braced from top to bottom with riveted diagonal angles. Above the roofs of the adjacent buildings the regular bracing consists of single 6x4-inch angles shop-riveted to vertical connection plates, which are field-riveted to the columns and to the top and bottom flanges of the cantilever floor girders which pass through the columns and support the portions of the floor overhanging the adjacent building. The connection plates have short vertical flanges riveted to tie plates on the flanges of the outside columns. The connections to the inner columns are made with pairs of long vertical angles, which engage the connection plates above and below the opposite end of the cantilever girder and are also riveted to the web of the latter. Their outstanding flanges are riveted to the web of the column channels, thus making a single continuous connection for both upper and lower diagonals and for the cantilever girder, the latter being thus supported by five rivets in double shear, and distributing its load over a long distance on the column web.

Where it was necessary to provide for doors in the panels occupied by sway-bracing, a pair of 6x4-inch vertical angles were riveted to the floor girders about 4 feet from the column so as to leave clearance for the door frame between them and the column. These angles were field-riveted to the connection plates at the ends of the diagonals, and the latter braced the remainder of the panel between columns, so as to continue the vertical stiffening truss with a diminished width from story to story. Below the roofs of the adjacent buildings the floorbeams of these panels consisted of pairs of 15-inch channels field-riveted together, back to back, with vertical connection plates between their webs. These plates received the field-riveted connections of the diagonals above and below the floorbeam flanges and had shop-riveted vertical and flange angles, which were field-riveted to the web of one column and to flange plates on the other column, thus making a very deep and rigid column connection for the girder and braces and distributing the girder loads over a considerable length of the column. X-bracing, as above described, was provided in two panels of each wing, namely, in the plane of the wall and between the columns adjacent to it. The pairs of columns thus connected are 11-12, 10-13, 28-29 and 27-30.

Messrs. Warren & Wetmore were the architects for the building; Mr. F. A. Burdett was the consulting engineer, and the general contract was awarded to Messrs. M. Reid & Company. Messrs. Clark & Company were the contractors for the foundations. The J. B. & J. M. Cornell Company was the contractor for the 1,700 tons of structural iron and steel, and Mr. H. A. Forsyth was in charge of the detailing and designing.

(To be continued.)

The Erection of the Clairton Bridge.

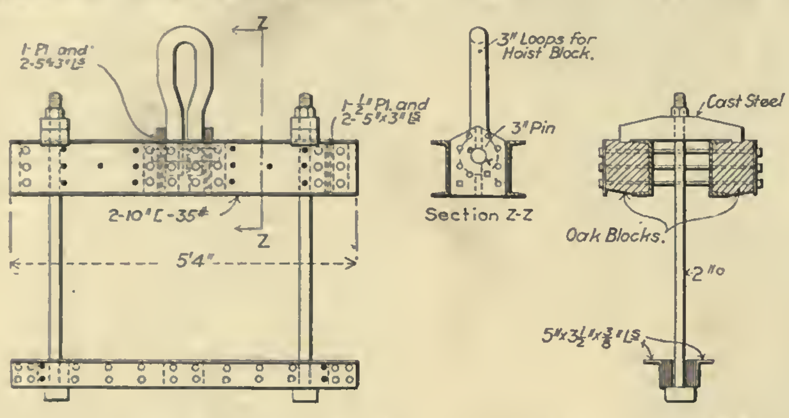
The curved viaduct approaches of the Clairton Bridge, across the Monongahela River, near Pittsburg, have, at the west end, three single-track, plate-girder spans and at the east end three double-track plate-girder spans, all of them seated at a skew on masonry piers and having girders from about 86 to 117 feet long over all. The massive channel span of this bridge was described and illustrated March 12, and the plate-girder approaches, March 26. The maximum girder weight in the approaches was about 62 tons and the total number of field-rivets driven in the approaches was 11,236. Before the channel span was erected, both approaches were erected by the use of pile falsework and a two-bent through traveler.

This traveler was built principally of 12x12-inch timber, with double 4x8-inch bracing, and was provided with a 48-foot boom on the forward end of each sill. It had a vertical and horizontal inside clearance of 35 feet and 23 feet, respectively. It was sway-braced by 6x12-inch knees in each bent and had 4x8-inch horizontal X-bracing in the plane of the lifting beams. The latter were made with two 12x12-inch timbers, one on top of the other, fastened together so as to partially develop the strength of a built beam by means of the bolts through the scabs and diagonal members. The shackles for the topping-lifts of the booms passed through holes bored on the line between the timbers, and thus served as keys, which, with the bearing plates bolted on both sides, helped to connect the beams. The tackles were suspended from the beams by 2-inch square stirrups, with loop eyes engaging 3-inch pins, which rested on top of the beams in seats between the ends of spacing planks spiked on to the timbers to prevent the ends from sliding.

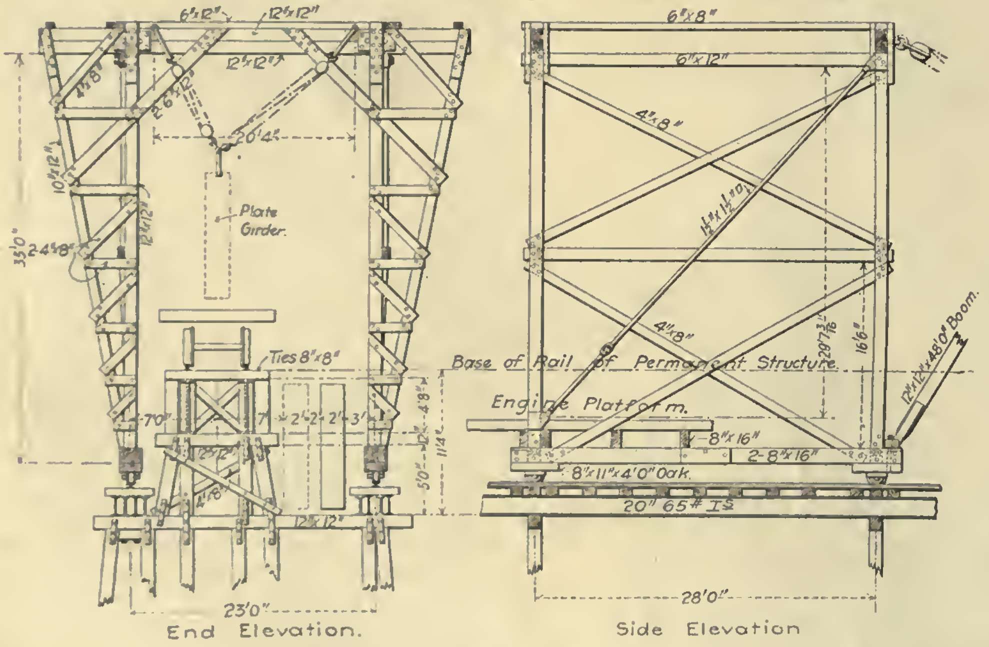
The falsework for one of the east shore spans consisted of two low bents, braced together longitudinally to form a tower, midway between the piers. In all other girder spans the falsework consisted of two similar towers braced together by longitudinal timbers at each story. The bents were of simple construction, made with 12x12-inch vertical and horizontal timbers, 3x12-inch diagonal braces and 6x8-inch sash pieces. There were three lines of 6x12-inch longitudinal struts at water level, three lines of 8x16-inch at the pile tops and at the middles of the bents and two lines of 12x12-inch on top of the caps. The longitudinal X-braces were 6x8 inches and all connections were made with ¾-inch bolts and cast-iron washers and steel scabs. On shore the bents were seated on 12x12-inch sills, and in the river the sills were each supported on seven piles. The falsework carried two lines of traveler stringers, each line composed of four 20-inch I-beams, supporting a single rail. Between the rails there was a set of pony-bents for the standard-gauge surface track, with its center line about 5 feet from the axis of the span.

The bents were framed and assembled on shore, floated to position and erected by the booms of the traveler, which moved forward on the completed falsework. After the falsework was completed for the west approach, one of the girders for the eastern span was unloaded by the traveler and seated in position on the piers. The second girder of the same span was delivered to the traveler and the bracing for the first span was assembled and riveted, while the girders for the succeeding spans were erected as above described. The traveler was then used to remove the falsework from the abutment to the river pier, after which it was taken down and reassembled on the opposite side of the river for the erection of the falsework for the east viaduct and for the channel span.

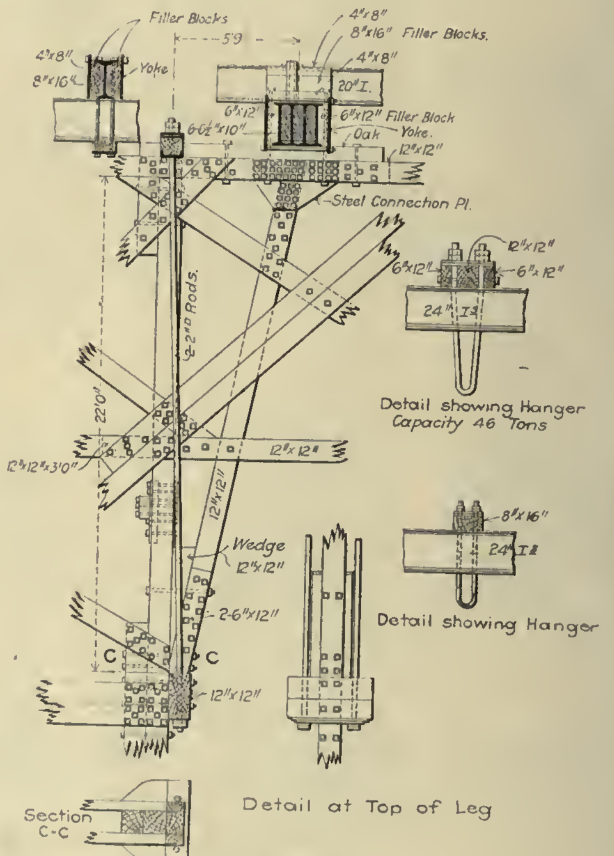
The operations on the east side of the river were modified to correspond with the change in the structure from a single to a double-track viaduct. The falsework and traveler, being used only for handling single girders, required no change. Both girders of the shore span were successively unloaded by the traveler and temporarily seated on the falsework, as close as possible to the pony-bent. The traveler then moved on to the center of the next span and unloaded the up-stream girder and temporarily seated it on the falsework and moved forward to the falsework of the next span. The girder was then slid transversely across the traveler track to its permanent position on the downstream ends of the piers, and the traveler returned and unloaded the two center girders of this span and seated them on the piers in their final positions between the rails of the traveler track. The traveler then unloaded the fourth, or upstream girder, and held it suspended while the cars were withdrawn from the falsework and the pony-bents of the material track were removed. The girder was then lowered into its final position, and the same operations were repeated in the third span. Meantime the through girders of the shore span had been slid to final position and the traveler erected all of the floor system and removed the falsework.



Yoke for Hoisting Tackle.



Traveler for Girder Spans and Falsework



Detail at Top of Leg

Clairton Bridge: Details of Travelers and Hoisting Tackle for Erecting Girders, Trusses and Falsework.

The double-track main span has two trusses, 88 feet deep, 498 feet long and 32½ feet apart, on centers, which weigh about 1,000 tons each, and are supported on masonry piers, 500 feet apart on centers and about 50 feet high above pool level. The total weight of the span, exclusive of track, is 2,743 tons, which is heavier than any other double-track span of the same length yet built. The cross-sections of the top chord and end post are stated by Mr. H. S. Jacoby, professor of bridge engineering at Cornell University, to be larger than those of any other simple truss bridge.

The main channel lies between the piers, has a depth of about 12 feet and affords navigation for great numbers of river steamers and for large fleets of coal barges, which are so numerous in times of high water that the obstruction of more than half the channel at once was prohibited. Under these conditions it was determined to first erect half of the bridge from the west abutment to the middle of the river and then to remove the falsework and erect the second half, thus leaving at all times an unobstructed water-way of about 210 feet. This involved a temporary middle pier to carry the 500-ton end of the semi-span. The pier was built with six transverse bents of 12x12-inch timber, framed and braced, as shown in the drawing, and supported on nearly one hundred 40-foot piles. Clusters of dolphin piles, bound with wire rope, were arranged in triangular form at the ends of the pier, and the whole was surrounded by heavily sheathed fender piles, to protect it from collision with boats, drift or ice.

The top of the pier was 16 feet below the center line of the bottom chord, and the traveler and material tracks were carried on pony-bents, seated on the double caps of the pier bents. At this point the river bottom consisted of a comparatively thin layer of mud and sand overlaying a bed of gravel, varying from 5 to 20 feet thick, which rested on the sloping surface of slate rock, dipping about 3 degrees parallel with the axis of the bridge. On this account it was expected that considerable settlement would take place in the pier and falsework, and provision was made for this in the blocking on the falsework and by cylindrical cast-steel sand boxes, about 3 feet in diameter, which supported the trusses at the center point. They were placed upon a tier of 20-inch I-beams, which in turn rested on wooden cribbing, carried on another tier of 20-inch I-beams, which distributed the load over the bents of the false pier. The distance between the two tiers of 20-inch beams was sufficient to allow the introduction of 100-ton jacks, in case the pier settled more than was counted upon, which would, of course, have made it necessary to raise the span at the center, in order to get the far end on the masonry. The jacks were only intended to be used in case of this emergency, which did not occur, as the center pier did not settle as much as was provided for, consequently, the jacks played no part in the operation.

The bridge was erected at a height calculated to be sufficient to allow for settling, so that it would only be necessary to lower the bridge by emptying the sand boxes. The boxes provided for a movement of 18 inches and were filled with dry, fine, sharp sand and covered with a steel plunger engaging a 6-inch pin, which connected it to a cast-steel shoe, temporarily attached to the foot of the vertical post. The sand was heated when put in the box and the piston was immediately set on it, calked with oakum and painted with tar, which was filled in to the top of the box, so as to prevent water from collecting there or leaking through.

The falsework for the semi-span consisted of seven intermediate bents and a pier bent, framed and braced, as shown in the elevation, and supported on twenty-one piles. The bents were braced together in pairs to form towers and the towers were united by longitudinal timbers in four horizontal planes and by the track stringers. The falsework bents above the pile caps were made with steel scab plates and ¾-inch bolts and may be considered as each composed of five different groups of vertical and inclined posts, two groups to carry the traveler tracks, two groups to carry the trusses and a center group for the material tracks and working platform.

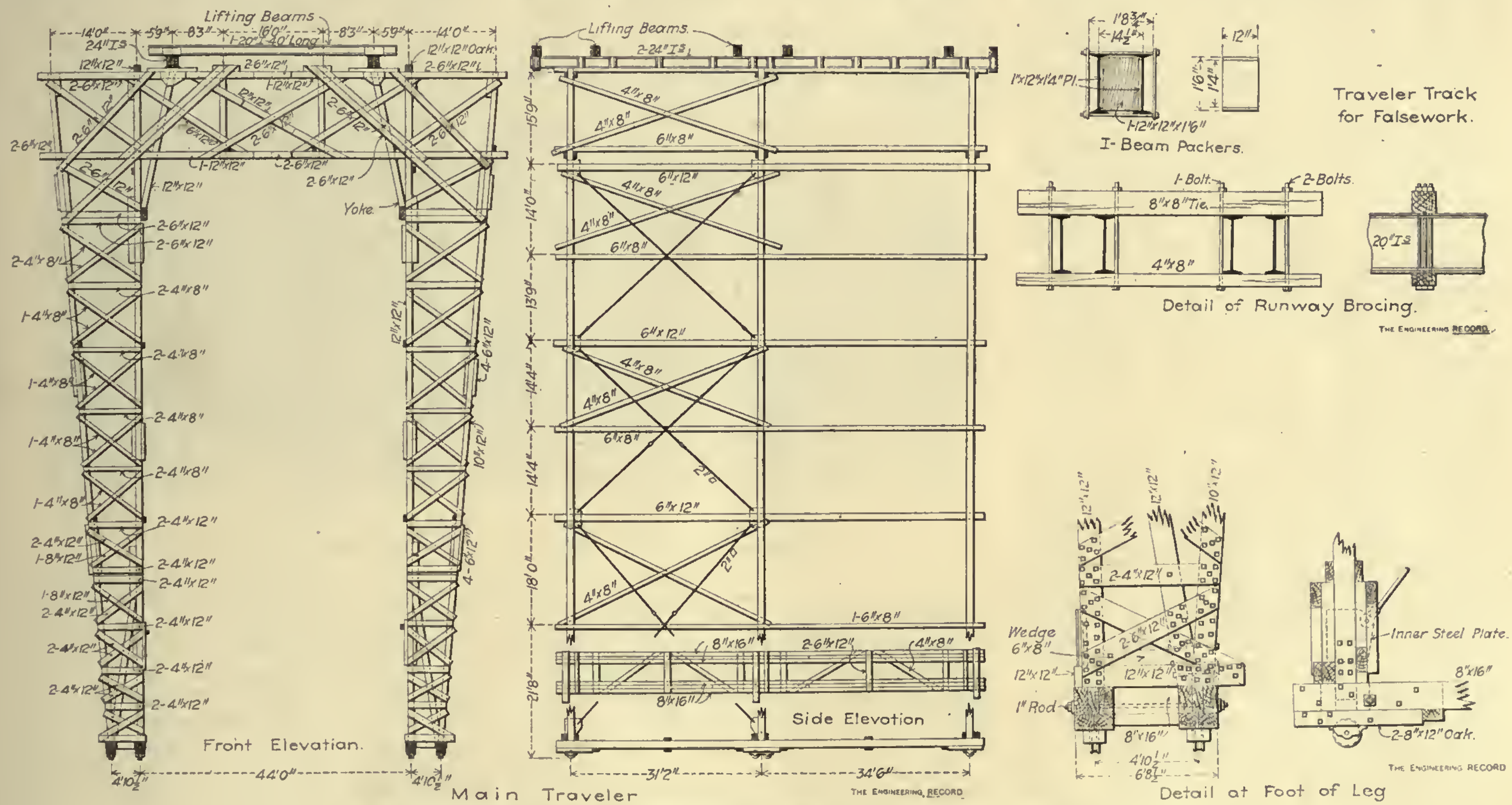
The traveler moved on two standard-gauge tracks, 48 feet 10½ inches apart on centers. Each of the four track rails was carried by two 20-inch I-beams, arranged to lap past each other where supported on the bent caps and rigidly braced by clamps 6 feet apart, as shown in the detail. The I-beams of each pair were clamped together with wooden fillers and steel yokes, and bolts spaced about 5 feet apart.

It was expected that the center pier would settle about 5½ inches under maximum load, and a diagram was prepared showing the position of the top of the pier and of the falsework caps before settlement, the top of the pier after settlement, the line of lower chord pins before settlement, when at the position of no stress; when cambered for dead load and without camber. These were drawn to a scale of 1½ inches to 1 foot, vertically, and instructions were given to take frequent levels and compare them with a bench mark on shore, so as to adjust the camber wedges and sand box in accordance with the settlement, which was successfully and easily accomplished.

The three-bent traveler had a total height and width of about 116 feet and 76 feet over all and a vertical and horizontal inside clearance of about 98 feet and 42 feet. Excepting longitudinal X-brace rods and the lifting beams, it was built entirely of wood. Two sets of longitudinal girders on the center lines of the trusses, each consisting of four 24-inch I-beams bolted together with wooden separators, were seated on the caps of the main bents and carried six transverse lifting beams, each of them composed of a single 20-inch I-beam, 40 feet long and calculated to be efficient for a 5-ton load at the center. These beams were provided with short bearing blocks, fitted between the flanges on both sides and bolted to the main girders. Where the main girders rested on the top chords of the transverse trusses, the latter were reinforced by slightly inclined posts, seated in yokes suspended from the tops of the vertical posts and bolted at their upper ends between steel jaw-plates on the chord timbers, as shown in the detail.

The principal truss members were handled by tackles, suspended from stirrup rods carried by wooden beams resting on the tops of the main girders. These were of various sizes, with capacities of 15, 18, 22 and 46 tons each. The traveler was rigged with twenty sets of eight-part Manila tackle and a number of small tackle, web lines, etc., and was operated by two eight-spool hoisting engines, stationary on the temporary center pier. The chord and end post pieces were handled by a special yoke clamp. The heaviest single piece was the end post, weighing about 65 tons. The middle section of top chord weighed about 47 tons, and there were about 21,500 field rivets driven in the completed span.

The erection of the bridge was accomplished without serious mishap by an average force of about 60 men working about 90 days, including the time required for building and moving the falsework and erecting the approaches. Mr. J. B. McIntyre was the chief engineer of the St. Clair Terminal Railroad Company. The bridge was fabricated by the American Bridge Company of New Jersey, Mr. Paul L. Wolfel, chief engineer, and erected by the American Bridge Company of New York, Mr. S. P. Mitchell chief engineer, and Mr. H. A. Greene, erecting manager of the Pittsburg division.



Clairton Bridge: Details of Travelers for Erecting Trussed and Girder Spans.

* * *

Engine Lubrication Under Pressure was referred to in an article on engine tests in a recent issue of the "Electrician," of London. A 120-horse-power compound engine running at 450 revolutions per minute was operated at no load, and friction cards were taken with oil at 30 pounds, 5 pounds and without pressure, and the result showed 2.128, 2.409 and 3.333 horse-power, respectively. It was concluded that a great increase in oil pressure did not bring a correspondingly large advantage.

Smoky Chimneys.

Extracts from a paper by Mr. Hastwell Grayson, read before the Liverpool Architectural Society and printed in the "Journal" of the Royal Institute of British Architects.

The principle of a flue is simple. Smoke consists of warmed air charged with particles of matter, either wholly or partially consumed. The warmth makes it lighter than the atmosphere, and therefore smoke rises by the easiest way, which should be up the flue. The trouble begins when the flue is imperfect, inadequate, or when other forces are at work counterbalancing the natural tendency of the smoke to rise. Failure may show itself in two ways—there may be a steady down-draught, or the upward draught may be so sluggish that puffs descend occasionally. The first is more usual when the fire is just lighted or nearly out. In either case, the nuisance may be accentuated by wind or the absence of it.

The chief cause of smoky chimneys is the lack of air supply at the base. A cubic foot of fresh air must be provided for every cubic foot of smoke that passes up the chimney. The Royal Commission on the Ventilation of Factories, after making experiments, ascertained that an ordinary fire in an ordinary room sent 4,000 cubic feet of smoke up the flue per hour, and that, after hermetically sealing the windows and doors, the same flue drew 3,000 cubic feet per hour. Before seeing this fact quoted I had made some personal observations of the smoke discharged through the chimney-pots above an office building: it seemed to me that the velocity was five feet a second in still weather. As the diameter of the flues was about 7 inches, the volume of smoke discharged would be 4,500 cubic feet per hour, or equal to the capacity of a room 15 feet broad, 25 feet long, and 12 feet high. I do not believe that in a substantial building 3,000 cubic feet of air per hour could be produced with windows and doors hermetically sealed, unless the air came down one-half of the chimney and the smoke went up the other half. It is well known that buildings with thick walls and fireproof floors, such as blocks of flats or offices, are most liable to down-draught. These blocks have great numbers of fir s lighted daily.

They have very few outside doors, and a special effort is made in them to keep the windows and internal doors draught proof.

In a comparatively small office building, with the only entrance protected by heavy swing doors, there may be 30 or 40 grates in constant use, every one of which should have its 4,000 cubic feet of air per hour. This supply is impossible unless special means are adopted to provide it. In an airtight building time is often the architect's ally; for every minute settlement and every infinitesimal shrinkage provides an additional air inlet. But buildings specially constructed should have special ventilation. Even then some flues will smoke, because tenants persist in closing up the inlets. Warmed fresh air is almost unprocurable. Architects, therefore, can only supply fresh air from the outside, and trust that the tenants will use the inlets. But tenants, more often than not, consider fresh air a draught and ventilators an unnecessary fad. Air inlets are least objectionable when near the ceiling, as that position allows the fresh air partially to lose its chill before reaching the occupants of the room; high inlets are also useful as outlets, when the fire is not lighted. The best form seems to me to be a grating at the side of a chimney breast into a flue that finishes just above the roof, with cast-iron gratings on opposite sides. A contractor who has built many offices once advised me to have doors very close fitting at the floor, but very easy at the top, and with the rebate of the frame cut well back. By doing this a concealed inlet can be provided 3 feet long by ¼ inch deep, equal to 9 square inches. This device has extra value when the hall or corridor is warmed.

For years, when opening the front door on a winter evening, it puzzled me to find out what became of the immense volume of chilly air which came rushing in; two or three hundred feet entered per second, but the house seemed able to absorb it indefinitely. The answer is that the flues drew up a greater quantity, and the cold heavy air from the outside drives the lighter air in the house out by every ventilator and crevice that was acting as an inlet before the door was opened.

Given an air supply, the next consideration is the flue. The majority of architects and builders feel certain that a 14x9-inch flue is much too large; and the proportion is stupid. The opening at the junction of the grate and the flue is seldom 36 square inches, and often much less. Chimney-pots vary in area from 40 to 60 square inches. A 9x9-inch flue can be more thoroughly cleaned, and works well enough.

Chimney-pots have this in common: the more efficient the uglier; but the reverse is not as true as potmakers would have us believe. Pots with the ordinary zigzag rim cause an updraught much as the V in the body of a kite forces it up. Louvres, trumpet-mouths, spirals, and many other horrors force up the smoke when the wind blows; but even an archimedean revolving cowl or a lobster-back is useless in still weather. Trumpet-mouthed blowers, or drain-pipes with the socket outwards, built into a stack at an angle of 45 degrees a few feet below the pot, will sometimes cure a flue that is only troublesome when the wind is in one particular quarter.

The value of at least two bends is always insisted on in specifications, but in practice the bends are often scamped, and are difficult to provide in the attics, especially when the fireplace comes between other flues. The reason for the undoubted advantage of bends is not obvious. The contraction which is usual in making them may have something to do with it; they may act slightly as baffle-plates, and, of course, the top bend catches the rain and helps to keep the lower part of the flue dry; probably under various atmospheric conditions all these reasons may have at least some truth in them.

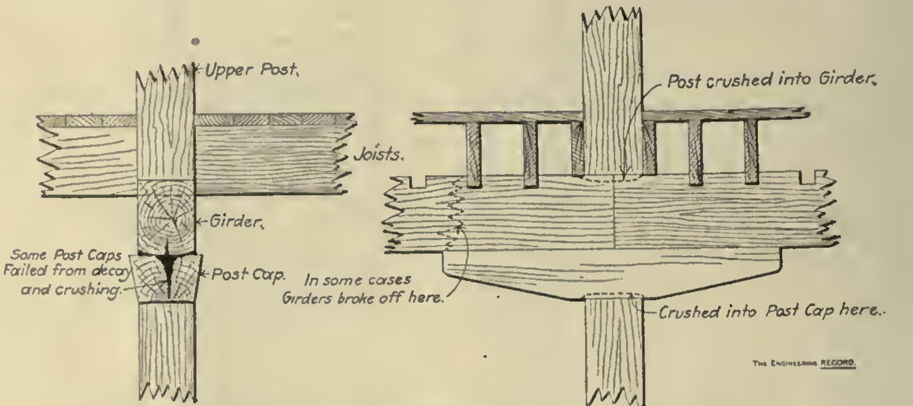
The height of the chimney-stack is of the greatest importance; but again the reason is not obvious. When the wind blows at right angles to the ridge, the velocity must be greater nearer the ridge, and probably steadier. When the wind is not at right angles to the ridge, I cannot see how it can affect the flue. If the straightness of the flues in the chimney-stack above the roof helps the force of the smoke, it is curious that bends should be useful below. There can be no appreciable difference in temperature or atmospheric pressure at the top of two flues, one of which is five feet higher than the other; yet we know that five feet extra height to a stack may work wonders. That it is advisable to keep a flue warm is more obvious, for as soon as the smoke approximates in temperature to the atmosphere its tendency to rise is lost. All outside stacks should have 9 inches of brickwork between the flues and the weather. Single flues should be avoided, and above the roof it is better to have 9 inches of brickwork on the most exposed side and end, even if there is only 4½ round the rest of the chimney.

The plan of a stack and the direction of the wind seem to have no connection. A chimney much exposed to a west wind is just as likely to be satisfactory with its axis north and south as east and west. It is better to have the middle pots in a long stack raised a little above those at the ends, but the flue at the leeward end is just as likely to draw well as that at the windward.

We frequently hear it stated that on account of other buildings, trees, or mountains, the wind is deflected and rushes down vertically on to some unfortunate flue and drives the smoke back to the grate. That argument, I believe, is generally false. A strong wind acts on the principle of an hydraulic jet pump, or one of those little sprays for fixing a pencil sketch. It drags after it the air on the lee side of an obstruction and tends to create a vacuum. If the air that replaces it comes from the inside of the building the chimneys will smoke. A vacuum is especially likely to occur in a cul-de-sac, or an area with buildings on all sides. Take an oblong building with an area, and the block on one side rather lower than the others. If a strong wind blows directly on to the low roof, it will bound on to the high one and create a vacuum in the area. Should the gust be prolonged, air will rush out through the crevices in the walls and windows and transfer the vacuum to the rooms. It was found in an important Liverpool building designed on these lines that the flues on the floor level with the bottom of the area smoked, but none of the others. Most buildings are not so fortunate, as a vacuum generally sucks impartially from all rooms round the area. An air trunk through the bottom of the low part of the building, in some convenient place, would probably allow the vacuum in the area to be filled direct from the street and save the down draught.

The Collapse of the Floors of a Warehouse in Cincinnati.

A 32 1/3x82 1/3-foot, five-story and basement warehouse in Cincinnati had the wooden roof and floors supported on the brick side walls and on a single longitudinal row of wooden columns. The tenant used it for sugar storage, and in flood-time, when a large number of barrels of sugar were stored on the second, third, fourth and fifth floors and the first and basement floors were unloaded, the interior suddenly collapsed, all the columns and floors fell to the basement and the contents of the building were destroyed, involving a loss of about $45,000, besides the damage to the building. The tenant held the owner responsible for the loss, and the owner contended that the tenant was to blame for overloading the building beyond a reasonable amount. A local engineer was retained as a structural expert and from his report it appears that the building was strong enough to sustain the loads everywhere except at the column and girder connections, and that the details at these points were so much weaker than the rest of the structure as to reduce its capacity far below its apparent and reasonable strength. The direct cause of the failure appeared to be the use of pine timber, under transverse crushing stress, between the ends of the main columns. The principal details of the design and calculations of load and capacity are here presented from the report and show how the building was wrecked by a load which could have been safely carried by beams and columns of the same size, with slightly modified details.


Upper Post.
Joists.
Girder.
Some Post Caps Failed from decay and crushing.
Post Cap.
In some cases Girders broke off here.
Post crushed into Girder.
Crushed into Post Cap here..
The Engineering Record.

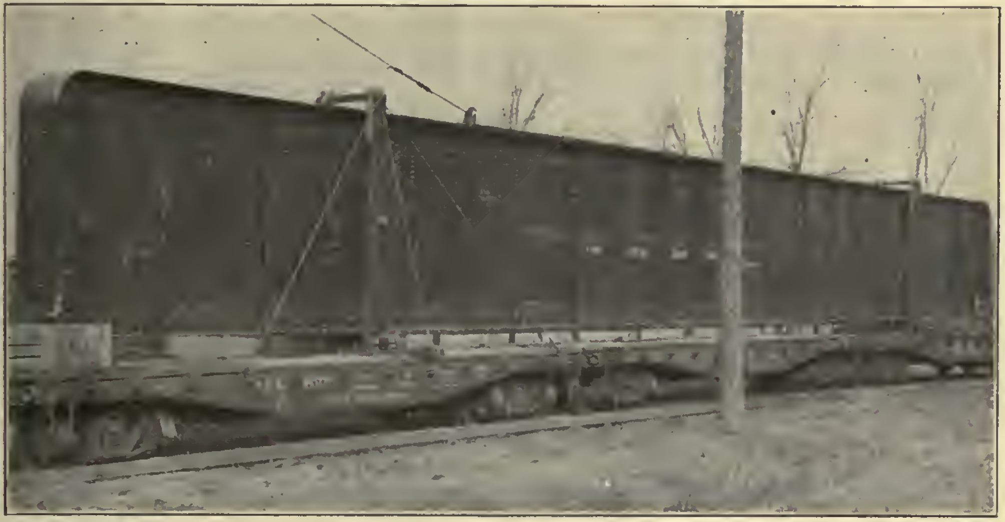
Cincinnati Warehouse: First Floor Beam and Column Connection.

The dimensions of the timber varied somewhat in different stories, but for the first story the columns were 12 inches square, 11 feet 9 inches apart on centers and were capped with 10x12-inch longitudinal oak corbels, 6 feet long. The corbels supported 12x16-inch longitudinal girders, with butt joints on the column centers. Transverse joists, 2½ inches wide, 14 inches deep and 12 inches apart on centers, carried by the longitudinal girders at one end and built into the brick walls at the other ends, were floored with 2-inch longitudinal floor planks. The lower ends of the columns passed between the pairs of joists and were seated, without bed plates or cushions, on the upper sides of the longitudinal girders, with the center of the column directly over the end joint in girders. The upper sides of the girders were notched 2½ inches to receive the dapped ends of the joists. All timber was white pine, assumed to weigh 25 pounds per cubic foot.

The floors were loaded with barrels of sugar, which had an average diameter of 25 inches, length of 31¼ inches and weight of 340 to 350 pounds. They were piled as close together as possible, three tiers high, and produced a computed load of 166 pounds per square foot of floor. The weight of the floor construction was about 14 pounds per square foot, and, as each column supported a floor area of 188 square feet, the total load per column per story was 33,840 pounds. The net section of the floor girder was 12x13½ inches and it was computed to have an ultimate capacity for a concentrated load of 116,330 pounds at the center and a safe load of 17,600 pounds with a deflection of 0.3 inch.

The successive floor loads gave totals of 129,172 to 138,100 pounds in the first-story columns (according to arrangement of barrels) and they were calculated to have a safe load of 456,840 pounds. The distributed load on each joist was 2,736 pounds and the computed safe load was 5,671 pounds. These loads, although large, were not dangerous, and the only critical points were the column bearings, where the crushing stresses were more than 900 pounds per square inch. The transverse crushing strength of white pine is given at 600 pounds per square inch by Trautwine, and is thus far below the unit strength required.

Under these loads the lower ends of the first and second-story columns penetrated the upper surfaces of the floor girders and the fibre of the timber was badly crushed. The injured places were concealed between the floor joists and were dark and almost inaccessible, so that little or no attention was paid to them and no examination was made. The basement was sometimes flooded and the ends of the girders decayed and split open, making V-shaped spaces on the upper sides, into which the feet of the columns penetrated.



Long Through-Span Double-Track Plate Girder Loaded on Three Steel Cars.

This condition of the timber, together with a possible settlement of some of the column foundations in the softened ground, started a failure in some of the lower stories, which progressed rapidly and wrecked the whole interior of the building. The girders broke at one or both ends and all the floors were precipitated into the basement. In some cases the girders were broken off short at the wall ends, and at the column ends beyond their bearings on the 6-foot corbels. The basement columns were made with pairs of 12x12-inch timbers and one of them remained standing with its upper end carried far out of perpendicular, with no visible means of support, and still carrying a 66-ton load.

Pennsylvania State Roads seem to be regarded with great favor just now. Commissioner Hunter has received 52 applications for a total of 106 miles of road, an excellent showing for the short time the State aid system has been in force. The applications from Montgomery County far exceed those of other sections in number and length of road desired. Lycoming and Bucks Counties come next.

Steam Turbine Power Plant for Boston Navy Yard.

An interesting change in the practice of the Bureau of Yards and Docks of the Navy Department is the introduction of Westinghouse-Parsons steam turbine units for furnishing current for lighting and for operating dry dock pumps and miscellaneous machinery. The initial installation of this character is in process of construction at the Charlestown Navy Yard, Boston, and for the present, one Westinghouse-Parsons turbine generating unit of 750 kilowatts capacity will be placed in service. This turbine will be of the new short-barreled type and is now under construction at Pittsburg. A Worthington surface condenser will be employed, using salt water for circulation. The condensers will be located between the foundations, which consist of concrete piers. It is expected that a running vacuum of 28 inches will be secured through the aid of a dry air pump. Steam will be furnished at 150 pounds pressure by Babcock & Wilcox boilers in units of 350 horse-power, equipped with Roney mechanical stokers. Coil superheaters in the boiler settings will furnish steam to the turbines with a superheat of about 100 degrees Fahrenheit. The boiler house will be equipped with a complete outfit of coal and ash handling machinery.

The present power plant is the outcome of an appropriation made in 1898 by Congress for a dry dock and pumping plant to be located at the navy yard; the new plans for a dry dock equipment provide for a power plant located near the outer end of the new dock with piping connections to both old and new docks so that the one pumping plant will be able to handle them simultaneously or separately. During the period of construction of the new dock, the work of the Bureau of Yards & Docks at this yard underwent considerable enlargement, necessitating an immediate increase in an electrical generating equipment for supplying light and power to buildings and departments. In view of this situation, it was decided to supersede the dock pumping plant originally designed by a central lighting, power and heating plant for the entire department, although retaining the dry-dock pumping equipment, which will now be electrically driven from the central station. It is also intended to supply from this plant electric light and power to the vessels docking which do not happen to be under steam. The power system as now under construction is, therefore, considerably more comprehensive than originally laid out.

The turbine plant will supply three-phase alternating current at 2,300 volts, this voltage being used for general distribution and for direct use in larger motors, while for lighting, lower voltage will be provided by transformation. The turbine generator will be served by a 37½-kilowatt Westinghouse compound exciter unit.

The engineering work is under joint execution by the Department of Yards and Docks and the constructing engineers, Westinghouse, Church, Kerr & Company, who are installing the plant.

A Long-Span Double-Track Plate-Girder Bridge.

Two tracks of the Chicago Terminal Transfer Company cross the Illinois and Michigan Canal on a through plate girder span 114 feet long on centers. The girders are about 115½ feet long over all and 29 feet apart on centers, and are skewed about 11 feet. The intermediate floorbeams, about 9½ feet apart, are perpendicular to the girders. The floor is X-braced by single angles with horizontal connection plates filed-riveted to the lower flanges of the floorbeams and to the projecting edges of the cover plates in the lower flanges of the main girders, one panel of X-bracing extending through three beam panels. Each rail is carried by two lines of 18-inch 55-pound I-beam stringers, and the girders have bearings on pins of large diameter, which engage their webs.

The bridge is proportioned for a dead load of 2,200 pounds per linear foot for each girder, and for a live load consisting of two locomotives weighing 310,000 pounds each, on a 51½-foot wheel base, followed by a train load of 4,000 pounds per linear foot, on each track. The maximum stresses produced by this loading are 12,335,100 foot-pounds moment, 475,500 pounds shear, in the girders; 850,000 foot-pounds moment, 106,200 pounds shear, in the floorbeams, and 95,450 foot-pounds moment, 45,500 pounds shear, in the stringers.

The main girders are somewhat peculiar in that the 119½-inch webs ⅜ inch thick in the center panels are made with two plates spliced with double 1-inch cover plates on the neutral axis of the girder. In the remaining panels the web is made with single full depth plates increasing to a thickness of ⅝ inch at the ends, where they are reinforced by double cover plates on each side in the short end panels. The upper corners are rounded to a 12-inch radius and the lower corners are bevelled slightly and have the bottom flanges cut off to clear the riveted pedestals.

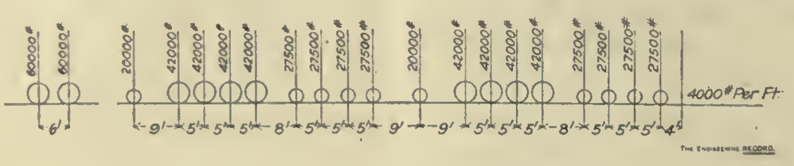
The top and bottom flanges are alike except that the first cover plate in the top flange reaches from end to end of the girder and in the bottom flange it is only 94 feet long. Each flange has in addition three other 24x¾-inch cover plates, two 16x¾-inch full-length side plates and two 8x8x¾-inch angles. The side plates are spliced with 8x¾-inch plates, and the flange angles are spliced with pairs of 7x¾-inch plates, one on each flange, all flange splices breaking joints. The web is spliced at alternate panel points with double cover plates having six vertical rows of shop-driven rivets. The floorbeam webs are made with short end sections extending above the top flanges to form guesset and connection plates and have their inclined edges stiffened with flange angles to serve as knee-braces. They are connected to the webs of the main girders by pairs of vertical angles filed-riveted through both flanges.

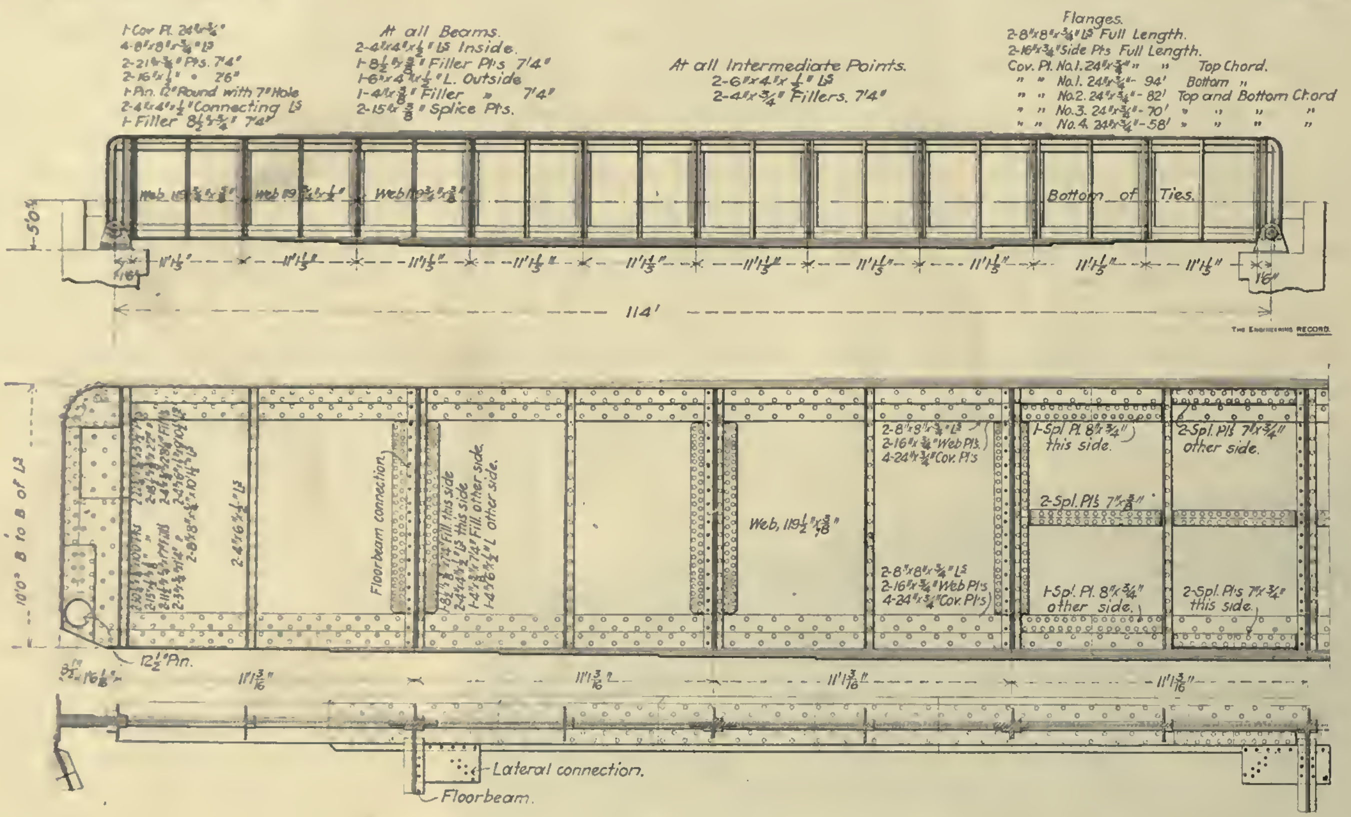
The track stringers are seated on horizontal shelf angles reinforced by the upper ends of the web-stiffeners and are web-connected to the floorbeams with short vertical angles. They are supported at the abutments on cast-iron pedestals 8 inches high. Each end pin is a hollow steel casting having various diameters in different parts of its lengh, the greatest being in the center, where it has a bearing 12½ inches in diameter and 5½ inches wide on the reinforced girder web. On each side of the center the pin is unfinished except for three bearings 11½ inches in diameter and 1½ inches wide which have narrow guide ribs on each side and engage the half holes in the webs of the pedestal. At the fixed end the pedestals are seated directly on the abutment masonry, and at the expansion end they are seated on nests of 5⅞-inch rollers with cast bed plates which have a cross-section resembling a row of ordinary T-rails. The pedestal at the fixed end is made 11 inches higher than that at the expansion end so as to allow for the thickness of the rollers and bed plate.

The girders were riveted up complete in the shops and weigh about 125,095 pounds each as shipped, loaded on three steel cars of a capacity of 100,000 pounds each. The middle car was a spacer and the bearings were near the centers of the end cars, where the girder was set to swivel on supports inside steel yokes. The yokes were made with a lower transverse channel sill resting on the car floor and two uprights, each made of a pair of channels slightly battered longitudinally and riveted together and to the upper cross piece so as to form a rectangular frame enclosing the girder. The top of each vertical post was guyed by three loop-end rods, one of which was pin connected to the end of the sill piece, and the others had the lower ends bent to pass through the stake holes and were screwed up on bearing plates on their under sides. Wooden cushion blocks were bolted to the tops of the yokes to give bearings for the top flanges of the girders.

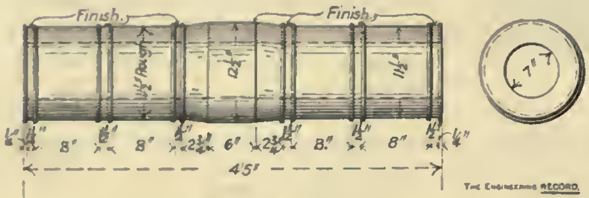
The bridge conforms to the specifications of the Chicago Terminal Railway Company, Mr. F. E. Paradis, chief engineer, and was built and erected by the Chicago Bridge & Iron Works, Mr. Horace E. Horton, proprietor.

The Action of Frost on foundation walls in Maine has often resulted in serious damage to the building when special precautions were not taken to provide for the upheaval. The ground freezes to a depth of several feet in the winter and when the stone footings have been made with vertical faces, it has been known to lift them bodily to a height of 3 inches by adhesion of the frozen earth to the vertical surfaces. This is successfully prevented by making the foundation walls of flat stones, laid in cement mortar and battered on both sides. For an ordinary building in Bangor, Me., where the soil is chiefly blue clay, they are carried down to a total depth of about 8 feet below the surface, so as to extend just beyond the 6-inch concrete cellar floor and terminate just below the grade line. Such a wall is about 4 feet wide at the base and 2 feet wide at the top, and receives the concentric brick wall 20 inches thick. A space about 9 inches wide on the outer face of the wall is filled with gravel, and at the bottom of it 4-inch porous land tiles with open joints are laid to conduct the drainage to the sewer. It opposes an effectual barrier between the clay and the masonry and allows the former to shrink and swell, under the influence of the weather, without disturbing the masonry.

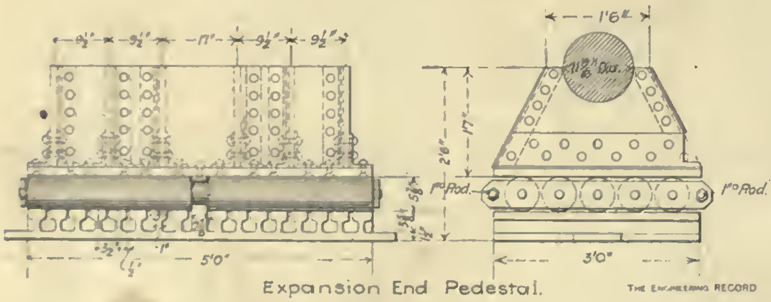




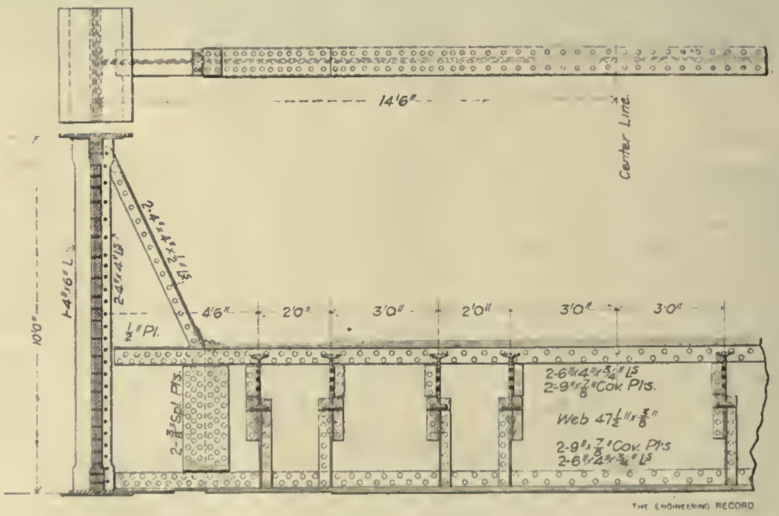
Partial Inside Elevation of Girder and Sectional Plan showing Bottom Flange.



End Bearing Pin.



Expansion End Pedestal.



Half Cross-Section.

Loading Diagram and Details of Long-Span Plate Girder Bridge, Chicago Terminal Transfer Company.

Earthwork at the Washington Filtration Works.

By E. D. Hardy, Assistant Engineer.

The site for the Washington aqueduct filtration plant covers an area of about 43 acres and has quite an irregular surface, the minimum elevation being 125 and the maximum 185, making an extreme difference in elevation of 60 feet. The elevation of the foundation of the filters was made 155, thus making the greatest depth of fill, as well as cut, 30 feet. The amount of excavation exceeded the fill, however, by 615,000 cubic yards, the former being 880,000 cubic yards and the latter 265,000 cubic yards.

The reasons for fixing the elevation of the foundation at such an elevation that the excavation and embankment were so widely different were, first, that had this elevation been greater, the foundation of the south row of filters would have been considerably above the fixed grades of the streets surrounding them, and second, that there would have been a constant additional expense for coal, to pump the water from the fixed elevation in the Washington City reservoir to the filters.

Steam Shovel at Work on Washington Filters.

The work of excavation was begun in May, 1903, in a small way, the principal work being that of stripping the soil and piling it for future use for covering the completed filters. The plant employed in this work consisted of one New Era grader drawn by a traction engine, and of 49 wheel scrapers. The grader was used very little as the surface was too irregular, covered to a greater or less extent with stumps of large oak trees and was hard and gravelly. The wheel scrapers were very satisfactory, not only in moving the soil, but in piling it.

Later the plant was increased by: No. 1, a 35-ton Vulcan steam shovel, with a 1¼-yard dipper; No. 2, a 50-ton Vulcan steam shovel, with a 1½-yard dipper; No. 3, a 55-ton Marion steam shovel, with a 2½-yard dipper; No. 4, a 55-ton Marion steam shovel, with a 2½-yard dipper, and No. 5, a 60-ton Bucyrus steam shovel, with a 2½-yard dipper, together with eight locomotives of standard gauge from the Manhattan Elevated Railroad; 80 4-yard dump cars; 14 6-yard dump cars; two 10-ton grooved rollers and a road machine.

Part of the excavated material was deposited by means of the dump cars in the low area immediately south of filters Nos. 25 to 29, with an average haul of about 1,600 feet. [A description of the purification plants showing the location of the beds was printed in The Engineering Record of March 14, 1903.] The remainder of the wasted material was deposited by the same means in the Soldiers Home Grounds with an average haul of about 1,800 feet.

The material excavated was a mixture of clay, sand and gravel in varying proportions, enough clay being present to make an impervious foundation for the filters over practically the whole area.

The rate of progress and amount of material excavated was as follows: May, 1903, 12,100 cubic yards; June, 12,500; July, 34,100; August, 56,200; September, 77,100; October, 90,450; November, 90,540; December, 94,200; January, 1904, 56,400, and February, 62,820.

The number of hours that each steam shovel actually worked, the amount excavated during the month and average per hour, are shown for several months in the accompanying table.

The work of excavation has been rather difficult during the winter months as the weather was unusually severe, freezing the ground to a depth of about 2 feet and thus compelling the contractors to break it up by blasting. At the time of writing, March 18, the balance to be excavated is about 257,000 cubic yards. It is estimated, however, that this material will be needed in making the fills over filters, around walls and in the roadway around the reservoir.

Steam Shovel Performance, Washington Filters.

Shovel number.	Number of hours.	Cubic yards.	Average per hour.
		September.	
1	234	15,150	65
2	429	28,120	65
3	251	18,480	74
4	210	15,350	73
	1,124	77,100	
		October.	
1	88	4,200	48
2	381	25,200	66
3	306	22,250	73
4	422	38,800	92
	1,197	90,450	
		November.	
1	135	6,800	50
2	316	15,150	48
3	368	26,640	72
4	433	37,420	89
5	55	4,530	82
	1,307	90,540	
		December.	
1	155	4,570	30
2	184	8,780	48
3	201	11,730	58
4	262	27,580	105
5	369	41,540	113
	1,171	94,200	
		January.	
2	224	9,130	41
4	289	20,670	72
5	308	26,600	86
	821	56,400	
		February.	
2	178	6,760	38
4	324	26,040	80
5	311	30,020	96
	813	62,820	

The amount of filling under filters, when completed, will amount to about 65,400 cubic yards. In making the fill the site is cleared of all perishable material. It is then built up in 3-inch layers, each layer being rolled with a 10-ton, grooved, steam roller, which passes over each layer at least six times. Selected material is used for making this fill containing clay and gravel which is found naturally mixed in parts of the excavation. The several layers are sprinkled with the desired amount of water from an ordinary road sprinkler. The best results were secured when the water was sparingly used.

The work is being done by Mr. J. D. Maclennan, receiver for Cowarden, Bradley, Clay & Co., at 30 cents per cubic yard for excavation and the same price for fill.

Centers for Stone Arches on a New Swiss Railway.

Stone Arches in large numbers, both single arch bridges and viaducts, have been built on the Albula Railway, in Switzerland, with a wide range of spans. In the construction of the centers special care was devoted to having them accurately made of suitable and strong wood. The centers were all—with one exception—made to rest on end supports only, and as a rule were single or combined strut-framed constructions. The centers were made rather larger than the arch to be formed on them, so as to allow for settlement due to compression. One two-hundredth of the width of the span was found to be sufficient, provided good, firm wood and accurate workmanship were employed. The exception was a 27 meter arch, the centers of which were supported in the middle by staging 15 meters high. The arch was in this case made by carrying on work in four places at the same time. The total settlement of the center was only 25 millimeters. The centers were, as a rule, loaded on the top before the work of construction at the haunches was commenced, this being done so as to prevent the top of center from rising on account of its being loaded at the haunches. In cases where the centers were not loaded on top in this manner the final shape of the arch clearly indicated that deformation had taken place, and demonstrated the advisability of loading. The centers of arches up to 30 meters span were placed on wooden wedges, these, when striking the center, being gradually cut away. The centers of the greater arches were placed on iron tubes filled with sand. In some cases the settlement of 10 meter span arches, when the centering was removed only four days after the closing of the arch, was from 2 to 3 millimeters; 16 meter arches, when their centers were struck twelve days after closing, deflected only 1 millimeter; but in these cases the arching was done in dry, warm weather. A series of illustrated articles describing this interesting railway and its construction was printed in recent issues of "The Engineer," London.

With the single exception of an 80-meter steel bridge, there are no steel bridges nor viaducts on this railway. The reason for this was that masonry in nearly every instance was not only cheaper than steel, but offered a great advantage, in that by its use there was no break in the foundation for the permanent way, and little or no expense for maintenance. Masonry arch viaducts were used instead of retaining walls in nearly every case in which the height of the walls would be 7 meters or more. In such places the viaducts were not only cheaper, but in the event of any difficulty due to the nature of the ground, possessed advantages.

The Value of Tests for Bacteria of Specific Types as an Index of Pollution.

Extracts from a special report by H. W. Clark and Stephen DeM. Gage, in the Thirty-fourth Annual Report of the State Board of Health of Massachusetts, for 1902.

In recent years increased attention has been given by those interested in sanitary problems, and especially water supply and water purification, to methods for the determination of fecal bacteria in water, and to the significance of their presence as a determining factor in judging the degree of purity of a water.

During the past eight years the work along this line at the Lawrence experiment station of the State Board of Health of Massachusetts has covered a wide field, and has included examinations of over 18,000 samples, including 4,700 samples of polluted river water, 9,100 samples of filtered waters, 2,200 samples of other potable waters, including samples from springs, curb wells, tubular wells, domestic wells, ponds and other surface supplies, etc., and 2,100 miscellaneous samples, including shellfish, sea water, ice, milk, dust, excrement from men and animals, grains, food stuffs, etc. Investigations have also been made upon the seasonal distribution of B. coli, the elimination of B. coli from water by storage, as in reservoirs, and studies upon the similarity between the length of life of B. coli and B. typhosus under a variety of conditions.

A number of investigators have published results seeming to show the presence of bacteria of the colon type in samples from sources apparently removed from pollution, and these results tend to discredit the value of tests for organisms of this type as an indication of sewage pollution. Nevertheless, the colon tests, correctly interpreted, are, undoubtedly a valuable aid in the analyses of certain classes of water where the determination of suspected pollution becomes necessary. That B. coli are widely distributed is not to be disputed when we consider that this organism is found in the fecal discharges of men and the major animals widely used as a dressing for arable soil, and in the intestinal contents of many of the smaller animals, both domestic and wild, and in the evacuations from fowls and some of the migratory birds. Flies and other insects may also act as carriers of these germs, depositing them in places where we would least expect to find them. Examinations of 48 flies at the experiment station resulted in the finding of B. coli in or on nine of these, and bacteria of the strepto type in or on three others. No relation could be traced between the locality where these flies were caught and the finding of the test organism. Flies caught about the filter house at the station where sewage is continually present frequently failing to show the test organism, while others, obtained from localities removed from sewers, privy vaults, stables or any of the usual sources of contamination, gave positive reactions.

The principal types of bacteria used as indices of pollution are the colon type, the sporogenes, sewage streptococcus type, and occasionally the aerogenes and the chologenes types. The colon type has received the most study; it is widely distributed in nature and since it is the most numerous of these types in normal sewage, it is of the most value as a positive indication of sewage pollution. The streptococcus type and sporogenes types have not yet received the study necessary to determine their value as indications of pollution. The aerogenes and chologenes types have no specific value, but are included by the tests applied in some laboratories under the colon type.

In the filtration of a polluted water, such as that of the Merrimack River, bacterial tests are, as is well known, of more value than chemical analyses. The filtered water may be changed but little from the raw water by filtration, as far as chemical analyses can determine, and yet a source of danger be absolutely removed, as shown or strongly indicated by baterial tests. Long-continued comparisons of the bacterial examinations, as applied to raw and filtered waters, have shown that the B. coli test is a more delicate indication of filter efficiency, when filtering water as polluted as that of the Merrimack River water, than tests of the total number of bacteria present in the filtered and unfiltered waters. Disturbing factors in filtration shown slightly or not at all by ordinary bacterial counts and comparisons are often shown strongly by B. coli tests.

In the examination of spring waters the degree of purity of samples, collected in a careful and proper manner from properly guarded springs, is almost absolutely shown by chemical analysis. B. coli was found in only six of all the spring water samples examined that were collected directly from the springs by employees of the Board, and in four of these waters both inspection of the surroundings of the spring and chemical analysis would alone have condemned the waters. In one case the entrance of B. coli occurred, and pollution was not otherwise shown by either inspection or chemical analysis. This accidental pollution was evidently only applicable to this sample, however, and not to the general flow of water from this spring. It is evident, of course, that however pure the water might be as coming from the ground, accidental contamination from the person collecting or bottling the water might introduce B. coli into the spring itself and this contamination not be shown by chemical analysis, and this was probably the case in this instance.

In the samples of spring waters, as sold upon the market, the chemical analyses did not and could not reveal such slight accidental contamination as might introduce B. coli, shown by the detection of this germ, and this contamination might be of considerable moment. The determinations of numbers of bacteria in these samples were of little significance, as the waters had been bottled for indefinite periods of time, with a plentiful chance for the increase of the bacteria normally present in them when drawn from the springs.

In the examination of ground waters from driven wells, comparisons of the chemical, bacterial and B. coli analyses show that in all of 128 samples quoted in the report, the chemical and bacterial, including B. coli, examinations were recorded, in which B. coli was found in a tubular well water, chemical analyses also showed the water to be of a poor quality. In one instance, as has already been stated, accidental pollution of driven well water, to such an extent that the health of the people using this water was seriously affected, as shown by many cases of typhoid fever, was not indicated by either chemical or bacterial tests, but was indicated by the presence of B. coli in a water that had never before given positive tests for this germ, and in which subsequent tests, after the passing away of this pollution, again gave negative results.

Eighteen samples of water from filter galleries showed no evidence of pollution by B. coli tests in 1 and 100 cubic centimeters.

The complete analyses of samples from a large number of domestic wells show that polluted waters that might become unfit for consumption at any moment are more plainly indicated by single chemical analyses than by single determinations of B. coli. The presence of B. coli at the time of examination may indicate actual danger to health and its absence even in the most polluted of these waters—chemically—may indicate lack of imminent danger, but the chemical analyses are certainly the more decisive.

The results of the examination of samples from ponds and lakes show with considerable clearness that in the examination of surface waters from inhabited localities, the question of obtaining positive tests for B. coli is only one of taking a sufficient volume of water for the test. They also show with considerable clearness that the degree of contamination of these waters varies inversely as the volume required to give a positive test for B. coli.

The number of B. coli in a river as polluted as the Merrimack varies in inverse ratio with the dilution of the entering sewage by the river water, and is affected by the temperature, the numbers of B. coli being larger during the warm weather than during the cold weather. In effluents from water filters the effect upon filter efficiency of dilution of the raw water in winter is less marked than the effect of high temperature in summer, the work of a filter in warm weather, when biological processes are active, being far more satisfactory than during cold weather.

The number of B. coli in a water is reduced quite appreciably by storage of the water.

In examination of shell-fish from suspected sources, the determination of fecal bacteria, such as the colon bacillus, is of considerable importance, as showing the purity or pollution of these sources.

As an indication of the presence of B. coli the presumptive test, so called, has, judging from our own work, little value unless suported by subsequent confirmatory tests. In a few instances, where one is dealing with a given kind of water continuously, the observer may become so expert as to be able to judge the presence of B. coli by the presumptive test, followed by the litmus lactose agar plate and the appearance on the agar streak, but if the classes of water are varied, even the most expert observer will fall into serious errors if he depends on those tests alone. The presumptive test includes at least 58 well-described species of bacteria, of which 12 would be included in the colon type, as determined at Lawrence, 7 species are of the aerogenes type, 3 species are of the chologenes type and 13 species are not sufficiently well described to identify them with or exclude them from the three preceding groups. Besides these, there are 23 species which would show positive results by the presumptive test alone, which would never be included in the fecal group.

Results of examinations for B. coli in different volumes of water show that tests in both 1 and 100 cubic centimeters are of value, the tests in the larger volumes being confirmatory of the tests in the smaller volume. In cases where a considerable number of samples are taken from the same source, the tests in the larger volume frequently give more information as to the quality of the water than do the tests in 1 cubic centimeter.

Outbreaks of typhoid fever coincident with the finding of B. coli in normally pure waters, *i. e.*, in water known to be safe under ordinary conditions but becoming polluted by the entrance of polluted water, have occurred in at least three instances within the observation of the writers, where the danger was not indicated by chemical tests or by a significant increase in the numbers of bacteria beyond the usual limits of variation for waters of their class.

Comparative tests for the relative viability of B. typhosus and B. coli show us that there is a very great similarity between the length of life of the two germs under a great variety of conditions. Both germs appear to follow the general laws of the removal of bacteria by sand filters, a somewhat greater viability being noted in the case of B. coli than of B. typhosus. Most organisms of both types are destroyed quite rapidly by the effect of cold either in fluid culture or when frozen in ice. When caught in ice, both germs will live, in slowly reducing numbers, for a considerable length of time, and under these conditions the morphological and cultural characteristics of the species may lose their identity and appear to merge into a common type which there are reasons to believe would be nonpathogenic. When subjected to heat, both species appear to follow about the same rule, the majority of the typhoid germs being destroyed by five minutes' exposure to a temperature of 45° C. and nearly all of the B. coli being destroyed by five minutes at 50° C., a few individuals of each surviving exposure to temperatures up to and including 80° C. The thermal death point appears to lie between 80° and 85° C., a point somewhat higher than has usually been set for these species. Both species are rapidly destroyed by sunlight.

The York Haven Power Plant.

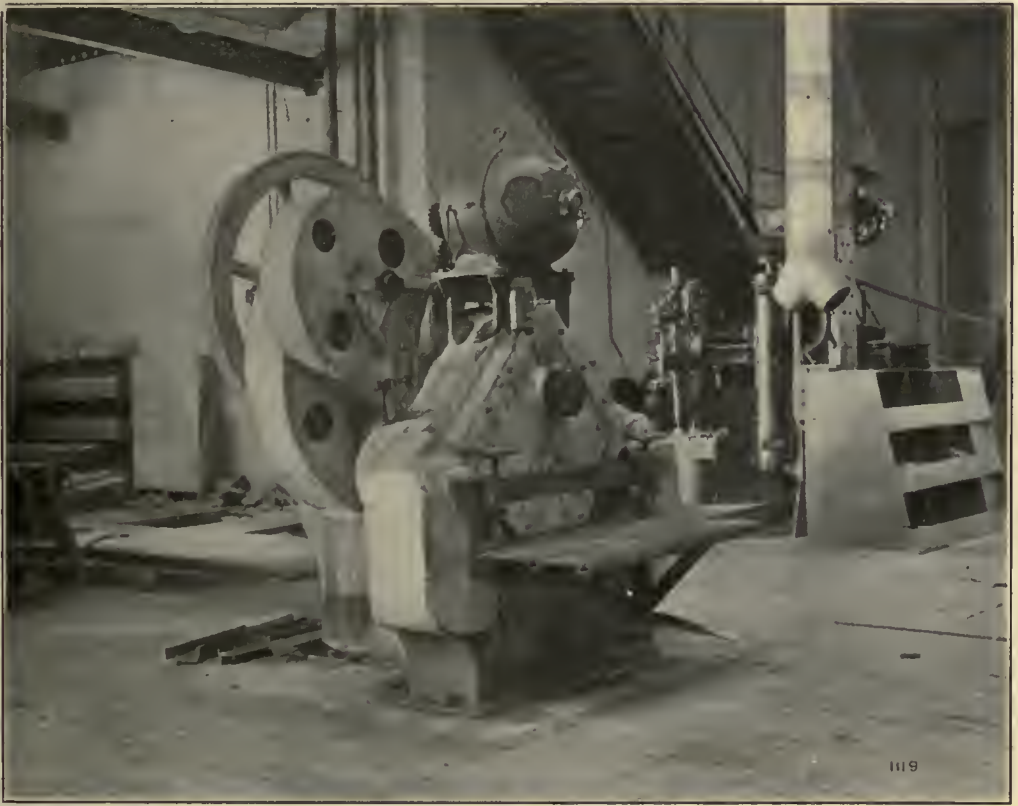
The foundation of the power plant on the Susquehanna River at York Haven has been cleared of all the debris which was left by the demolition of the power house and wire alley, caused by the ice gorge in the river in March. An account of this gorge and the flood was printed in The Engineering Record of March 12 and 19. The substructure of the power plant and the retaining wall were found, after careful and thorough examination, to be absolutely intact, not a stone having been moved nor the cement cracked. The reconstruction of the generator building has been commenced.

The brick walls of this building, up to a height of about 10 feet above the foundations and 5 feet above the high point of the last flood, will be built 3 feet thick and laid in cement. The wire alley on the substructure will not be rebuilt. Instead of this, it is proposed to construct an arched iron bridge from the generator building to the transformer building for the purpose of carrying the cables above the high point of the last flood. This will leave the walls, on top of which the wire alley was constructed, free, as a spillway in case the flood overreaches that high point, which is not likely, as this wall is 34 feet above low water. None of the machinery belonging to the power plant was injured to any degree, except a switchboard, so that the work of reconstruction will do on very rapidly.

A Motor-Driven Shear.

An interesting adaptation of the direct electric motor drive for a machine tool is illustrated in the accompanying reproduction of a photograph of a shear in the Charlestown Navy Yard, Boston. The motor is fixed in a rigid manner, in full sight and accessible, but on the top of the machine, as shown, out of the way of the workmen, and it drives the shear through a train of gears having the usual flywheel. The machine is designed for cutting angle iron as large as 6x6x1 inches in size, which can be sheared square across the bar or at any angle up to 45 degrees, and the motor, which is of the Crocker-Wheeler manufacture, wound for 220 volts, is of 10 horse-power capacity.

As to the machine itself, which was built by the Long & Allstatter Company, of Hamilton, O., attention may be directed to the enclosing of the gears and to the bracket form of the table in front. The gears effect the reduction of the motor speed of 850 revolutions per minute through three gear trains, all of the spur pattern. The iron table is carried on brackets, and holding-down clamps are provided, as indicated. The power is transmitted to the spindle through a friction clutch, which enables the operator to run the motor up to full speed before starting the shear itself. The clutch jaws are faced with renewable steel wearing plates.



Arrangement of Motor Drive for Angle-Iron Shear.

Steam Boilers of the Lancashire type have been installed in the power station for the portion of the Lancashire & Yorkshire Railway that has been equipped for electric traction, as mentioned in the editorial columns April 2. There are 16 boilers, each 32 feet long and 8.5 feet in diameter with two flues each 3 feet 5 inches in diameter. The working pressure is 160 pounds per square inch and the shell plates are 13/16 inch, the flue plates 9/16 inch and the end plates ¾ inch thick. The plant was designed by Messrs. Dick, Kerr & Company, of London.

Accident to a Diver in Boonton Reservoir, New Jersey.

An accident of unusual character in waterworks construction, which cost the life of an efficient diver, occurred at the Boonton reservoir of the Jersey City Water Supply Company early this week. The large masonry dam impounding the water in this reservoir was described and illustrated in this journal August 8, 1903, and by reference to the drawings printed at that time it will be seen that two 48-inch steel pipes were laid through the bottom of the dam near the old river bed. These two pipes extend through the embankment at the heel and toe of the dam, ending in low vertical face walls with wing walls, much like a culvert, and were provided for controlling the water level in the reservoir during the completion of the dam. Each pipe contains a 36-inch gate valve, set between two reducers, at the bottom of a gate well formed in the masonry of the dam near its upstream face. The inverts of the pipes are 105 feet below the top of the dam, and the upstream ends are about 90 feet from the back of the dam. It is the intention to close these two valves permanently, when the reservoir is finished, as the gate-houses and other pipes control the supply to the aqueduct leading to the city, and there is a long waste weir to care for floods.

The dam is nearing completion, and the reservoir is partially filled, the depth of water at the entrance to the pipes being about 70 feet when the accident occurred. At the beginning of the week it became necessary to open the valves, in order to prevent the water from rising too high. One valve was opened successfully, but the other stuck when it was about half open, and in the effort to open it farther the stem was broken at the lower end. In order to get at the valve to repair it, an attempt was made to stop the flow of water in the pipe by plugging the inlet end of the pipe with a wooden ball. This ball was made 56 inches in diameter and loaded with lead, so that when it was submerged it could readily be handled by one man, by means of a rope attached to it. The ball was lowered from a float and guided to place by lining in the rope, but did not wholly stop the flow, as the water rushed through the pipe in large quantities. At this juncture the diver was sent below, after full explanation of the situation and a caution of the danger due to the suction. Returning to the surface, he reported that there was a space at the bottom of the ball, which, he thought, could be stopped with sandbags. He soon went down again and placed some sandbags at the right-hand side of the ball, and then came up to get the bags for the left side. After going down to place the second set of bags, he sent up distress signals. His helpers essayed to bring him to the surface, but were unable.

Other divers were called and additional apparatus brought on a special train from Jersey City; every effort was made to free the imprisoned man. Just what happened cannot be known, but from the reports of the other divers who went down it is thought that after placing the second bags, he returned to examine those placed first. Apparently he attempted to push the bags more firmly into place, and they gave way, or else they had gradually yielded to the pressure, for he was found with his leg caught between the ball and the end of the pipe. The accident happened early Monday afternoon, and up to the time of going to press, all efforts to recover the body and to stop the flow through the pipe had failed. The man is believed by some observers to have lived for twenty to twenty-four hours after going down the last time. The air supply was kept up much longer.

Early American Chain and Wire Bridges.

It is rather surprising that so little care is taken in this country to preserve data concerning the early work of an engineering nature. For some reason the average engineer has no regard for the past, and tears down obsolete structures without other purpose and desire than to get them out of his way as quickly as possible. Others who have played no small role in the engineering work of the last thirty years refuse to give information concerning the early designs. The Engineering Record has repeatedly been told by these men that they did not wish their early work mentioned, for while it was as good as that of the same time, it was so far behind present practice as to be discreditable to their reputation. No arguments based on historical necessities avails with either class of engineers. Fortunately, the American Iron & Steel Association has started a movement to gather and make public data of this character, and in a recent number of its "Bulletin" there are the following interesting statements concerning early chain and wire bridges, prepared by Mr. Austin N. Hungerford, of San Francisco.

One of these early structures was built by James Finley, in 1801, across Jacob's Creek, in Western Pennsylvania, according to a system on which he received a patent several years later. Jacob's Creek is a small tributary of the Youghiogheny River and forms part of the dividing line between the counties of Fayette and Westmoreland. From the earliest settlement along its borders the water power was used for saw mills, salt works, and other manufacturing purposes. Not only was it the site of the first chain suspension bridge, but in 1789, very near the bridge site, was built the first iron furnace west of the Alleghenies (The Alliance Iron Works). The road across the creek at this place was the main line of travel from the lower part of Fayette County northeast and west and continued later to Greensburg and Pittsburg. This being a main route of travel, undoubtedly a bridge of some kind was at the place, but the first official mention of a bridge is in the records of Fayette County, of date March 12, 1801, in which is a correspondence between the Commissioners of Fayette and Westmoreland Counties, which resulted in a meeting of the two boards with Col. Isaac Meason on the banks of the creek on the next following Tuesday, "to consult and complete contract relative to James Finley, Esq., undertaking to erect an iron bridge over Jacob's Creek." On April 14 a contract was completed with James Finley to build the bridge for six hundred dollars, each county to pay one-half the amount, the bridge to be a "patent iron chain suspension structure" of seventy feet span and to be completed on or before December, 1801. It was completed at the appointed time and was in use until 1833, as in August of that year the Commissioners agreed to build a wooden bridge in place of the old suspension bridge, and thus ended the life of what Mr. Hungerford claims to have been the first chain suspension bridge in the county.

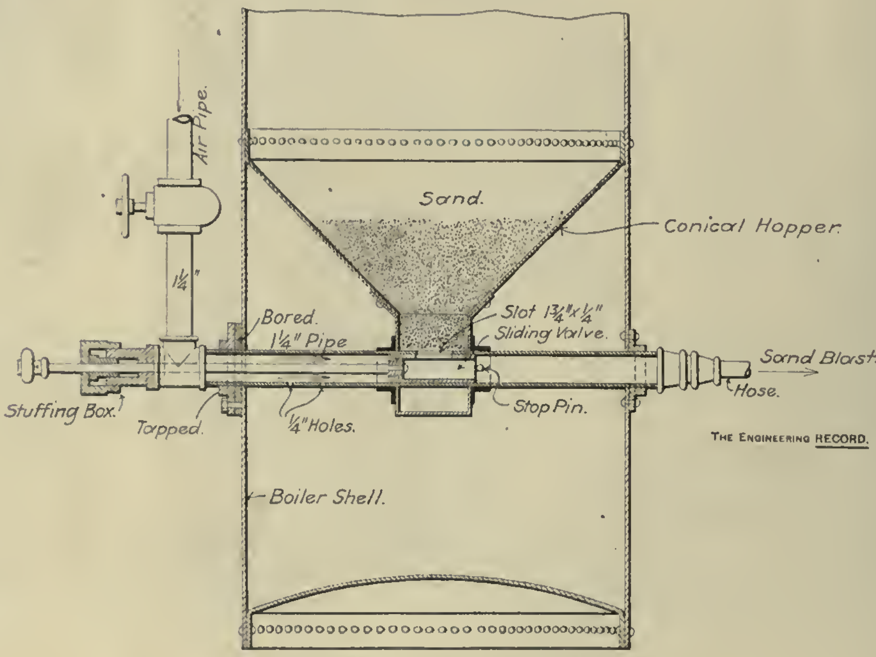
The practical success of the chain bridge over Jacob's Creek for eight years enlisted the attention of bridge builders in different parts of the country at that time, and several bridges were constructed on the Jacob's Creek plan. A heavy freshet in the Spring of 1808 destroyed the wooden bridge over Dunlap's Creek at Brownsville, Fayette County, and on February 14, 1809, the County Commissioners prepared plans, specifications, and estimated expenses, and a copy was sent to the President of the United States, with a request for an appropriation in aid of building the bridge. This request may seem singular, but it must be remembered that the site was on the line of the proposed National Road, which was soon after commenced at the eastern end and was finally built and passed over this bridge. It was not, however, until 1835, when, under the advice of Capt. Richard Delafield, then government engineer of the work, that a cast-iron bridge was built over Dunlap's Creek and made a permanent structure for the National Road. The metal was furnished by the Government, and it was completed under the superintendence of George W. Cass, who had come to the section years before as one of the engineers of the National Road. This is said to have been the first cast-iron bridge built west of the Alleghenies.

No further mention appears of the request made to the President by the Commissioners of Fayette County, and it is presumed that nothing came of it, as on May 26, 1809, a contract was awarded for building the abutments and 1,000 perches of stone wall along the banks of the creek. A heavy flood in June washed away the bank at the site, when changes were made and the bridge was built and completed during the summer. It was suspended by chains as patented by James Finley, similar to the one on Jacob's Creek. It was thirty feet above the water, very long, and cost $1,660. It continued in use until Thursday, March 20 1820, when it fell with a crash under a heavy weight of snow and the added weight of a team and heavily loaded wagon.

At the same time that the bridge at Dunlap's Creek, at Brownsville, Fayette County, was being built, James Finley was superintending the erection of another bridge under his patent at the Falls of Schuylkill. In 1807 Robert Kennedy occupied a tavern at the Falls, and on April 9 of that year the General Assembly of Pennsylvania granted him the right for the use of water power on condition that he would build locks around the Falls for the accommodation of the "long boats" which came down from Reading. Kennedy failed to construct the locks, and in a year or two sold his water rights to Josiah White and Erskine Hazard, who built there a rolling mill and wire factory. Kennedy, with Conrad Carpenter, under an act passed on February 22, 1809, to build a bridge and levy tolls, built a chain bridge under the Finley patent, with two abutments and two piers, all of cut stone and three spans, two of which were 153 feet in length. Early in January, 1811, this bridge broke down under the weight of a large drove of cattle.

James Finley, in an article dated January 17, that year, said: "The break of the Schuylkill bridge by a drove of cattle is an occurrence which deserves attention. An ill-judged clip or coupling piece broke, with which two parts of the chain were joined together." The Schuylkill Falls Bridge Company was incorporated on April 2, 1811, with Kennedy, Carpenter, and others as members, and another chain bridge was built, which also gave way in 1816. After the destruction of the chain bridge White and Hazard, who built at the Falls of Schuylkill a wire factory, constructed a wire suspension bridge across the river for foot passengers only, and also provided that only eight persons should be on the bridge at one time. The suspension wires were fastened at one of the top windows of the mill and were stretched across the river to some large trees on the west side, from which steps descended to the ground. This was probably the first wire bridge in the United States, if not in the world.

A cotton factory was built at Rokeby, on the Brandywine, near Wilmington, Del., about 1809 or 1810. Mention is made of it in later years as "near the old wire bridge." No facts concerning the time it was built, or how long it lasted, are obtainable. It was, however, in all probability later than the White and Hazard bridge.



A Sand Blast Apparatus for Field Use.

The chain bridge built on the Brandywine in 1809 or 1810 was on or near the site of the wooden bridge built in 1762, which served its purpose until the completion of the chain bridge. The post road, which passed over the bridge, "was the main thoroughfare from the Eastern to the Southern States, crossed over the Brandywine on a hanging bridge, passed through the Borough of Wilmington, veered off to the west and southwest ranges of the northern banks of the Christiana, and continued toward the South." In 1806 a company was incorporated with a capital of $20,000 to build a stone bridge, but it was not done. In 1808 100 citizens of Brandywine and Christiana petitioned the Levy Court of New Castle County that the old bridge be repaired or a new one built. Commissioners were appointed, who reported in favor of a new bridge on May 2, 1809, and on the same day Commissioners were appointed to build one "on the plan of the bridge at Falls of Schuylkill River," with three chains, its width to be decided upon later. It was completed in 1810, at a cost of $4,000, and was in use until 1822, when it was swept away by a flood.

Chain bridges built at Cumberland and

Georgetown, Md., about this time were probably constructed under the patents of J. Templeman, of August 16, 1808, and March, 1810. This information is given by the index to the Patent Office records, for the papers themselves were destroyed by the fire of 1836, which wrecked the building where they were kept.

The Upper, or Callowhill Street, Ferry of Philadelphia, was opened in 1692, and used until about the time of the Revolution. A floating bridge was set up at the Ferry and destroyed by the heavy freshet of 1789. It was restored, and again destroyed in 1810. The cornerstone of a bridge was laid with Masonic ceremonies on April 28, 1812. The bridge was built on a novel plan by spanning the river with a single arch and discarding a center pier. It was destroyed by fire on September 1, 1838, and under the Free Bridge Act of 1839 the Commissioners contracted with Charles Ellet, Jr., to erect a wire suspension bridge of his own design, with a span from center to center of 358 feet. It was built and opened to the public on January 2, 1842, and was in use for more than 30 years.

Sand-Blast Apparatus for Cleaning Steel in the Field.

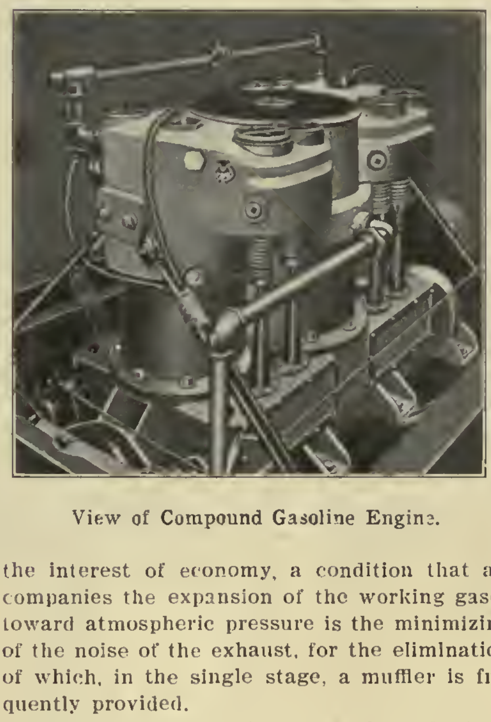
A simple sand-blast apparatus has been constructed and used by the United States Engineer Corps for removing rust and cleaning steel work exposed to fog and wet salt air in the batteries of the coast defences at San Francisco Harbor. It consists essentially of a 6x6x6-inch steam-driven air compressor, a receiving tank and a sand tank with mixing apparatus, pipes and nozzles. The compressor delivers into a common kitchen boiler 12 inches in diameter, which acts as a storage and receiving tank. From it a 1-inch pipe from 200 to 300 feet long delivers the air to the mixing apparatus, which is contained in another kitchen boiler, 20 inches in diameter and 60 inches high. In the lower part of the second boiler there is riveted a conical hopper, which forms a false bottom about 2 feet above the original bottom.

The bottom of the hopper terminates in a short vertical pipe, intersected by a 1¼-inch horizontal pipe, about 20 inches long, which is diametrical to the boiler and pierces both sides of it. This pipe serves as the barrel of the mixing valve and communicates with the sand hopper by a 1¾x¼-inch slot in the center of the upper side. One end of the pipe has a T connection to the air compressor pipe and the other end has a reducing coupling to the ½-inch flexible blast hose. The air end of the pipe is capped with a stuffing box, through which passes the valve stem, terminating in a hollow sleeve, which fits the pipe closely. The upper side of the sleeve has a slot corresponding to the slot in the pipe. When it registers with the latter the maximum amount of sand is delivered from the hopper through it to the center of the blast pipe and is there driven forward with the escaping air through the sand pipe and nozzle. The valve sleeve engages a stop when the slot is fully opened and can be pulled backwards to close as required.

The nozzles are made of hardened steel and are heavy to resist the wear, which is considerable. They are fitted with tips made of 3/16-inch tube steel about 1 inch long. They are hardened in nitrate of silver and wear to a diameter of ⅜-inch in from two to three hours. The apparatus works most satisfactorily under an air pressure of from 25 to 30 pounds and cleans sheet steel surfaces at a cost of four to five cents per square foot, much better than can be done at any price by hand labor. The machine cost about $400, including $265 for the compressor, and was designed and supplied by the Rix Engineering Company, San Francisco. It is described and illustrated in the report of Assistant Engineer J. H. G. Wolf, to Lieutenant Colonel Thomas H. Handbury, in charge of defences at San Francisco Harbor, and published in the 1903 annual report of the Chief of Engineers, U. S. A.

A Compound Gasoline Engine.

A compound gasoline engine has been developed by the Eisenhuth Horseless Vehicle Company, of Middletown, Conn. It employs three cylinders, two high-pressure and one low-pressure, and the principle on which the production of work is effected in two stages is the generation of power in the high pressure stage in the usual way and the utilization of the pressure of the exhaust or discharge from the high-pressure cylinder for further generation of work by expansion in the low-pressure stage. In short the engine is the result of an effort to utilize the pressure of the waste gas of combustion from the ordinary single-stage gas engine, which pressure is said to amount sometimes in regular practice to 60 to 80 pounds, particularly in automobile practice. The scheme of this utilization is to pass the exhaust from the first stage into a secondary cylinder where the gases can expand to a pressure approaching the atmospheric, driving a piston which is linked by connecting rod and crank to the shaft rotated by the high-pressure pistons and connections. While the distribution of work as outlined was sought for in the interest of economy, a condition that accompanies the expansion of the working gases toward atmospheric pressure is the minimizing of the noise of the exhaust, for the elimination of which, in the single stage, a muffler is frequently provided.



View of Compound Gasoline Engine.

The high-pressure cylinders work on the four-stroke cycle and their pistons and cranks travel together, but they are controlled to receive their respective charges of gas and air at alternate revolutions, one cylinder receiving its fresh charge while the other is on its explosion stroke. Thus the engine is arranged to develop an impulse from the high-pressure stage at every revolution. In the meantime, however, the discharge from the two explosion strokes in two successive revolutions has been expanded in the low-pressure cylinder. The crank of the low-pressure cylinder is 180 degrees behind the high-pressure cranks, and as the high-pressure pistons begin their return stroke, the low-pressure piston starts its forward stroke. During its return stroke the low-pressure piston discharges to the atmosphere, so that it is ready for its pressure charge at every forward stroke. In other words, at one forward stroke it takes the products of combustion from one of the high-pressure cylinders and at the next receives the gases from the other high-pressure cylinder, giving to the common shaft a forward driving force between the high-pressure impulses. By this arrangement the designers are able to say that with three cylinders they have an engine developing an impulse every half revolution.

The accompanying reproduction of a photograph is a view of a 60-horse-power engine built especially for automobile work. It is the result of five years of trials, during which it is stated that 23,000 miles, recorded by cyclometer, were covered, besides additional mileage, for which there was no cyclometer record. Each of the high-pressure cylinders has a 7¼-inch bore and a 6½-inch stroke, and the low-pressure cylinder a 12-inch bore and a 6½-inch stroke, indicating a cylinder ratio of 1 to 2.7. The low-pressure cylinder is located in the center between the high-pressure cylinders and the valves, which are of the lift, mushroom-head type, are disposed, as indicated in the engraving. On one side of each high-pressure cylinder is the gas intake valve and on the opposite side the high-pressure exhaust valve, next to a low-pressure admission valve in each case. Next to the gas intakes to the high-pressure cylinders are the low-pressure, or final exhaust valves. As to the performance of the engines, the following results are given of a test of a 12-horse-power compound gasoline motor. When the center cylinder was in use, 13 brake horse-power were developed, at 720 revolutions per minute, but when the center cylinder was disconnected, the brake horse-power at the same number of revolutions was 8.9, indicating a gain of 4.1 horse-power, or 46.2 per cent. to be credited to the use of the low-pressure cylinder.

The engine is controlled by a method of limiting the opening of the inlet valve, and it is stated that the engine can be run at any speed between 200 and 1,000 revolutions per minute. Water jackets are only provided with the high-pressure cylinders. The low-pressure cylinder has two methods of exhaust. One, the usual two-cycle engine port exhaust, is opened automatically by the action of the piston when it reaches the lowest point of its stroke, and the other double exhaust valve, which is opened at the extreme top of the cylinder. The latter allows the gas to pass out as the piston moves upward, closing when it reaches the upward end of the stroke. The low-pressure piston, by its extra weight and number of impulses, is designed to balance the two explosion pistons.

Letters to the Editor.

Cast-Iron Columns.

Sir:—In the course of the discussion of the merits of cast-iron columns, which has recently been revived in connection with the Darlington disaster, it has been stated that recent experiments have shown that the formulas in general use are entirely too favorable to this material. Will you kindly cite the experiments referred to, and indicate where the data relating to them are obtainable?

In this connection I have made some comparisons of results obtained by using the accepted formulas, taking three cases which cover a wide range. The formulas used were:—

1st. The original Gordon formulas, viz.,

$$f = \frac{80,000}{1 + \frac{L^2}{600\ d^2}}$$

2nd. The formula given in the Carnegie Handbook,

$$f = \frac{80,000}{1 + \frac{L^2}{800\ d^2}}$$

These formulas give the ultimate stress and a factor of safety of five was used in obtaining the safe stress.

3rd. The New York Building Department formula,

$$f = 11,300 - 30 \frac{L}{r} \text{ (safe stress)}$$

The three cases assumed were:—Case 1, a column 6 inches in diameter by ¾ inch—10 feet long; case 2, a column 8 inches in diameter by 1 inch—12 feet 6 inches long; case 3, a column 12 inches in diameter by 1½ inches—15 feet long.

The following are the tabulated results:

	Case 1	Case 2	Case 3
Formula No. 1	9,600	10,089	11,636
Formula No. 2	10,667	11,115	12,488
Formula No. 3	7,700	9,500	9,960

or, in other words, the Building Department formulas give results averaging about 90 per cent. of those given by the original Gordon formulas and about 82 per cent. of those given by the Carnegie-Gordon formulas.

These results were somewhat surprising to the writer, and led him to apply the accepted formulas to a steel column case, with the following results:

A column composed of two 12-inch, 20½-pound channels, latticed; $r = 4.61$ in., $L = 38$ feet. 5 inches, $L \div r = 100$.

1st. By the Carnegie-Gordon formula,

$$f = \frac{50,000}{1 + \frac{L^2}{36,000\ r^2}},\quad f \text{ (ultimate)} = 39,130,\quad f \text{ (safe, factor 4)} = 9782$$

2nd. By Carnegie straight line formula,

$$f = 17,100 - \frac{57\,L}{r},\ f = 11,400$$

3rd. By Building Department formula,

$$f = 15,200 - \frac{58\,L}{r},\ f = 9100$$

The result given by the Gordon formula is 4 per cent. higher than that given by the Building Department formula, and that by the Carnegie formula 21 per cent. higher.

These results show that the Building Department formulas are much more conservative than others sanctioned by good practice.

It has become customary to specify a bending test for cast-iron column material, which requires an ultimate strength far in excess of that given by the best authorities. The test usually required is that bars 1x1 inch in section and supported at points 4 feet 8 inches apart, shall sustain a central load of 500 pounds before breaking. This necessitates an ultimate tensile strength of 21,990 pounds, and an ultimate compressive strength of 109,950 pounds. The Building Department is not quite so severe and requires an ultimate tensile strength of 19,090 and an ultimate compressive strength of 95,450 pounds. The first test has been frequently employed in this city, and the writer has seen a number of bars sustain a load as high as 560 pounds before breaking, and the average of a series of experiments was 520 pounds, showing that the ultimate compressive strength of the material was about 114,000 pounds, and that columns designed by the Building Department formulas would have a factor of safety of 10. This should surely be enough to cover inherent imperfections. It would seem that we need more light.

Very respectfully, William M. Farrar.

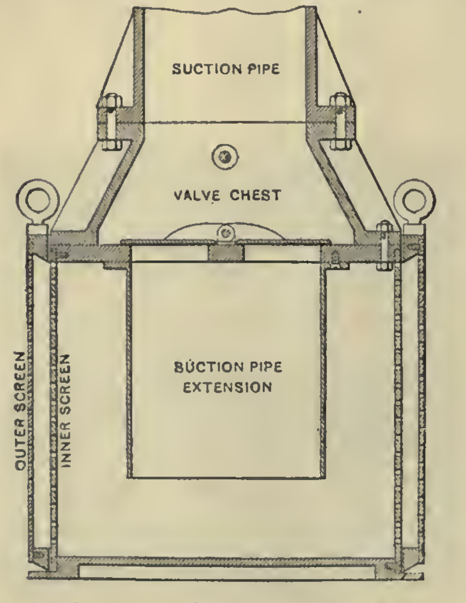
New York, April 11.

[The tests made at the Watertown Arsenal and at the works of the Phoenix Bridge Company for the New York Building Department are the most comprehensive that have been made. Data concerning them can doubtless be obtained from the Department.]

Superheated Steam.

Sir:—In regard to your editorial on the subject of economy, due to use of superheated steam, which appeared in The Engineering Record dated January 2, 1904, we beg to say that the comparative results that Prof. Jacobus obtained at the test of the Millbourne Mills engine, indicated a net saving of 19 per cent. in coal. This, it cannot be denied, should be regarded as a very satisfactory saving. In your estimate of the probable coal saving resulting from the use of steam with 150 degrees of superheat, you are in error in assuming that the superheat at the Millbourne Mills was 443 degrees at the throttle. The superheat at the entrance to the receiver of the engine above referred to was 374 degrees, not 443 degrees, and the superheat of the steam entering the high-pressure cylinder, 300 degrees. The superheat of the steam entering the low-pressure cylinder was about 145 degrees. Substituting these figures in your calculations, the resulting saving due to the use of steam with 150 degrees superheat at the throttle of high-pressure cylinder, and 72 degrees superheat at the inlet of the low-pressure cylinder would be 8 per cent.

As offsetting this saving, we note your remarks with regard to depreciation, increased cost of maintenance, and extra first cost of installation. In reply to which we would say that our experience indicates that the saving of first cost in boiler installation, due to the decreased amount of evaporative capacity required, nearly offsets the extra cost of superheater. The reduction in the amount of coal to be handled reduces the labor required for operation. There is little if any increase in the cost of an engine to use superheated steam over that of an engine to use saturated steam, and as for the pipe line requirement to carry the superheat, modern practice has given so much experience in regard to this that there need be no fear as to the reliability of joints, valves, insulations, etc. In many cases where coal costs $3 per ton or more, the saving in coal has completely covered whatever extra cost there was due to the installation of a superheating form of apparatus in less than one year.



A Continuous Service Suction Pipe Strainer.

In the editorial referred to, further comparison is made with a test published in The Engineering Record of November 8, 1902, of an engine at the Atlantic Mills, which showed a total steam consumption of 1.21 pounds of coal per indicated horse-power per hour. We cannot agree with you that it is fair to present to the ordinary layman such a result in comparison with the results obtained at the Millbourne Mills, without further explanation of the differences in the form of apparatus installed at each plant. An examination of the report of test at the Atlantic Mills will show that there was superheat of about 41 degrees in the steam at its entrance to the high-pressure cylinder. Allowance for this would probably bring the coal consumption at the Atlantic Mills up to 1.24 pounds. A further allowance should be made for the difference in pressure of 170 pounds at the Atlantic Mills, as against 140 pounds at the Millbourne Mills. Allowance for which would probably increase the coal consumption about 3 per cent. At the Atlantic Mills there was a vacuum of 28 inches, as against 26 inches at the Millbourne Mills, which would account for a probable difference of 2½ per cent. more. The principal difference, however, between the two installations lies in the difference in evaporation between boilers, due to the fact that feed-water heaters and economizers were used at the Atlantic Mills, while none were used at the Millbourne Mills. The allowance to be made for the difference in this respect between the two plants amounts to about 16 per cent. Allowing then for the gain in the Atlantic Mills test, due to increased steam pressure, difference in vacuum and difference in evaporation at the boilers, we get a total difference of 21½ per cent. in coal consumption, and on this basis the Millbourne Mills engine would show a coal consumption of 0.987 pounds per indicated horse-power per hour (which is a coal consumption, we believe, could be obtained in a carefully designed installation). This shows a saving in coal of 21 per cent. over an installation of the best type using saturated steam. An allowance should be made for the steam and exhaust of the vacuum pump for the condenser, but experience has shown this should not be more than 2 per cent. It consequently follows that the saving really shown at the Millbourne Mills amounts to about 20 per cent. in coal over the best known records. We think that if the matter, as presented in your editorial of January 2, was shown in this, the true light, a far better idea of the advantages due to the use of superheated steam, would be the result.

Yours truly, Providence Engineering Works.

Providence, April 6.

A Continuous-Service Foot-Valve Screen.

Most men who run pumps know by experience the annoyance caused by having twigs, paper and other unwelcome substances enter the suction pipe and find their way into the pump valves. A number of devices are in use intended to prevent these troubles. A particularly efficient device is shown by the accompanying cut. It consists essentially of two concentric cylindrical screens surrounding the extension to the suction pipe below the foot valve, as indicated. The inner screen is rigidly fastened to the diaphragm containing the valve so as to be flush with the flange at its top, and at its bottom is fastened to a blank flange in the manner indicated, the flange extending beyond the screen so as to form a seat for the outer screen. The outer screen is attached at top and bottom to two rings of metal which hold it at a fixed distance from the inner screen. Two lifting eyes are attached to the top of the upper ring at diametrically opposite points.

Excepting for valves of the largest size, one man can attend to the cleaning of the screen in a few minutes. The lower edge of the bottom ring carrying the outer screen is beveled, as shown, and as the screen is lowered into position this edge acts as a scraper to clear the inner screen. It will be seen that in consequence of this arrangement the pump can be run continuously without exposing the entrance to the suction pipe at any time. All the water enters through the vertical sides of the screen and so the apparatus can be set close to or upon the bottom of the pump well, pond or other body of water from which the pump is drawing. The device is made by the Newman Manufacturing Company, of 26 Cortlandt Street, New York, which also builds a special form of foot valve and screens for underwriter pumps.

O. F. Nichols.

The chief engineer of the Department of Bridges of New York City, was born in Newport, R. I., in 1845, and, like his classmate, Lefferts L. Buck, had some preliminary shop experience before entering the famous class of 1868 of the Rensselaer Polytechnic Institute. It has often been claimed that a considerable part of the value of collegiate training is to be found in the association together of students from many sections, all working for the same purpose, and it is not difficult to appreciate the force of this argument when such a class is considered, containing, in addition to Messrs. Nichols and Buck, engineers now so well known as Messrs. Thomas Appleton, V. G. Bogue, R. E. Briggs, M. T. Endicott, and A. V. Powell. Moreover, in the class before were Messrs. S. J. Fields, F. J. Hearne, G. B. Mallory, and F. H. Saylor, while in the following class were Henry Burden, Robert Forsyth, and Theodore Voorhees. It is only by looking backward in this way at the classes of a technical school that the full significance of the value of student life is appreciated, and it is possible to appreciate how much good may result from mere attendance at a high grade institution of this character.

Immediately after graduating in 1868, Mr. Nichols joined the engineering corps engaged on the work of laying out and constructing Prospect Park in Brooklyn. This corps was one of the most remarkable ever organized, on account of the number of men in it who subsequently attained a high position in the engineering profession. Messrs. John Bogart, C. C. Martin, Rudolph Hering, V. G. Bogue, and James Owen were among Mr. Nichols' associates on this work. Later he became connected with the engineering staff engaged on the elevated railway on Greenwich street, New York, which was being managed by Charles T. Harvey. The system of construction was covered by patents, and for this reason the line was sometimes known as the West Side patented elevated railroad. The experience on this early railway construction is of some interest because at a later period in Mr. Nichols' career he again engaged in similar work in positions of the highest responsibility. After his connection with the Greenwich line was finished he became an assistant engineer to Mr. Edward Cooper, in New York, who was in charge of the business interests in that city of the New Jersey Steel & Iron Company, of Trenton.

From December, 1871, to 1875, Mr. Nichols was engaged in railway work in Peru. His classmate, V. G. Bogue, had been in Peru for about two years, at first as engineer for a Peruvian company and later in the employ of Henry Meiggs; in the summer of 1870 he was appointed assistant engineer on the Callao, Lima & Oroya Railroad, and spent a year on location and construction. He was then appointed division engineer, and was instrumental in bringing to Peru a number of American engineers. Among those who came over to take part in the work on this famous line was Mr. Nichols. He was placed in charge of several sections, forming what was known as the tunnel division, and was in charge of some very difficult construction, particularly the Cuesta Blanca tunnel. Later he was appointed a division engineer on location and construction, and his classmate, Mr. L. L. Buck, about the same time took charge of the construction of the famous Verrugas viaduct. About 1873 Mr. Nichols was appointed division engineer on the Chimbote & Huaraz Railroad, and remained on this work until he returned to the United States, about the beginning of 1876.

On his return to the United States he was appointed assistant superintendent for the Edge Moor Bridge Works on the construction of the Metropolitan Elevated Railway in New York. The Edge Moor company had undertaken to build a road from Rector Street to Forty-second Street in a few months' time, but damage suits and other litigation prevented the execution of the contract, and eventually the section was split into three contracts, of which the Edge Moor Bridge Works received one. In 1877, Mr. Nichols was assistant engineer and general inspector for the New York Park Department on the Brook Avenue sewer, in what is now the Borough of the Bronx.

About this time one of the most interesting railway undertakings in South America was reaching a head. More than half of Bolivia lies in the basin of the Amazon River, and this low district has long been famous for its rubber. The development of this territory had been proposed many times, but it was not until 1869 that any definite plan for the work was formulated. Late in that year Col. G. E. Church received a concession from Bolivia, under which the National Bolivian Navigation Company was incorporated. The following year he obtained from Brazil a concession authorizing the organization of the Madeira & Mamoré Railroad Company. The latter company was incorporated in London, but was practically a branch of the navigation company whose stockholders were all Americans. In 1877, a contract was made between these two companies and Messrs. P. & P. Collins, of Philadelphia, for the survey and construction of the railroad for the sum of £5,900 per mile. Mr. Nichols was appointed resident engineer of the railroad company, and sailed for San Antonio on the Rio Madeira River about the beginning of 1877. The purpose of this project was to construct a railroad around the falls of the Rio Madeira, which are practically the only serious obstacle to the commercial development of the rich half of Bolivia that lies east of the Andes. About sixty engineers, representing the best professional experience of eastern Pennsylvania, were sent to take part in this work by Messrs. Collins. Nearly 70 miles of the line were carefully surveyed and a location was made along this portion of the route. About 60 miles more had been covered by a preliminary reconnaissance before the undertaking collapsed. As soon as the first vouchers arrived in England, suit was brought to prevent their payment, and for many years litigation ensued. The contractors received practically nothing and the engineers engaged on this enterprise had a most unfortunate experience before they finally returned to the United States. A very interesting and complete history of the undertaking is being published for private circulation at the present time, but a good idea of it can be obtained from an article contributed to "Railroad Gazette" of January 1 of this year by Mr. Nichols. Attention is particularly called to this article because it will prove of interest to many engineers looking forward to a possible engagement on the Panama Canal construction.

O. F. Nichols.

Mr. Nichols was engaged in Europe for some time in connection with the litigation over this unfortunate railway project. On his return in 1879 he became an assistant engineer with the New Jersey Steel & Iron Company, and remained with the company until the fall of 1881, when he became assistant superintendent of the Peter Cooper glue factory in Long Island City, where he remained about a year. From 1882 until the middle of 1885 he was resident engineer of the important bridge at Henderson, Kentucky, and after it was completed he became chief engineer of the water-works of Westerly, Rhode Island, then under construction.

In 1886 Mr. Nichols was appointed principal assistant engineer to Mr. J. J. R. Croes, at that time chief engineer of the Suburban Rapid Transit Railroad Company, of New York. That company constructed an elevated railway in what is now the Borough of the Bronx, and introduced a number of important features of design. The work attracted considerable attention, and Mr. Nichols' connection with it led to his appointment in 1888 as chief engineer of the Brooklyn Elevated Railroad. In this line he introduced a number of new types of construction, which were explained a few years ago in a discussion on elevated railway design at a meeting of the American Society of Civil Engineers. Another undertaking of his, for the purpose of eliminating some unnecessary grades, was described in a paper by him before the same society, and is particularly instructive for the full explanation it gives of a method of shifting elevated tracks without interfering with train movements. Mr. Nichols remained with the company until 1896 as its chief engineer, and during the latter portion of his connection with it he also acted as general manager, a position of great responsibility, on account of the need of operating the road at the absolute minimum of expense consistent with safety.

In 1896, Mr. Nichols was appointed principal assistant engineer of the Williamsburg Bridge in New York and was afterward made engineer of that structure. He remained in charge of the work—which has been described in so many articles in this journal that further reference to it is unnecessary—until last summer. Early in January of this year he was appointed chief engineer of the bridge department of the city, and, as such, is in charge of all of the bridge engineering work throughout Greater New York, except such as falls to the Department of Parks.

Mr. Nichols joined the American Society of Civil Engineers in 1876, and served on its board of direction in 1892 and 1893. He joined the American Society of Mechanical Engineers in 1896. He has been a member of the Institution of Civil Engineers for twelve years and received a Telford premium for a paper contributed to its proceedings.

Book Notes.

Many people have expressed of late a desire to have a general description of American and foreign work in reinforced concrete construction. A great number of bridges, buildings, conduits and other structures have been built on many different systems, as the readers of this journal have been informed by the many articles on the subject in its columns. A review of the whole field, exclusive of its mathematical side, has been written by Mr. L. J. Mensch, a specialist in concrete-steel work, and published under the title "Reinforced Concrete Constructions," by Cement & Engineering News, 162 La Salle Street, Chicago. It describes in a general way the applications of this system of construction to many notable bridges and buildings as well as minor purposes, and it is particularly interesting to learn how widespread is the use of concrete-steel. As a mildly technical explanation of such work, free from the mathematical vagaries of many enthusiasts on the subject, the little book will undoubtedly prove useful to many engineers and architects. It is sold at $2, and is profusely illustrated.

The latest number of Van Nostrand's Science Series is a discussion by Dr. Sanford A. Moss, of "The Layout of Corliss Valve Gears." The great present demand on this and kindred subjects is for something practical as well as comprehensive. This little manual fully meets the demands on this particular topic. It is published at fifty cents by the D. Van Nostrand Company, New York.

So many inquiries have been received lately concerning the work of the Isthmian Canal Commission, which was recently succeeded by the commission now at the Isthmus, that it seems desirable to mention the older board's report. It was printed as Senate Document 54, 57th Congress, first session. The volume contains the full report of the Commission, 263 pages long, 533 pages of appendices and a 10-page report recommending the selection of the Panama route after the New Panama Canal Company had offered to sell all its rights, property and unfinished work for $40,000,000. The report itself is already familiar to the readers of this journal. The appendices are of great value. Among them are a history of the Universal Interoceanic Canal Company, the de Lesseps enterprise; a report on the hydrography of the Panama route, by Mr. A. P. Davis; a number of treaties between France, New Grenada, Colombia and Spain; contracts between Nicaragua, Colombia and various corporations; and an elaborate monograph on the industrial and commercial values of the canal, by Prof. Emory R. Johnson, one of the commissioners. The volume contains a number of illustrations, but unfortunately none of the maps and drawings essential to a thorough study of the report. The most important of these omitted illustrations have been published in The Engineering Record, so that with a file of this journal at his command, the reader will have little difficulty in comprehending everything in the documents.

The "Proceedings" of the sixth annual meeting of the American Society for Testing Materials have just appeared in a well-printed and illustrated volume of 490 pages. It is several months late, owing to the destruction of the plates by fire just before the book was ready to go to press, but beyond the delay there seems to have been no other detrimental result which can be attributed to the incident. In its report of the meetings which are covered by this volume, The Engineering Record pointed out the great value of the papers and discussions to all engineers and architects interested in the manufacture and use of structural materials of any class. Now that the full text of many of the papers can be examined more carefully than was possible at the time of their presentation, this opinion is much strengthened, and it seems beyond dispute that the Society is one which is doing a great work in a manner both businesslike and scientific. This volume of "Proceedings" is sold at three dollars by the secretary, Prof. Edgar Marburg, University of Pennsylvania, Philadelphia, and every reader desirous of obtaining an acquaintance with the latest thought in the broad field of engineering materials is advised to secure a copy, and also to join the Society.

Compendium of Drawing. Compiled from the Instruction Papers in the Architectural, Mechanical Engineering and Sheet Metal Pattern Drafting Courses of the American School of Correspondence. Chicago, American School of Correspondence, two volumes, cloth, 9½x6¼ inches, 477 and 410 pages, many illustrations; $3 per volume, $5 per set.

In these two volumes are 7 of the 45 regular instruction papers in the architectural course and 5 of the 44 in the mechanical engineering and sheet metal pattern drafting courses of the American School of Correspondence at the Armour Institute of Technology. The chief aim of the books is to acquaint the public with the standard, scope and practical value of the various instruction papers by means of a personal examination of a few of them. It should be stated at once, however, that these two volumes form one of the most thorough and practical expositions of mechanical drawing that have yet been published. No one can examine them even hastily without being impressed by the fact that the course has been planned by experienced teachers who have also a practical knowledge of what is wanted in the best drafting rooms to-day.

The volume on mechanical drafting opens with a general article on working drawings, by Mr. C. L. Griffin, mechanical engineer of the Semet-Solvay Company. It explains what is wanted for clearness and completeness on such drawings, and gives directions for doing the work expeditiously and neatly. Then follows an unusually clear discussion of mechanism, by Mr. Walter H. James, of the Massachusetts Institute of Technology. It shows how to lay out the parts of machines so they will move in any desired manner and contains a large number of problems which will be of material aid in fixing in mind the various rules for such work. The third chapter is on machine drawing and explains the actual methods employed by the draftsman on such work. The fourth chapter is a remarkably good general explanation of the various stages through which a design passes in the drafting room before it is embodied in the final set of drawings. The fifth chapter is a detailed explanation of the many different methods that may be followed in preparing shop drawings, and is full of facts that every draftsman should know, but a good many do not. The remaining chapters, by Mr. William Neubecker, of the New York Trade School, cover in a satisfactory manner the special drafting required to prepare sheet metal patterns.

The volume on architectural drafting contains papers by Messrs. Ervin Kenison, Harry W. Gardner, William H. Lawrence and D. A. Gregg, of the Massachusetts Institute of Technology, and Mr. Frank C. Brown, of Boston. It opens with a chapter on the selection and care of instruments, which is followed by one on elementary exercises in their use. The third chapter is devoted to orthographic and isometric projections. Perspective drawing is next taken up in a manner easy to comprehend and the method of preparing perspective drawings of buildings is shown in all its stages. The fifth chapter is on the always interesting subject of rendering in pen and ink, and is illustrated by many well selected sketches. The final chapter is a very interesting and tastefully illustrated paper on architectural lettering. The suggestions are all based on legibility as well as good general effect, and, if adopted, will prevent the deplorable titles of grotesque letters with which some architects disfigure their drawings.

In both books, it is apparent that care has been exercised to give instruction which the average correspondence student can comprehend readily. It has been borne in mind that such a student cannot rely on the personal assistance to be gained in the class room, and the instruction papers are correspondingly complete and clear.

Briquettes and Patent Fuel. Their manufacture and machinery connected therewith. By Philip R. Björling. London, Rebman, Ltd.; cloth, 10x6 ins., 254 pages, 121 illustrations, $3.

The rapidly increasing interest in compressed fuel renders this book a timely one. About eight years ago the author contributed articles on the subject to the "Colliery Guardian" and "The Mineral Industry," and this volume contains both series of papers, with many additions. The washing, drying and crushing of the fuel is first explained, and then many types of briquette machinery are described. The most valuable section of the book gives an explanation of the great variety of bonding materials that have been tried. It is this feature of patent fuel which has been the cause of most of the failures to secure good results, and the great amount of detailed data given by the author will be of particular service to the engineer making an investigation of the subject. The volume closes with a discussion of the financial aspect of the briquette business and the calorific value of artificial fuels of this type.

The Relative Volume of Ashes and Coal—a figure of value in calculating the spaces required for storage in power-plant design—is 1 to 3.76 in the power station of the Brooklyn Rapid Transit Company, at the Brooklyn Bridge, where No. 3 buckwheat coal is burned. This plant is employed to a large extent to drive the cables for hauling trains across the bridge, and an average of 60 tons are consumed daily. The ashes, which contain 14 per cent. of combustible matter in them, amount in a day to 26 cubic yards. As the coal occupies 44 cubic feet per ton, it will be found that the ashes amount to 26.5 per cent. of the volume of the coal. Assuming the ashes to weigh 1,000 pounds per cubic yard, the ratio of the weight of the ashes to the weight of the coal passed through the station in a day is 1 to 4.6.

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Steel-Concrete Construction.

At the present time there is unquestionably more experimental work being done in concrete-steel investigations in the Central States than elsewhere in the country, and it is not at all surprising that the Western Society of Engineers is now discussing the subject. At the last meeting of this body two very important papers were presented, one by Professor W. K. Hatt and the other by Professor Malverd A. Howe. Both gave the results of experimental work on beams of large size, conducted in a careful manner and in accordance with a well-laid program. It is in work of this nature that the most valuable engineering data must be sought, and these two papers indicate not only what good work their authors are doing, but also the importance of many more investigations of this character.

Since the Committee on Masonry of the American Railway Engineering and Maintenance of Way Association recommended provisionally the methods of computing concrete-steel structures which were suggested by Professor W. K. Hatt in his paper before the American Society for Testing Materials in 1902 renewed interest has been shown in his work. It is therefore gratifying to learn from his recent paper before the Chicago organization that his later tests, which are not yet finished, show that this method of computation is confirmed by the full-size tests now being made. His work further confirms that of Considère in certain respects; for example, the deflection of reinforced concrete beams before cracking is about ten times that of a beam without reinforcement, and the strength of a beam reinforced with steel rods whose cross-section constitutes two per cent. of the total section of the beam is from four to five times that of a plain concrete beam.

These tests are being made as a rule with good arch-ring concrete mixed 1:2:4, with broken stone, although some of the experiments have been conducted with 1:3:6 concrete, and in a few cases the beams have been made with 1:5 gravel concrete. As a rule, however, the proportions first mentioned are employed, as the purpose of the tests is to show the utility of the theory for really good construction, which implies rich concrete for beams. In such beams the first visible indication of failure has been a tension crack in the concrete at the center of the span, not due to any slipping of the plain bars employed for reinforcement. With the lean concrete, mixed 1:3:6, failure has been due to the slipping of the bars in the concrete near the ends of the beams, which was naturally accompanied by cracks running diagonally upward from the supports toward the point of application of the load, which was always at the center of the beam. The value of some form of bond or stirrup in such cases is evident. After the formation of the first crack in tension it spreads upward, and the tensional strength of the steel and compressive strength of the concrete are brought into play. The character of the steel used for the reinforcement is found to affect the results very materially.

An interesting fact mentioned by Professor Hatt respecting the behavior of concrete-steel beams under flexure is that there is a point at somewhere between a half and a third of the maximum strength of the beam up to which the ratio of the load and deflection remains nearly constant. The stress-strain diagram then changes its shape until the appearance of the first visible crack. It is this crack, and the load producing it, which Professor Hatt advises using in applying factors of safety during computation. His experiments up to the present time indicate that his theory, which was explained in The Engineering Record of June 28, 1902, is sufficiently elastic to predict the first point of change in the stress-strain diagram and the first visible crack of a reinforced concrete beam of really first-class construction. Future experiments are to show how well the theory is in accord with tests in the case of lean concrete.

Professor Howe's tests have been made with beams reinforced by Johnson corrugated bars, and their primary purpose was to determine the strength of full-size beams built by regular concrete workers; it was also decided somewhat later in the investigation to measure the deflections and the movement of the neutral axis. The data of these experiments are given quite fully in the paper, but their main value to most engineers is their proof of the practical utility of the formula for computing the strength of concrete-steel beams which was brought out by Mr. A. L. Johnson several years ago and is fully explained in the publications of the company in which he is interested.

The two papers will rank very high in the literature of the subject for years to come, not only on account of their actual merit as contributions on a branch of engineering which will long remain the subject of discussion, but also because they indicate clearly the character of the experimental studies which must be made in great number before concrete-steel design will be placed on a really satisfactory basis.

Covering the Poughkeepsie Filters.

Ever since the first filter was built in 1872 to purify the water supply of Poughkeepsie, engineers have manifested a great deal of interest in the operation of those works. The plant was designed in a most creditable manner for the time, although it has a number of features which are now out of date. The original filter was supplemented about eight years ago by another, reducing the rate of operation to a figure corresponding with the best practice in Europe. A number of filters have recently been placed in operation, and considerable curiosity has lately been shown among those acquainted with the plant concerning the opinion which the manager would hold regarding it after he became well acquainted with the results obtained elsewhere, by recent works. A few days ago Mr. George E. Fowler, superintendent of the water department, submitted a report recommending a number of changes and giving some information regarding the plant which is of general value.

For some time there has been a leakage through the walls of the filters, permitting some of the unfiltered water above the sand beds to enter the clear-water basin. This has been slight in amount, but is nevertheless a condition which demands remedy. From time to time the water has also been in such a condition that it could not be treated satisfactorily on account of the sediment it contained, for there are no settling basins connected with the works. Mr. Fowler believes that unaided sand filtration will not accomplish the purification of the Hudson River water at Poughkeepsie at all times, as when it is heavily charged with clay, as occurred during the winter of 1901-2. He does not suggest the introduction of a sedimentation basin, but believes that ultimately it may prove desirable to provide for adding a coagulant at certain seasons.

The most interesting feature of his report is that which states definitely the necessity of covering the filters. For many years a small number of engineers have pointed to the Poughkeepsie works as a practical demonstration that roofs are unnecessary in a locality having similar weather conditions. Mr. Fowler states that covers are certainly needed. He says that it is impossible to maintain the filters in their present exposed condition in their highest efficiency, during either winter or the hottest portions of summer. The past winter has been the most difficult for the last twenty-three years, as respects its effect on the management of the works. In spite of the extreme cold, the management was more successful than ever before in dealing with frozen sand, after they were able to get at it. The trouble was in reaching it through the thick ice on the surface of the water. The filter surfaces have been in better condition throughout the winter than would have been considered possible. Nevertheless, it has been impossible to operate the works at their normal efficiency, and the degree of bacterial removal since the beginning of the year has been under 90 per cent., a record which is entirely too low for safety.

At the present time the leakage between the filters and the clear-water basin involves an unnecessary expense for pumping, which is estimated at about $900. The cost of removing snow and ice between January 1 and March 21 of this year has been $2,853, an extraordinary expenditure, that may not be necessary again for many years. The average during the last three years was $842. It is also estimated that two cleanings of the sand per year at a total cost of $150 and the services of a laborer at $520 would be unnecessary were the filters covered. In round numbers the covering would reduce the expense of operation about $2,412. The expense of lining the filters and constructing a roof of concrete over them has been estimated by a firm of conractors making a specialty of concrete construction at $33,468. In addition to this expenditure the work would require $12,000 more for removing and replacing the filtering material and repairing the clear-water basin. All told, about $45,000 will be needed to place the works in a satisfactory condition. The interest on this sum at 4 per cent. is $1,800 per annum, a sum considerably less than the annual saving which the work would make possible. The report does not state whether these estimates make any provision for the introduction of regulating devices and other modern improvements for a careful control of the purification process. They indicate, however, that in the opinion of Mr. Fowler, whose expert management of the plant for many years has been frequently mentioned in technical papers, the open filter must be considered a back number in climates like that of Poughkeepsie.

The importance of this report can only be appreciated by those who have been in close touch with the opinions regarding water purification expressed in many parts of the country. The lack of covers on the filters at Poughkeepsie and Lawrence has been so often employed as an argument of a practical nature against the modern construction of such works recommended by specialists, that Mr. Fowler's statement of the money value of roofing, based on long experience, is most welcome.

The Lateral Pressure of Granular Materials.

The lateral pressure of granular materials, particularly earth and grain, has been attracting much attention of late, and the manner in which the subject is handled in the United States and Canada, as compared with the treatment on the other side of the Atlantic, is characteristic of the difference in the methods of conducting enginering work. The technical literature of France, and that of Germany even more so, is replete with articles on these pressures, but probably four-fifth of them are wholly mathematical in their nature. Most engineers of a studious frame of mind have examined at one time or another the numerous volumes which make up the Weisbach handbook of engineering, a series of volumes which, in its latest revised form, is more of an encyclopedia than a handbook. In the second of these books there is a voluminous discussion of the theory of earth pressures, which is typical of the treatment of the subject usually given in Europe. The pressures exerted by earth are determined partly by analytical methods and partly by the use of most intricate diagrams. One in particular, which is used early in the discussion to determine the general laws of earth pressures, is a most complicated mass of big circles, little circles, tangents and chords, seasoned with a few ellipses and decorated with letters from both ancient and modern alphabets. It is really something of a strain on the customary belief in the direct and simple methods by which Nature works, to assume that when an earth bank gets ready to slide any such complicated system of forces comes into action as such a diagram presents.

In the opinion of The Engineering Record there has never been any analysis of the lateral pressures of granular materials which excels in clearness and practicability that of Rankine. It is based on certain assumptions, but so is every other mathematical treatment of the subject, and every one of these analytical treatments is of no practical value until it is supplemented with certain data obtained experimentally. On this account, without in any way reflecting on the utility of mathematical investigations, it has long seemed strange to many practicing engineers that the subject was not investigated on a wholly experimental basis. The design of steel work columns is now generally based on a straight-line formula deduced from the results of experiments, and the same is true of the design of cast-iron columns. The thrust of earth or grain against the walls holding it in place presents problems of computation which have the same class of difficulties as those connected with struts, and it is high time that empirical formulas were used for these pressures. Very likely one reason they have not been employed long before is because it is much easier to work out an analytical method by making assumptions to get over all the difficult places, than it is to conduct a series of careful experiments.

Fortunately some very valuable experiments have been made lately in Canada by Mr. J. A. Jamieson, and in the United States by Mr. E. P. Goodrich. Mr. Jamieson's investigations were made with grain and have been recently described in a paper read before the Canadian Society of Civil Engineers. Mr. Goodrich's investigations were made with earth and were described in a paper read before the American Society of Civil Engineers on Wednesday of this week. As both these papers can be procured from the secretaries of the respective societies, it is unnecessary to print an abstract of them in this journal. It might be pointed out, however, that Mr. Jamieson concludes from his experiments that the intensity of both the vertical and the lateral pressure produced by grain is entirely dependent on four factors; 1, The coefficient of friction between the grain and the walls of the bin; 2, the ratio of the breadth or diameter of the bin to the depth; 3, the ratio of the horizontal area of the column of grain to the area of the walls of the bin; 4, the angle of repose of the grain, or, what is the same thing, the ratio of the lateral to the vertical pressures. Mr. Goodrich finds, from his experiments, that in many cases the resultant of the lateral pressures on a plane should be applied at a point four-tenths of its height above the bottom; angles of internal friction and not of surface slope should be used in all formulas which involve the sliding of earth over earth.

The most valuable feature of the experiments of Mr. Goodrich are those which demonstrate beyond question that investigations of this nature, to be of practical value, must be on models of large size. In the loading of earth, a cone of compressed material forms under the point where the load is applied and an arch action arises which exerts a seriously disturbing influence in experiments on a small scale. His experiments show the following facts of practical value: 1, With some moist earths, a heavy load will induce in the material a possible development of excessive lateral thrusts under subsequent repetition of relatively smaller loads. 2, When dealing with quicksand, the problem is to confine the water which it contains and account need be taken only of pure hydrostatic pressures. 3, The lateral thrust of new fills against retaining walls decreases with time and repeated aplications of the load. 4, Neither saturated nor loose dry materials are liable to exert the greatest lateral thrust, and, with slight saturation and rather moist condition the lateral thrust is liable to be relatively small. 5, When dealing with clay, the problem is to remove the water which it contains and guard against the creeping of the material under excessive loads.

The curves which show the results of Mr. Goodrich's investigations will be found in his paper and a discussion of them in this place is unnecesary. Valuable as the paper is, the data are far too few to furnish a wholly satisfactory understanding of this important subject. A great deal of experimental work must be done with different materials in a painstaking and scientific manner before the engineer is in possession of sufficient information for him to feel confident that the pressures which he assumes in his calculations are really those which are the greatest that can occur. Fortunately, the main value of Mr. Goodrich's paper lies in the clear description he gives of his methods of experiment and of the steps in the work which are most likely to cause error. His assertion that the results of different experimenters did not vary more than ten per cent. from all sources of error inclusive, is most gratifying. When engineers are able to compute the maximum lateral pressure on a retaining wall within ten per cent. of its correct amount, they will be far within the limits necessary for practical purposes. At the present time it makes no difference in the condition of our knowledge of this subject whether the lateral thrust in dry materials, differing only in size of particle, varies as the ordinates to a lituus or any other curve. The experimental data are too few to make it worth while paying much attention to such a refinement. It is enough to know that there is a variation, and what we most desire are results of a great many more experiments showing more completely the variations in question with all classes of material with different degrees of moisture in them. Such experiments are not particularly difficult to carry on and it might be well for the heads of engineering departments in our technical schools to direct the attention of members of their graduating classes to them.

Notes and Comments.

Water Purification at St. Louis has recently been very difficult on account of the amount of silt in the raw river water, which reached 6,000 parts per million. The water is clarified by sedimentation, and recently coagulation has also been tried. Sulphate of iron and lime have been used. At first there was trouble in the details of the process, but more recently this has been overcome. The chemicals are now added at the rate of 2 grains of sulphate of iron and 6 grains of lime to the gallon, while at East St. Louis the same water is being dosed with 10 grains of alum and 1½ grains of lime, with results which are reported to be less satisfactory.

The Height of Buildings in Paris is governed by regulations issued on August 12, 1902. It is apparent that the inspectors have recently forgotten them, for a recent number of the "Annales des Ponts et Chaussées" calls official attention to them. They limit the height of buildings on public streets in accordance with the width of the streets. Where this width is less than 12 meters, the height of the buildings from the sidewalk to the middle point of the top of the facade must not exceed the street width by more than 6 meters. On streets wider than 12 meters, the height of buildings must not exceed 18 meters, plus one-fourth of the excess of the street width over 12 meters, provided that in no case shall the height exceed 20 meters. Manifestly, the sky-scraper is not desired in the French capital.

A COAL BUNKER FIRE that was destructive to the bin is reported by the Boston Manufacturers' Mutual Fire Insurance Company. The bin consisted of a pocket blasted out of a ledge back of the boiler house, where the coal, delivered from an overhead trestle 90 feet north of the boiler house, piled up 25 feet high against the brick wall of the building. The wall was reinforced with steel I-beams, built into it 6 feet apart, and the tops of the beams were anchored to the ledge at the rear by 1½-inch iron rods. The most serious part of the fire was in the deepest part of the pile, close to the wall, and finally the anchor rods gave way. This allowed the wall to bulge inward several inches in places, and a section 86 feet long, averaging 36 feet high, will have to be rebuilt.

THE FIRST MAIN-LINE ELECTRIC TRAINS on a steam railway were put in regular service on March 29, between the Central Station and Benton, on the North Eastern Railway, and this company has thus won in its race with the Lancashire & Yorkshire Railway for this honor. The North Eastern Railway buys its current from the Newcastle-on-Tyne Electric Supply Company. The original voltage is 6,000 volts, which is reduced at substations to 600 volts for the third-rail conductors. The section of road to be operated electrically is 37 miles long, with double and quadruple tracks, and when everything is working smoothly it is expected that the run from Newcastle to Tynemouth will be reduced from 35 to 23 minutes for local trains, and to 15 minutes for express service. Three-car trains are now in use on the Central Station-Benton section, a distance of four miles, and the running time is eleven minutes, including several stops.

THE FLOOD-DAMAGED LANDS in the Kaw River valley have been investigated by the U. S. Department of Agriculture and it is interesting to learn that forestry is recommended as the remedy for the damages done last year. About 5,000 acres of plowland were covered so deeply with sand as to be worthless for agriculture for years to come, and these, it is suggested, should be planted with cottonwood saplings, about 1,200 to the acre. In twenty years the trees may be cut for saw logs. The land from which the fertile soil has been partly eroded may be planted with black walnut and hardly catalpa, 1,300 to 1,800 seedlings to the acre. These trees will not be successful if there is more than two feet of sand over the soil. Much of the land which had several feet of surface soil eroded and was then covered with silt can be built up by planting it with willows and cottonwoods. In places where the flood left vertical banks, the Department's advice is to slope the banks and plant them in willows, tying the poles two feet apart with woven fence wire, which will hold them in place even if there is considerable sliding of the banks. Work to reclaim these lands should begin at once, if the former fertility is to be restored. The immediate returns from the work will be small, but after half a dozen years some income should be obtained. The cottonwood is the best fuel tree in the Middle West, and catalpa plantations in Kansas yield six per cent. interest on land and labor, and about $10 a year profit per acre.

THE JAPANESE IMPERIAL EARTHQUAKE INVESTIGATION COMMITTEE has recently published a highly interesting pamphlet by one of its members, Mr. F. Omori, entitled "Application of Seismographs to the Measurement of the Vibration of Railway Carriages." It is with only a moderate degree of surprise that the public will learn of the value of instruments designed to measure earthquakes, for determining the vibrations of railway cars. Most of us have held the opinion that the jolts and shakes felt in railway traveling were perhaps somewhat mental, as well as physical, and the fact that we expected to be shaken about may have produced those sensations to a certain extent. Now this Japanese scientist tells us that the sensations are very real, after all, and that the instrument that detects the tremor of earthquakes is also useful in measuring those untrammeled leaps of the dining car, which guide the fork of the unwary traveler into his eye and deposit his coffee equally over his chin and necktie. With the aid of his earthquake instruments, Mr. Omori has examined the vibrations in different classes of rolling stock on several lines of railway in different physical conditions. His results are given in great detail, with several plates and many tables, and probably form the first scientific investigation on a large scale of a subject which is of immediate importance to car builders and traffic officials the world over. The pamphlet can doubtless be obtained from the Committee, which has its offices in Tokyo.

THE SPECIFIC HEAT OF STEAM when superheated has never been accurately determined, and for this reason it is gratifying to learn from "Engineering" that some careful investigations to determine it are being made at the National Physical Laboratory, Teddington, with the financial assistance of the Manchester Steam Users' Association. The determinations made by Grindley and by Griesmann were some two per cent. apart, while Regnault's experiments were conducted on a very small scale. The present investigation is in charge of Dr. Harker and Mr. Jakeman. Steam is generated in a gas-heated boiler and passed through a large drum and separator into a horizontal superheater pipe, which contains about thirty feet of very thin nickel-steel tape. An electric current at 100 volts can be sent through this resistance tape, and the steam heated thereby; the temperature generally used is about 165 degrees Centigrade, although as high as 300 degrees has been reached. Electric thermometers have been inserted at the ends of the superheater, which is lagged with mica and asbestos, and, it might be added, experiments on laggings will form part of the investigation. The steam finally passes into a condenser through a stuffing box, the apparatus being designed for a capacity of eighty pounds of steam per hour. The importance of such experiments at this famous research laboratory is very great, and it is worthy of note that a private company is supplying part of the funds, just as in the United States the most important investigation of superheated steam yet undertaken in this country is being carried on at the expense of a private corporation. Such expensive experimental work emphasizes what this journal has often asserted of late, that many of the most important engineering data are obtained by engineers in the employ of great manufacturing companies, and the time has gone by when the independent engineer can afford to belittle the scientific work of this nature.

THE DURABILITY OF PAINT on the steel framing of buildings is a subject which ought to receive the careful attention of the engineers and architects of Baltimore. It is probable that not for many years to come will it be possible to see the results of so many and diversified tests of the preservation of steel by paint as the stripping of the framing of the Baltimore buildings affords. These buildings were put up at different dates and painted in the regular trade manner of their period, without any expectation that a great conflagration would uncover their steel skeletons and permit a careful examination of their condition to be made. A great deal has been said about the lessons of this fire respecting steel, concrete, terra-cotta and building stones, but the very important information to be learned concerning the protection of the steel surfaces by paint seems to be overlooked. This is all the more surprising because the feature of high building construction which now arouses most discussion is the character and durability of the various methods of painting the skeletons of such buildings. In the case of at least one building in Baltimore the results are highly gratifying. This is the Union Trust Building, built in 1897-98, which was exposed to most severe heat, as previously explained in The Engineering Record. The steelwork was designed by Messrs. Purdy & Henderson, and was painted once in the shop and twice after erection with what is known in the trade as "No. 30 Superior Graphite" paint, which is regularly employed by these engineers in their work of this nature. The steel is being stripped of its protective terra-cotta and other coverings and about a third of it is now exposed. Although these surfaces which are now open to examination were subjected to great heat, the paint remains glossy and elastic. A few rivet heads show rust, but they are always likely to do so on account of the scale which adheres to them after being driven, and their condition is unimportant. Practically speaking the paint remains as serviceable today as when applied six or seven years ago.

THE SUMMER SCHOOL FOR ARTISANS at the University of Wisconsin, one of the most interesting educational novelties introduced by the late Professor J. B. Johnson, will begin its fourth annual session about June 27. Professor Johnson was one of the first instructors in engineering schools to appreciate the full significance of the rapid growth of correspondence schools. Instead of ridiculing them, he commended their good features and suggested methods of improving their early defects. The artisans' summer school arose from his investigation of correspondence instruction and was designed to supplement it to some extent by opening to those having sufficient theoretical knowledge all the laboratories of a great engineering college and giving to workingmen for a few months the advantages of study and experiment under the direct supervision of the faculty. The directors of correspondence schools are generally in sympathy with this summer school, and a large number of the students have had correspondence instruction. Last year the students came from twelve States and included machinists, electricians, stationary engineers, erecting engineers, carpenters and central station engineers. Five courses are offered, in steam and gas engines, applied electricity, drafting and machine design, engineering materials, and shop work. The requirements for admission do not extend beyond a working knowledge of English and arithmetic, but the policy is to allow a large amount of individual work so that the student may take advantage of all the preparation he has obtained. The school is conducted at the expense of the State of Wisconsin, and it is estimated that the entire outlay for attendance during the six weeks' term, including reasonable living expenses and all school fees, need not exceed fifty dollars. So far as The Engineering Record can learn, the school is filling a hitherto vacant field in a quiet and efficient manner, and has justified the ideas of its lamented founder.

The Atlanta Water & Electric Power Company's Plant at Morgan Falls.

An extensive hydro-electric power plant near Atlanta, Ga., which has been under construction for a little less than two years, is now nearing completion. The plant comprises a large masonry dam, a fireproof power house equipped with horizontal turbines and large alternating-current generators, and a high-voltage transmission line. The dam and power house are situated on the Chattahoochee River about 16 miles due north of the center of the city, where a favorable site was found.

This water-power development is designed to produce electricity for use in the city of Atlanta. For a number of years the availability and value of this power has been apparent, and the sole ownership of these water-power rights are now the property of the Atlanta Water & Electric Power Company. The final investigation and report on the features of the project were made in March, 1902. An examination of the proposed site of the dam at once showed the feasibility of erecting a dam of stable character. The land rises abruptly on each side of the river, forming solid walls of rock, the river being shallow and showing solid ledge rock bottom. There are, also, ample quarries close by for securing stone for masonry. Drawings and photographs which are reproduced herewith show the principal features of the plant and the methods and progress of construction, as well as the natural character of the site.

Atlanta is the fourth city in size south of the Ohio and Potomac rivers, the first three cities being New Orleans, Louisville and Memphis. The population of the city of Atlanta, within a radius of 2½ miles, is about 120,000. The growth and industrial development of this city within the past few years has been exceptionally large. An accompanying general map shows the relation of the dam site to the city and the location of the transmission line. A contract has been made with the Georgia Railway & Electric Company for the entire available power that can be developed from the river at this point, thus assuring a paying market for the output of the plant from its initial operation.

At a point on the Chattahoochee River locally known as Bull Sluice, and now more generally known as Morgan Falls, about 16 miles from Atlanta, the company has erected a masonry dam about 900 feet long and 50 feet high, and constructed a power house containing a hydraulic and electric plant. From this point it is constructing a high-tension pole transmission line to the city limits of Atlanta joining an underground transmission line of the Georgia Railroad & Electric Company, which line extends from the city limits to the sub-station of the latter company on Thurmond Street in the city. A large portion of the overhead transmission line is located upon a private right-of-way belonging to the power company.

Dam.—The construction of the dam has been executed by Messrs. Smith & Hardaway, subcontractors for the S. Morgan Smith Company, York, Pa., general contractors, supervised by Mr. William H. Cushman, engineer for the S. Morgan Smith Company, and under the general direction of Westinghouse, Church, Kerr & Company, New York, engineers. Messrs. John Bogart, New York; William De la Barre, St. Paul, Minn., and George B. Francis, New York, have acted as consulting engineers on various features of the design and installation.

The dam is founded on ledge rock for its entire length and width and abuts against ledge rock at its ends for its full height. The rock is a very hard gneiss and the formation is unusually fortunate for dam construction. The stratification and natural cleavage is such as to form a saw-tooth surface on which to place the masonry of the dam, giving a positive guarantee against slipping in time of abnormal pressure. One of the photographs looking westerly shows the site of the dam before construction had commenced; the east bank is of similar character, as is shown incidentally in a number of the views taken during the construction of the work.

The dam is divided into two main portions: one, a rollway portion, extending from the abutment on the west side of the river for a length of 700 feet; the other, the bulkhead portion, extending from the east abutment, a length of 200 feet and joining the rollway portion. The dam is built on a straight line from abutment to abutment and at right angles to the channel of the river at its site. The rollway portion is of uniform section with a nearly vertical upstream face and an ogee downstream face. This section has a total width of 64 feet at the base including the toe of the dam; is 43 feet through at the base of the main prism, eliminating the curved toe, and 15 feet through on a line 8 feet down from the top, that is, on a line at the base of the curved crest.

Atlanta Power Plant: The Dam Site at Morgan Falls, Looking West.

The cross-section of the rollway is shown by one of the accompanying drawings. Its crest is 48 feet above the level of low water in the tailrace, being at elevation 858. The profile may be described as follows: Below elevation 856 the upstream face is built to a batter of 0.20. Above this there is a bevel 3½ feet long horizontally ending at elevation 858; beyond the bevel the crest is a circular arc of 72 degrees 5 minutes 45 seconds having a radius of 9.87 feet, which extends down to elevation 852.37, from which level to elevation 827.17 the downstream face is built to a batter of 0.475; below the last-named elevation the toe of the dam is curved to a radius of 30 feet, the arc being 54 degrees 35 minutes and 30 seconds tangent to the batter and to the horizontal. During construction a portion of the rollway at the river channel was kept low in order to pass the waters of freshets and eight temporary waterway openings 17 feet wide, below elevation 825, which is 33 feet below the top of the rollway, were left through the bulkhead. These openings will be filled with masonry dowelled to the ledge rock and to the adjacent portions of the bulkhead with 2½-inch steel dowels. The gap in the rollway is now nearly closed.

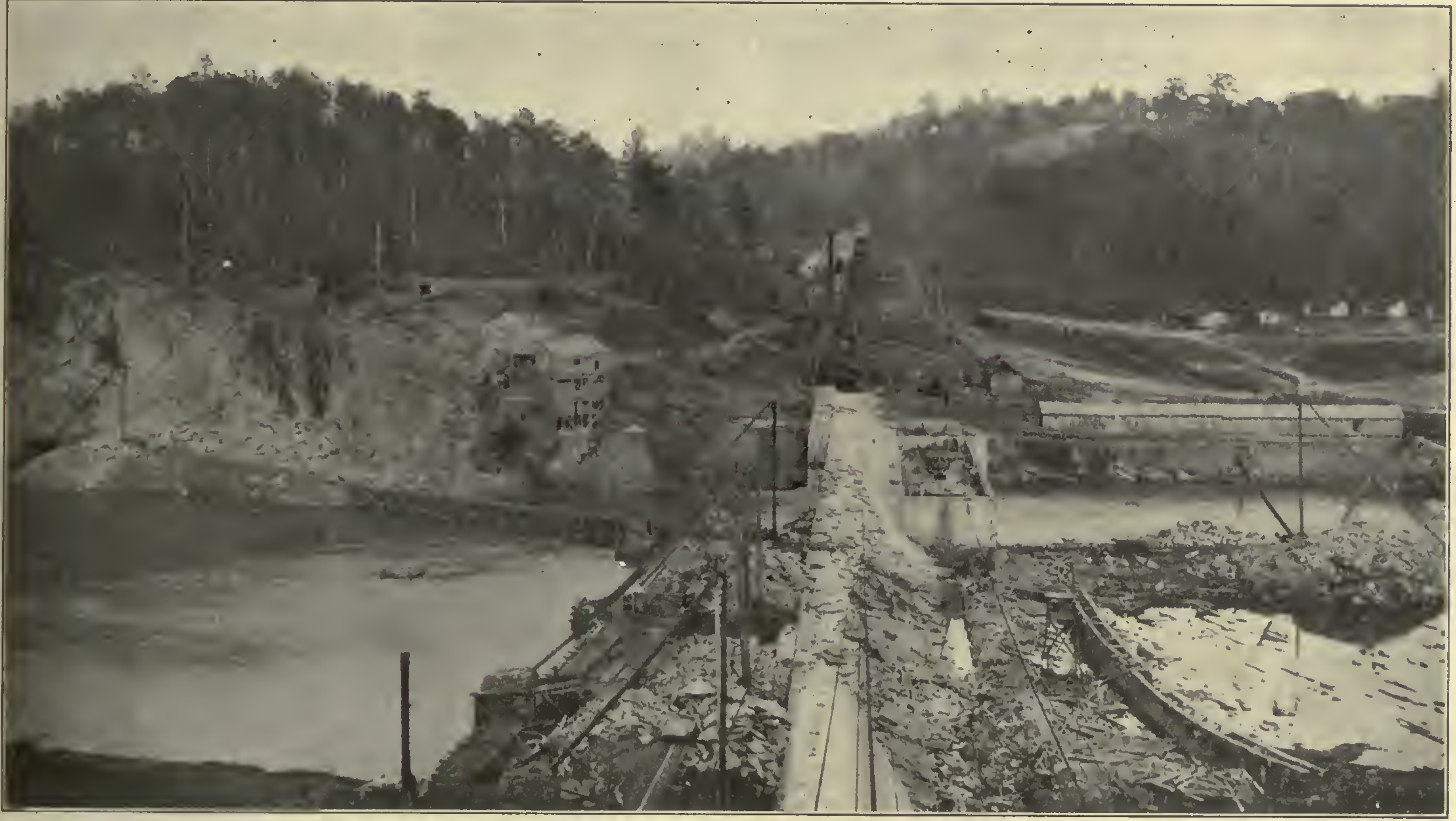
The downstream toe abuts against the ledge rock for a minimum vertical height of 5 feet, and in some places more. The upstream face of this rollway section is built of rubble masonry laid in Portland cement mortar. The downstream, or ogee, face is of Portland cement concrete troweled to a smooth surface nearly granolithic in its character. The body, or hearting, of the dam is of cyclopean masonry, constructed of blocks of ledge rock laid in Portland cement concrete of broken stone, no two pieces of rock touching each other, and all laid in a perfectly solid monolithic manner. The entire ledge at the base was cleared of all earth and gravel and after all loose rock was removed, was washed entirely clean before the dam construction was started.

The method of constructing the rollway part of the dam, the forms for the concrete facing on the downstream side, the character of the cyclopean masonry and the profile boards for the crest, as well as the shape and finish of a completed portion, are clearly shown in a number of the accompanying views. In building the upper part of the rollway the cyclopean masonry was brought to conform roughly to the cross-section of the crest and then the exact shape was worked out in the concrete. One of the pictures also shows the west abutment of the dam and the character of the ledge rock into which it is bonded.

The proportions of the concrete for the hearting are 1 part Lehigh Portland cement, 2½ parts sand and 5 parts crushed stone. The ingredients were mixed in cubical concrete mixers, made by the Thomas Carlin's Sons Company, of Allegheny, Pa., on the east side of the river, and transported in large buckets to the point of deposit by overhead cableways, three of which, made by the Trenton Iron Company and the Lidgerwood Manufacturing Company, span the entire river. The proportions of the concrete for the outer face of the dam, 1 foot or more in thickness are 1 part Portland cement, 2 parts sand and 4 parts broken stone. The mortar for the outer portion of the smooth downstream face was mixed in the proportions of 1 part Portland cement and 2 parts sand, and this was put on in connection with the building up of the underlying concrete.

The concrete mixer installation, the derricks, and the railways for conveying the concrete and materials are well shown in several of the photographs and the convenient proximity of the quarries supplying the stone is indicated. The cement storehouses and the camp for the workmen are also shown. There is some variety in the cableways. They are fitted principally with the Miller fall rope carrier and operated mostly with Lidgerwood hoisting engines.

The ledge rock placed in the hearting, and used for the upstream face, was taken from quarries on each side of the river immediately above the dam, and transported to the point of deposit upon temporary railways built for the purpose. The sand used for the mortar was nearly all taken from the bed of the river by a dredger, at a point about 2,000 feet below the site of the dam and was of excellent quality.



Atlanta Power Plant: General View of Dam during Construction, Showing Construction Plant, Quarry and Railroads; Looking East.

The bulkhead portion of the dam, through which are the penstocks and waste pipes and temporary waterway openings, is raised 10 feet higher than the rollway portion, and is buttressed on the downstream side by the piers, which support the power house. These piers are 5 feet thick and extend the entire width of the building. Between these piers are the tailraces. The masonry of the bulkhead is of the same class as the rollway portion, though, owing to the many openings, a very much larger percentage is of concrete. On the upstream side of the bulkhead are located the trash racks and gates.

The penstocks for the main wheels, seven in number, are 12 feet in diameter and are made of steel plates 5-16 inch thick. The penstocks for the two exciter wheels are 3 feet in diameter, and the steel is 3-16 inch thick. Near the center of the bulkhead is a waste pipe 6 feet in diameter, and at the end of the bulkhead, near the rollway section, are two more waste pipes 6 feet in diameter. The tailrace below the blukhead and power house is excavated out of solid ledge rock. The draught tubes are 10 feet in diameter for the large wheels, 3 feet in diameter for the small wheels and are hung from the masonry above.

The power-house building is 196 feet long, 40 feet wide and 28 feet 9 inches from floor to under side of trusses, all inside dimensions, has brick walls, steel and concrete roof, and is fireproof throughout.

Many features of the bulkhead for the dam and of the power house are shown in the cross-section and a number of the views. The power-house floor is 29 feet below the top of the rollway.

Work on the dam was started in September, 1902. The river was turned through the temporary openings under the bulkhead in November, 1903. At this time, April, 1904, the closure section in the channel of the river is nearly completed. Stops are to be placed on the upstream face of the bulkhead to close the temporary waterway openings, and these openings will then be permanently filled with masonry in such a manner as to thoroughly incorporate the closure masonry with the main bulkhead masonry.

Power House and Hydraulic Equipment.—The S. Morgan Smith Company has furnished and installed all hydraulic equipment and has constructed the power house and its accessories in acordance with designs and plans approved by Westinghouse, Church, Kerr & Company.

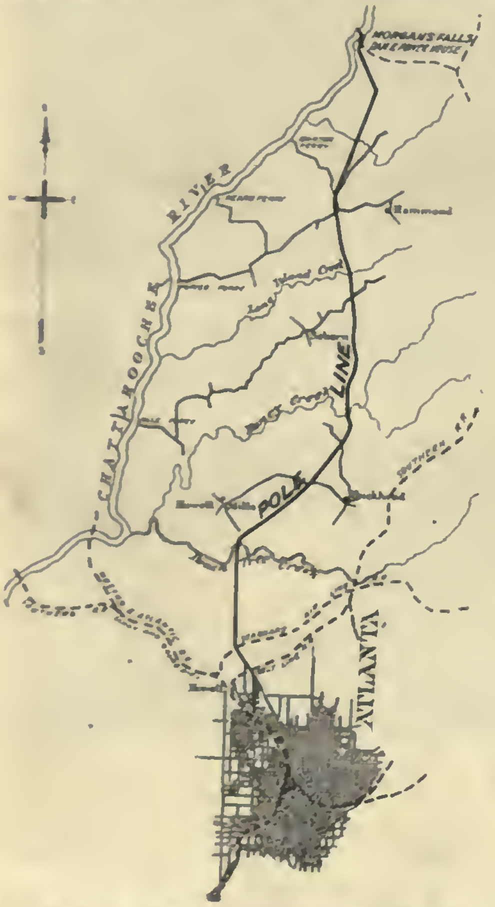
The power-house building is a substantial structure of attractive architectural appearance, rising above the tailrace openings. Construction that is fireproof is an important feature. No fire insurance will be required, thus saving this operating expense. The walls are of brick, laid in Portland cement mortar. The roof is of Portland cement and cinder concrete reinforced with steel and supported upon steel trusses. The floor is of concrete with a neat finish of Portland cement granolithic. The building is equipped with closets and toilet conveniences, also with an office for the operating engineer and with private telephone communication with the Atlanta sub-station. The inside finish of the building is attractive, the switchboard gallery being faced with white enameled brick, fitted with neat iron stairways and railings, and all walls and machinery being painted in a finished manner.

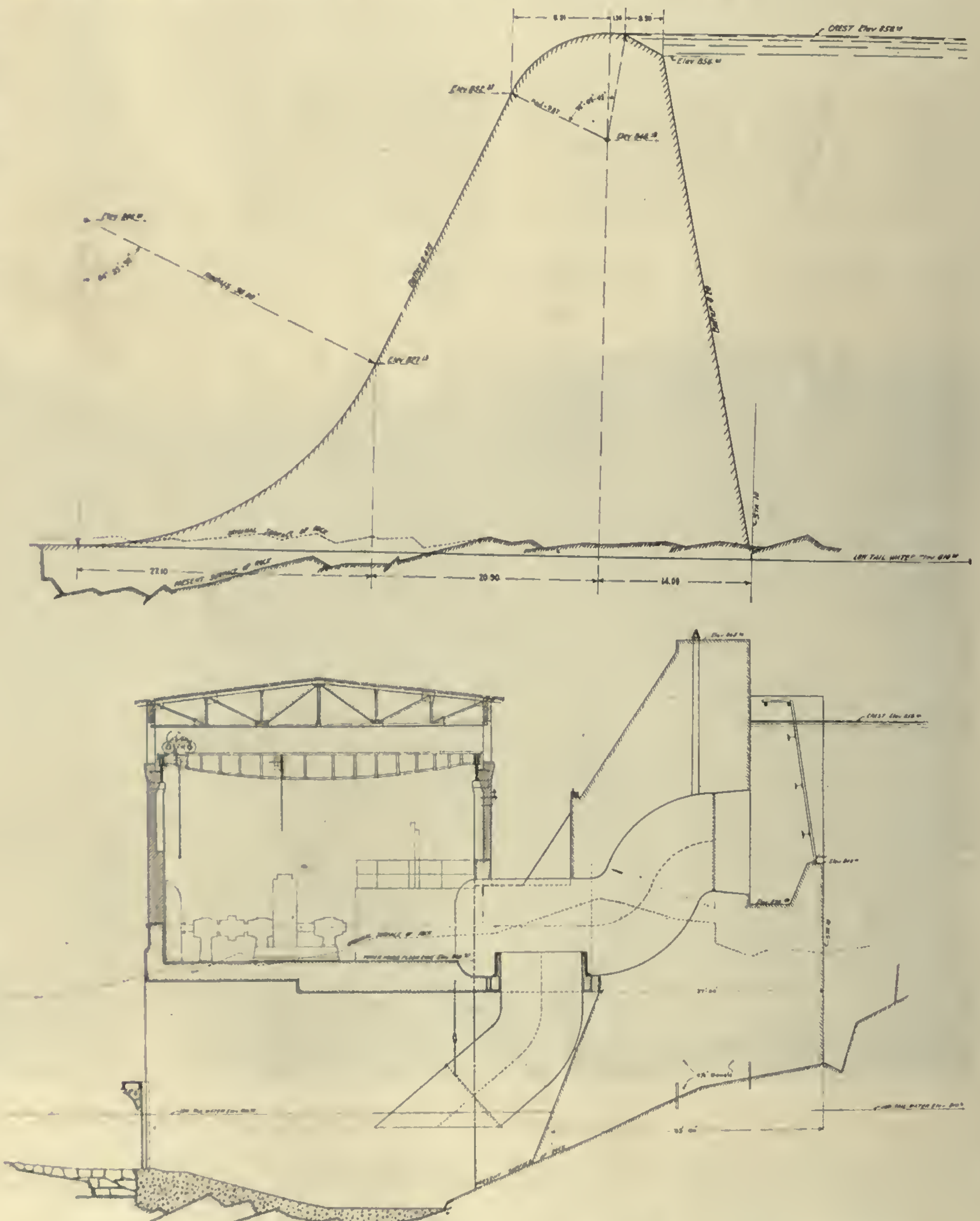
There are seven main turbines, each direct-coupled to a 1,500-kilowatt Westinghouse generator operating at 187½ revolutions per minute. Five units are sufficient to develop the average available power, leaving two units for surplus power and as a relay, permitting repairs on one or more units without in any way interfering with the operation of the plant. Each main turbine is built up with two wheels operating on one shaft, each pair developing about 2,400 horse-power under a working head of 48 feet, with an efficiency of not less than 80 per cent. The regulating gates are of the cylinder pattern, operated by a system of gearing and hydraulic control through an Ellicott speed governor.

There are two smaller turbines each direct-coupled to a 150-kilowatt direct-current Westinghouse generator operating at 450 revolutions per minute for exciting the fields of the main generators and for lighting the premises. Either exciter is of sufficient capacity to operate the entire plant, the other exciter serving as a spare unit.

The turbines were built and erected by the S. Morgan Smith Company. The head gate in front of each supply pipe is hand operated by a worm-geared gate hoist. Trash racks are placed in front of each gate. Floating caissons are provided for shutting off the water in front of any rack, thereby enabling repairs to be made to the head gates and trash racks. The bottoms of the trash racks are at elevation 840 and the bottoms of the inlet ends of the penstocks are at elevation 836.5, as shown in the cross-section through the power house. An air vent extends from the top of each penstock to the top of the bulkhead masonry and is covered with a cap. as is also indicated in the drawing.

On the downstream side of the power house provision is made whereby stop logs can be readily placed in position for shutting the water out of the wheelpits for the purpose of inspection or repairs of the draft tubes and foundations. Special care has been taken to provide sufficient means for effecting quick inspection and repair of all working parts of the plant. Overhead Whiting Foundry Equipment Company's traveling cranes of ample capacity to handle the heaviest piece of machinery are provided to facilitate the making of repairs quickly and with a minimum operating force of men. One 25-ton overhead crane is placed inside the building, traveling the entire length of the room, and equipped also with an auxiliary high-speed 1-ton hoist for handling small parts quickly. An overhead traveling crane of 3 tons capacity is provided outside the power-house building for handling the parts of the water wheels through large manhole openings in the wheel cases. This crane travels with one track resting on the upstream side of the power-house building and the other track resting upon the buttresses of the bulkhead.





Map Showing Location of Power House and Transmission Line; Sections through Railway of Dam and Through Power House and Bulkhead.

Electrical Equipment.—The design and construction of the electrical equipment, transmission line and underground cable system has been carried out by Westinghouse, Church, Kerr & Company, and in all respects the construction is of a character which promises durability and satisfactory service in operation. The generating and transmission equipment is designed for transmitting power at 22,000 volts pressure for about 16 miles to the sub-station of the Georgia Railway & Electric Company located in the city of Atlanta. The three-phase system is used, both for generation and transmission, at 3,000 alternations per minute. Current is generated at 2,200 volts, raised to 22,000 volts through step-up transformers and reduced to 6,600 volts through lowering transformers located at the Atlanta sub-station, where the current is utilized by the Georgia Railway & Electric Company, at 6,600 volts pressure, three-phase.

The generating and switchboard equipment has been furnished by the Westinghouse Electric & Manufacturing Company, Pittsburg, Pa. The generators are of the revolving field type with laminated field poles dove-tailed into the rim of a cast-iron spider, according to standard Westinghouse practice. Oil-insulated water-cooled transformers are used, the capacity at the power house being divided into seven units, each 1,500 kilowatts. Six units are sufficient for the entire output of the plant, leaving a spare transformer as a relay. The transformer equipment at the sub-station is a duplicate of that at the generating station, as to number and size of units.

The main station switchboard panels are of marble supported on steel framework, and the instruments and switches mounted on the board are of the latest design. Oil circuit breakers are used for the 2,200-volt generator and transformer circuits, as well as for the 22,000-volt feeder circuits. The circuit breaker construction is acording to the latest and best standard practice, including fireproof barriers between all high-voltage conductors. The removal of all high-voltage connections, bus bars and switches away from the immediate vicinity of the operating panels and the operating attendant is a prominent feature. The 2,200-volt oil circuit breakers of the Westinghouse Electric & Manufacturing Company's type E, together with all 2,200-volt bus bars and connections are located in a fireproof compartment beneath the switchboard gallery. These 2,200-volt circuit breakers are operated by distant hand control, from the switchboard panels above.

The 22,000-volt oil circuit breakers of the Westinghouse Electric & Machine Company's type C, on the high-voltage side of the step-up transformers, are located in a tower above the generator room at the land end of the building. These 22,000-volt circuit breakers are electrically operated, distant control, the operating mechanism being direct-current solenoids, which form a part of the oil switch mechanism, and the controlling switches are placed on the panels of the main operating switchboard. All 2,200-volt cables are carried in vitrified tile conduits buried in the concrete floor, and the 22,000-volt cables are isolated with fireproof barriers. The design and construction of switchboard and oil circuit breaker equipment for the sub-station is substantially the same as for the main power station.

Transmission Line.—Two independent duplicate transmission lines are provided, there being two separate pole lines. Either line is of sufficient capacity to transmit the entire output of the plant, the other acting as a relay in case of possible accident. Ordinarily both lines would be in service, this obtaining a minimum loss of power in transmission. Each line is composed of three No. 00 Brown & Sharpe gauge hard drawn copper conductors, forming an equilateral triangle 36 inches on a side. To minimize inductive effects each line is transposed.

A prominent feature of the line construction, both from a mechanical and electrical standpoint, is the unusual factor of safety obtained. Careful investigation was made before construction to determine the class of wood best fitted for the local conditions, and white chestnut grown on the highlands of Tennessee and North Carolina, noted for its mechanical strength and durability, was selected for this work. No pole is used smaller than 25 inches in circumference at the top on a 30-foot pole, with 120-foot spans, and particular attention has been given to extra large butt measurements. This timber is all winter-cut from green live stock, and each pole has been carefully selected and branded by the company's inspector before shipment. The poles are tarred for 2 feet above and below the ground line as an extra precaution against ground rot, and all gains and pole tops are protected with a coating of white lead.

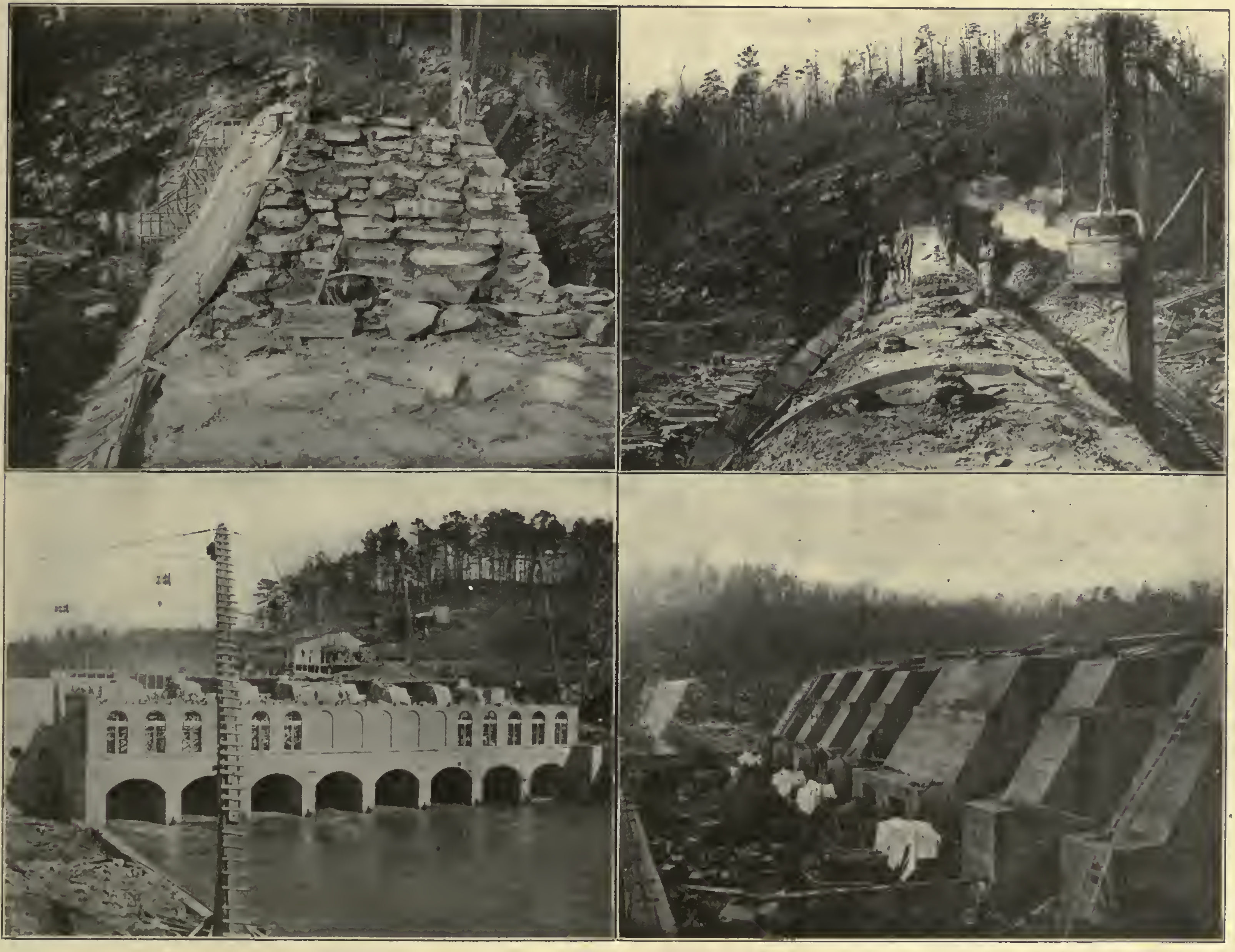
The crossarms, which carry two No. 00 wires each, are of unusually heavy construction for this weight of line, of carefully selected clear heart, long leaf yellow pine, thoroughly dried and painted two coats of preservative compound. Sharp curves in the pole line are carefully avoided, as far as possible. Whenever necessary on such gradual curves as occur, double crossarm construction is used, utilizing two crossarms the same as those mentioned above, thus obtaining a set of two insulators and two pins to share the strain and provide a relay in case of failure of either insulator. Extra heavy crossarm braces and fittings are provided, using steel braces, and all bolts in proportion, to secure a life in fittings that will equal or exceed the life of the rest of the pole equipment.

The high-tension insulators have received special attention, with the result that the factor of safety obtained is unusually large, thus assuring the most satisfactory line service. Brown porcelain triple-petticoat insulators are used, and every insulator is tested by the manufacturer at 80,000 volts, and designed to withstand a 47,000-volt "rain" test without puncturing or flashing over with salt water sprayed over the insulator far in excess of rainstorm conditions in actual service. The factor of safety in mechanical strains is such that the insulator will withstand without damage a strain in the direction of the pull of the wire of 3,000 pounds and an axial pull that will strip the thread of the pin, which conditions also are far in excess of actual service condition. For insulator pins selected locust wood is used, the pins being of extra heavy design and especially treated with preservative compound to secure long life.

This overhead line conveys current from the power house to the city limits of Atlanta, from which latter point the line is carried underground for a little over a mile to the sub-station. There is a terminal house of fireproof construction of brick, concrete and steel, located at the terminus of the overhead line.

Telephone Service.—A private telephone line is provided between the Morgan Falls power house and the Atlanta sub-station, using hard drawn copper wire, metallic return, with bridging instruments. This telephone line is carried on extra heavy crossarms, selected North Carolina yellow pine, painted two coats. Locust pins are used with heavy glass insulators. The braces are of steel extra heavy construction. The telephone wires are frequently transposed to secure a quiet line. This private telephone line, by the use of a portable instrument, places a patrolman in constant communication with headquarters.

Lightning Protection.—The lightning arrester equipment was furnished by the Westinghouse Electric & Manufacturing Company, in accordance with its latest designs. Low equivalent arresters with series choke coils for the protection of the power-house equipment and overhead line are placed in the high-tension tower at the power-house building. The conductor for dissipating lightning discharges to earth is a No. 00 copper cable attached to a heavy copper plate buried in charcoal in wet earth. A similar protective equipment is provided at the end of the overhead line, a part of the terminal



Atlanta Power Plant: Cyclopean Masonry in Dam; Forming Crest of Rollway; Power House Showing Waste Pipes; Bulkhead and Turbines.

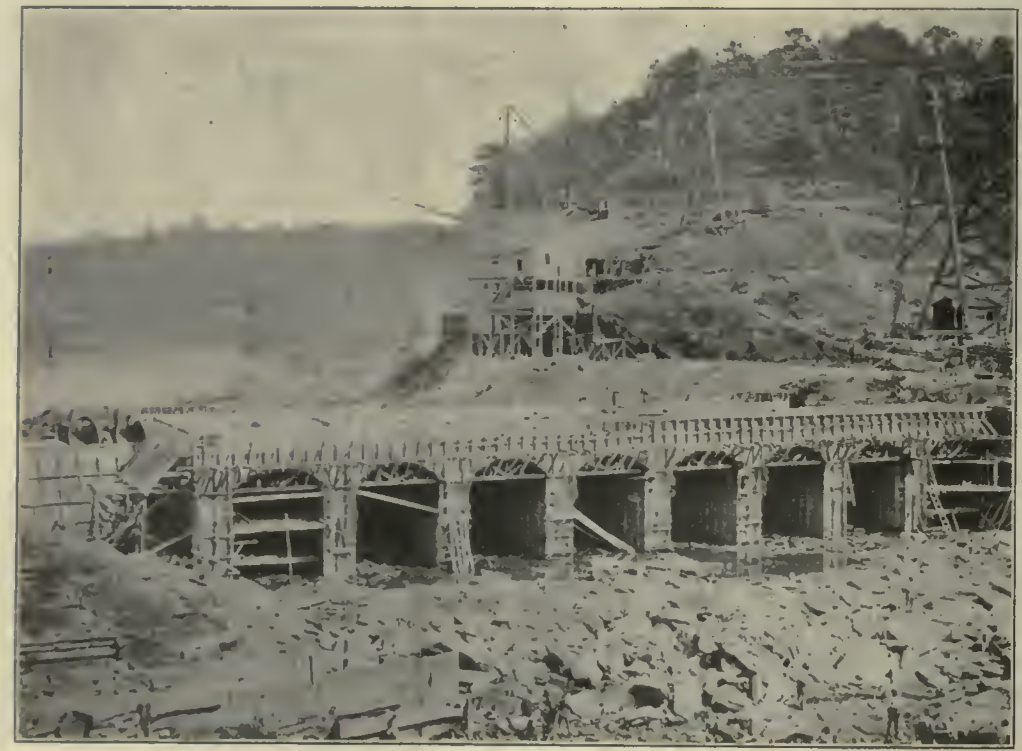
house being reserved for this purpose, thus assuring the best obtainable protection for the underground cable.

Underground Equipment.—The underground cable is No. 000 Brown & Sharpe gauge three conductor cable, paper insulated, and specially designed under exacting specifications to withstand the high-voltage service. As a further precaution against interruption to the delivery of power a duplicate cable is provided as a relay. Ordinarily both cables would be in service, thus obtaining a minimum amount of transmission losses. This cable is encased in an extra heavy lead sheath, with provisions in the installation to minimize effects of electrolysis.

The conduit system of vitrified tile ducts, 3½ inches square bore, is built up of four lines of single ducts, thus affording two extra ducts for possible future extensions to the system. The ducts are laid on a bed of Portland cement concrete 4 inches thick, and enclosed top and sides with 3 inches of concrete, with the top of the ducts not less than 3 feet below the surface of the street.

The standard manholes are each 8 feet long, 4 feet wide and 6 feet deep, spaced not more than 400 feet apart, built of Portland cement concrete. The concrete for the side walls was molded in blocks before being brought on to the ground, and laid in a Portland cement mortar, forming a 9-inch thickness of wall. Corner manholes are 6x6x6 feet, inside dimensions. All manholes have ample drainage to sewer, the drainage conditions being very favorable.

The entire installation herein described is now approaching completion and it is expected that delivery of current can be made to the Georgia Railway & Electric Company on or about September 1, 1904. The plant will be made complete in every detail and will be of the most modern and efficient type both in its hydraulic and electrical features.



Atlanta Power Plant: Power House Foundations, Tail Race, and Concrete Plant.

The Steam Turbine as an Exhaust-Steam Utilizer.

In The Engineering Record of November 9, 1901, there was described a so-called regenerative accumulator invented by Prof. A. Rateau, of the School of Mines, Paris. As outlined in that account, this device is a sort of heat storage battery to which exhaust steam from a reciprocating engine is conducted in the intermittent puffs characteristic of the discharge of such steam motors and from which a steady or continuous supply of steam at low pressure may be taken for utilization in a low-pressure steam turbine. Such a turbine for low-pressure working has already been brought out by Prof. Rateau, although no extended description of it has appeared in these columns, and a number of installations have been made where the combination of accumulator and turbine, as proposed in the article mentioned, have been in actual operation. One of these is located at the mines at Bruay, and the following information concerning it is largely taken from a recent issue of "Le Génie Civil." A similar employment of the turbine is intimated in the extended comment last week of the proposed Cunard turbine ships.

The scheme, in brief, is to carry the expansion of the steam to a greater degree than is ordinarily found practicable in a reciprocating engine. In the case of the Bruay installation the exhaust from the primary engine takes place at about atmospheric pressure, and the exhaust steam, under the regulation of the accumulator, is passed through the turbine and then to a condenser outfit which provides for creating the desired range of pressure for the working of the turbine. The primary engine in this case is employed for hauling, with the intermittent service to which hoisting engines are subject, and develops about 176 horse-power, corresponding to an hourly expenditure of about 17,600 pounds of steam. Assuming a loss of 20 per cent. through condensation in the cylinders and in the pipe lines, the engine rejects about 14,000 pounds of steam per hour. The application of the Rateau system, it is stated, allows for the expansion of this steam from 12.8 to 2.13 pounds per square inch and develops in the secondary machine or turbine about 300 electrical horse-power, the turbine being directly connected to two continuous-current dynamos. It is said that the power of the secondary unit can be raised to 450 horse-power when the hoisting machine is operating at full load. Ordinarily the engine delivers steam at the commencement of work during 15 or 20 seconds and then finishes the work without further acceptance of steam, and the duration of the various periods is about one minute.

The regenerative accumulator at the Bruay mines comprises a group of four vertical cylinders of boiler plate, all in communication with one another. It will be remembered from the early description, which was illustrated, that the tank is fairly well filled with shallow dishes or plates of cast-iron designed to hold the condensation of the exhaust steam. When the exhaust arrives in quantity from the primary engine it is distributed to and around the plates through a central channel. A part of the steam can pass directly to the outlet for utilization immediately in the turbine, while the excess condenses upon the materials forming the accumulator; that is, the cast-iron plates and the water contained in them. The pressure rises and with it the temperature; when the exhaust of the primary engine decreases in amount or ceases, the constant demand of the turbine goes toward lowering the pressure and an evaporation of the water takes place. It is this property of the apparatus which gives it the characteristic of what has been called a heat storage battery. It is said that in practice the variations of temperature of the steam range from 5.4 to 10.8 degrees, corresponding to fluctuations in pressure of 2.13 to 3.55 pounds per square inch. These variations are regulated by a careful calculation of the weights of materials in the accumulator and by regulation of an escapement or relief valve. At Bruay the total weight of cast-iron contained in the four cylinders is 48 tons.

Each of the cylinders is 16 feet high, exclusive of the heads, and has an inside diameter of 3.75 feet. There are thirty-five of the cast-iron dishes, each 42½ inches in diameter and about 4 inches in maximum height. They are of an annular form, of which the inside diameter is 15.75 inches, this hole in the successive dishes forming the central cylindrical channel through the accumulator from top to bottom. The walls and bottom of the dishes are 1 inch in thickness, and besides the inside and outside annular walls for holding the water there are radial ribs which add to the mass of cast-iron making up each dish. The depth of water to the tops of the side wall of the dishes is 2¾ inches, but a few of the ribs are extended 0.2 inch above these and act as the support of the dish next above. In other words, the whole mass of dishes is carried by the lowest or bottom plate, which in turn is fixed to brackets on the inside of the cylinder, and there is a space of 0.2 inch between one plate and the one next above it. The four cylinders are grouped closely together in a shallow pit just outside of the power house.

There are a number of accessories which are desirable for the best operation of the apparatus. From the top of one of the accumulators is carried an exhaust pipe to the atmosphere, and in this is fitted a back-pressure or relief valve to allow automatically for the escape of steam when the turbine is operating at light loads or is stopped altogether. At the turbine there is an expander which operates when the primary machine is not supplying sufficient steam for the operation of the turbine. This admits live steam at low pressure automatically, so as to avoid interruption of the dynamo operation. Finally, each accumulator is provided with an automatic valve for draining such surplus condensation as gradually accumulates.

A number of tests have been conducted of the low-pressure group at the Bruay mines. The installation was first operated with three cylinders to the accumulator in place of the four which there now are. While preliminary calculations established that the heat store should contain 60 tons of cast-iron, only 36 tons were put in the three on the score of economy. Pressure-time diagrams were made to record the variations of pressure within the three cylinders of the accumulator, the pressure being measured by a registering manometer. The range of pressure between the beginning and end of the cycle of operation of the primary machine amounted to 5.7 pounds per square inch. To diminish this pressure range the fourth cylinder was put into service in August, 1903, and the oscillations have been reduced to 2.13 to 3.55 pounds pressure. While the load on the steam turbine is subject to frequent variations, corresponding changes of speed have not exceeded 1 per cent. above or below the normal speed, which is 1,600 revolutions per minute.

Atlanta Power Plant: West Abutment and Rollway of Dam; Bulkhead and Power House Foundations Ready for Penstocks.

To show the operation of the turbine under the given ranges of pressure the accompanying table of tests is reproduced. The first seven lines give the results of tests made in April, 1902, independently of the accumulator. Their object was simply to determine the performance of the turbo-generator set. The remaining seven lines cover the tests made at the mines in January of last year, under the conditions of regular operation. These trials were conducted at lower power than the normal of the turbine and with lower vacuums. The turbine, it may be stated, consists of a number of light steel wheels carrying small blades on their periphery and turning between circular diaphragms. The diaphragms alternate with the wheels and are fitted with guide blades. These are fixed to the inside of the turbine piston. The steam passes successively through wheels and guide diaphragms from one end to the other and on leaving the turbine is conducted to the condenser.

One of the interesting points is a statement of the influence of the vacuum in the condenser on the steam consumption. The figures, which are cited as those to be expected in practice, are given in an accompanying table. The first line gives the pressures on the discharge side of the turbine; that is, the absolute pressure of the condenser, and the remaining three the steam consumption in pounds per horse-power hour under three different conditions of the pressure of the steam delivered to the turbine. The first column corresponds to the employment of a surface condenser giving a vacuum of 27.5 inches of mercury, the second column to that of a condenser, furnishing a vacuum of 26 inches, and the third to that of a condenser giving 24.6 inches of vacuum. The third line of the table corresponds to the normal case where the turbine utilizes steam at atmospheric pressure. The figures also indicate that with the steam delivered at atmospheric pressure an electrical horse-power is produced with an expenditure of 26.4 to 36.3 pounds of steam per hour.

The turbines, it is stated, will normally develop 65 to 70 per cent. of the theoretical power corresponding to the expansion of the steam from the pressure of the atmosphere to that of the condenser, while piston machines give under these conditions but 35 to 40 per cent. of this power. To show by figures the relative performance of the ordinary condensing plant and that having the accumulator-turbine outfit the following analysis was presented. Let it be assumed that the average consumption of the primary machine exhausting to air is N pounds per horse-power per hour. The application of condensing corresponds to an economy in consumption of 15 to 20 per cent., so that under these conditions there are for each horse-power developed an equivalent of 0.2N pounds of steam that can be disposed of. If it is assumed that this amount of steam is used in a high-class engine-dynamo unit consuming 16.5 pounds per electrical horse-power the additional power obtained through operating the plant condensing is equivalent to $0.2N \div 16.5 = N \div 82.5$ electrical horse-power. With the turbine the exhaust steam at atmospheric pressure will produce, it is assumed, an electrical horse-power at an expenditure of about 30.8 pounds of dry steam. The weight N coming from the primary engine will give about 0.8N pounds of dry steam, assuming the moisture forming in the engine and pipe to amount to 20 per cent. This weight of dry steam will then be capable of furnishing useful work of $0.8N \div 30.8 = N \div 38.5$ electrical horse-power. This calculation is taken to indicate that the latter case shows a utilization of more than double that of the former.

Water Rate of Low-Pressure Steam Turbine.

Steam pressure, lbs. per sq. in., abs. To turb.	Steam pressure, lbs. per sq. in., abs. From turb.	Revolutions per minute.	Electrical horse-power.	Steam per horse-power-hour, lbs.
12	2.22	1,690	262	39.6
12	2.22	1,830	271	38.3
12	2.22	1,840	272	38.1
14.4	2.57	1,700	331	38.5
14.4	2.61	1,800	340	37.4
12.8	2.32	1,591	278	39.6
14.7	2.78	1,598	320	39.4
8.8	3.48	1,585	87	87.1
7.95	3.41	1,595	72	95.5
7.24	3.28	1,580	72.5	86.0
7.53	3.28	1,600	76	85.8
7.38	3.25	1,600	75.5	73.5
8.95	3.2	1,600	105	73.0
8.95	3.1	1,600	115	70.0

Effect of Vacuum on Turbine Consumption.

Turbine exhaust, lbs. per sq. in. abs.	1.14	1.85	2.56
Steam per elec. H.-P.-hr., lbs.—			
28.4 lbs. steam pressure	20.5	22.7	26.4
14.2 lbs. steam pressure	26.4	31.7	36.3
7.1 lbs. steam pressure	36.3	47.3	61.6

Another form of accumulator seems also to have been developed and is now in process of installation at another group of mines. This consists in passing the steam from the engine through a body of water before it can reach the outlet leading to the turbine. It is built in a horizontal form and the incoming steam is distributed through a number of elliptic-shape submerged pipes extending from one end of the cylinder to the other. The axes of the ellipses of their cross-section are 7 and 16.5 inches. The steam escapes from these pipes through a large number of small orifices spaced along one of the walls of each pipe toward the bottom. The flow of steam creates an ebullition of the liquid, and an active circulation of the water is thereby created, which has for its object the bringing of the whole mass of the water into play as a medium for storing heat. It is said that tests by Prof. Rateau have shown that all the water contained in the accumulator participates in the regeneration. The dimensions of this type of accumulator are relatively small. One containing 350 cubic feet of water suffices with durations of 1 to 2 minutes on the part of the primary engine for the regeneration of 9,900 pounds of steam per hour. In the installation for which this accumulator was built a turbine of 350 horse-power driving an air compressor is supplied. The compressor unit is to have a capacity of 2,100 cubic feet of air per minute at a pressure of 85 pounds per square inch.

Progress in Construction of Jerome Park Reservoir, New York City.

Nearly nine years ago the Aqueduct Commissioners of New York city began the construction of a large distribution and storage reservoir in the northerly part of the borough of the Bronx, in order to supplement the existing distributing reservoirs in Central Park. This new reservoir, named the Jerome Park Reservoir, for the reason that a portion of its site was formerly occupied by a driving park of that name, has become widely known because of its importance and because of the investigations and reports concerning some features of its design and construction which have been made by eminent engineers and other parties. These reports have been reviewed in this journal in the issues of July 6 and November 30, 1901, January 11 and 18, 1902, and in other numbers, but it is not the purpose of this article to take up any of the questions which have been raised at various times, the present intention being to describe the work that is under way.

It was expected to have the reservoir ready for service in 1902, but various occurrences have delayed its progress. The causes of some of these delays have been indicated in the articles and editorials referred to; the change from ten hours to eight hours as the legal length of a working day on public works in New York State and the coal miners' strike of 1902 were prominent among the other causes of delays. It is now hoped to have the westerly of the two basins into which the reservoir is divided finished by the end of this year, and the easterly basin by the end of next year. Extensive extracts from the specifications and a number of the contract drawings were reproduced in the issues of this journal of July 13 and 27, August 10 and November 9, 1895, but no comprehensive description of the reservoir, its structures and its connections have ever been printed.

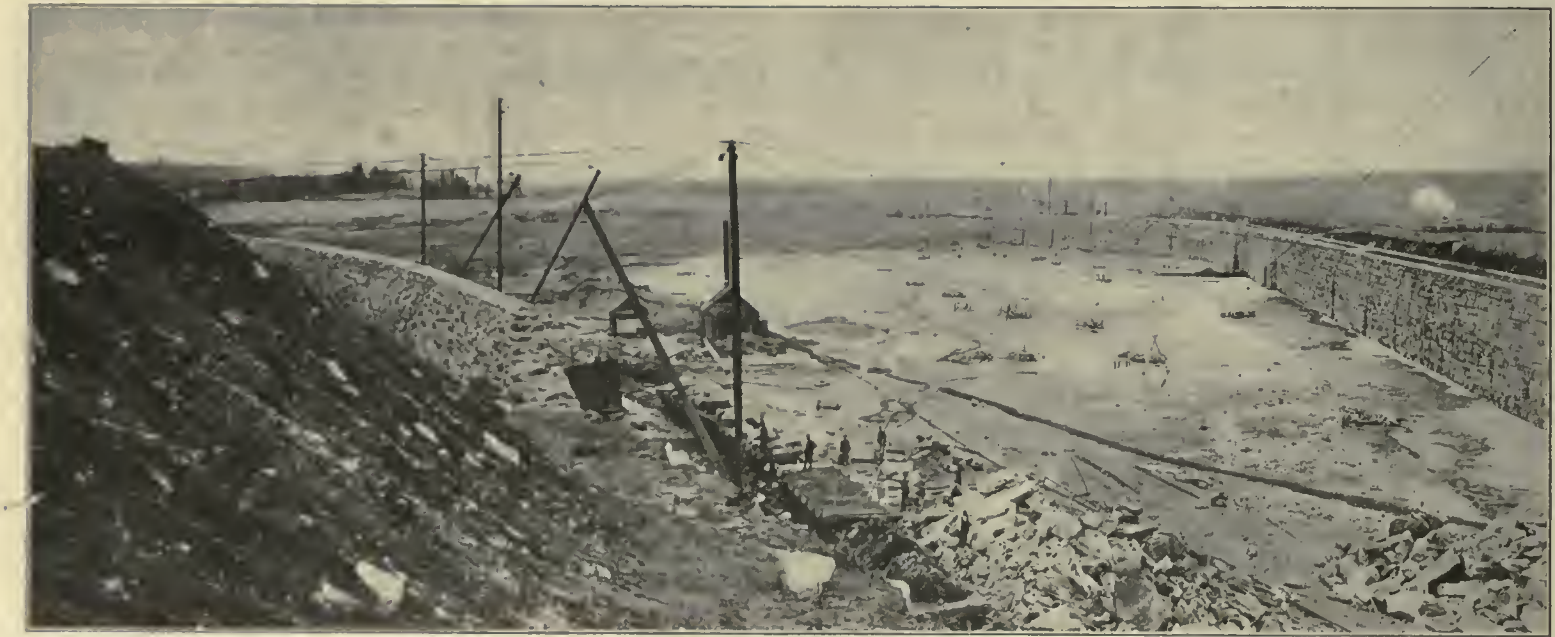
Jerome Park reservoir will be one of the largest artificial distributing reservoirs in the world, and its construction involves very large quantities of excavation and masonry. The extreme length of the reservoir is 5,800 feet, and the greatest width 2,650 feet, measured at the top of the embankment; its capacity will be between 1,900,000,000 and 2,000,000,000 gallons, and the water surface will have an area of 241 acres.

The average depth of water below full reservoir level, which is to be elevation 131.5 above city datum, will be about 25.5 feet. A division wall 4,200 feet long separates the reservoir into an easterly and a westerly basin, the former having an area at full reservoir level of 147 acres and a capacity of 1,174,650,000 gallons, and the latter an area of 94 acres and a capacity of 770,600,000 gallons. By far the greater part of the reservoir is in excavation for the whole or part of its depth, only about 1.5 acres of the site having been at such an elevation as to require no digging other than the removal of soft top soil. The maximum cut was 65 feet deep, and the average cut approximately 18.5 feet. The perimeter of the reservoir is made up of 5,000 feet of retaining or breast wall and 9,900 feet of embankment with a rubble masonry core wall and concrete slope paving, making the total length around reservoir about 2.8 miles.

There are seven gatehouses connected with the reservoir. Gatehouse No. 1 is situated nearly a mile north of the north end of the reservoir, at the point where connection is to be made to the new Croton aqueduct. From this gatehouse a short aqueduct will lead to the reservoir. Gatehouse No. 5 is situated near the center of the reservoir, and is the principal gatehouse or central controlling station at which the flow of the water from and into the aqueducts and reservoir can be directed in a variety of ways. The other gatehouses are located at various points around the reservoir, and control the flow of water into the pipes which will supply the various sections of the city as well as, in one or two instances, additional connections with the aqueduct. These structures may be described in more detail in another article. The preliminary drawings for Gatehouse No. 5 were printed in The Engineering Record, November 9, 1895; these have since been modified slightly. Drawings of some other gatehouses were also reproduced in that issue.

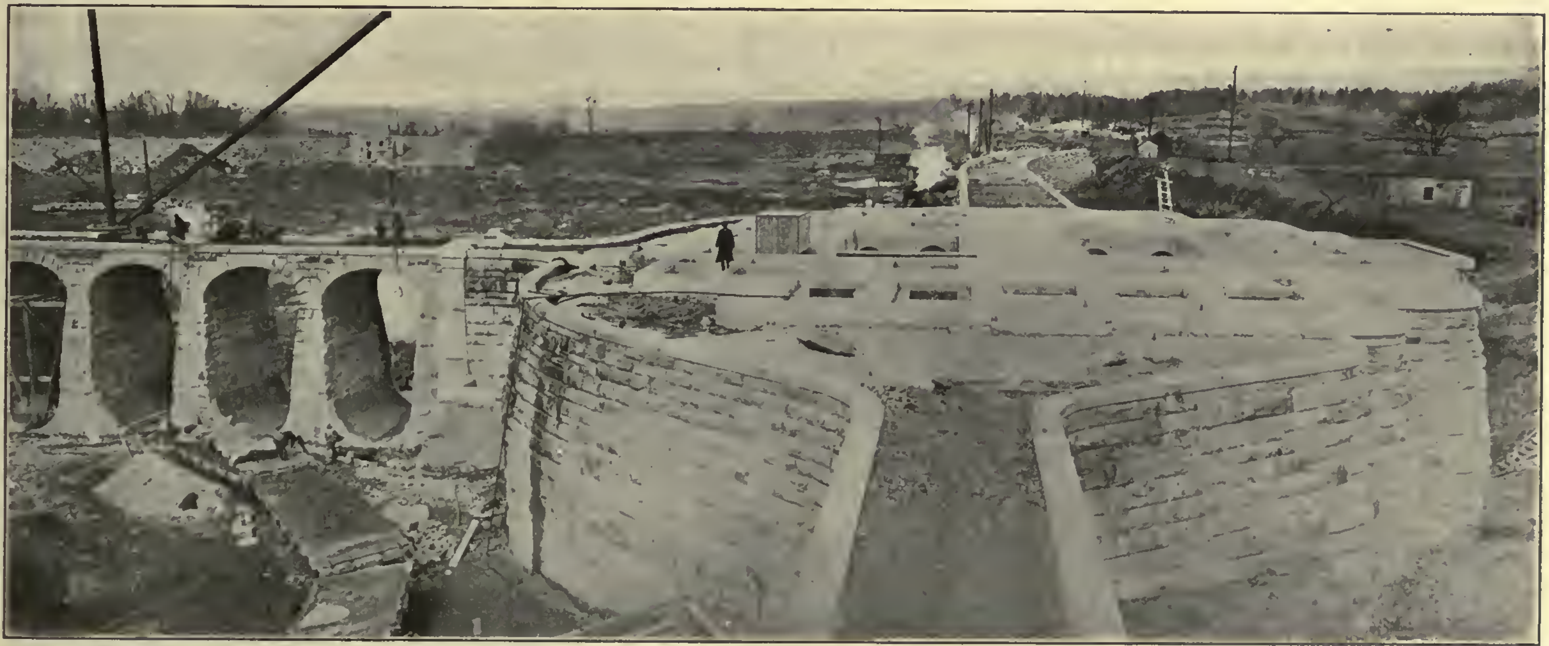
The division wall contains the aqueduct connections from the old and new Croton aqueducts to the main gate chamber, situated near the middle of the reservoir, the inlet conduits from this gate chamber to each basin and a continuation of the old aqueduct towards the city proper. The principal total quantities involved in the construction of the reservoir are estimated to be approximately as follows: Earth excavation, 4,060,000 cubic yards; rock excavation, 3,000,000 cubic yards; rubble masonry, used principally in the core walls of the embankments, the division wall between the two basins and in the foundations of the gatehouses and other structures, 297,000 cubic yards; Portland cement concrete, to be used for paving the 216 acres of the bottoms of the two basins, for paving the slopes of the embankments and for portions of the aqueducts and other structures, 225,000 cubic yards; cut granite masonry, in the copings of the walls and in the gate chambers and other structures, not including the superstructures, 6,500 cubic yards; cast-iron pipes for connections to the distribution system and for drains, from 48-inch to 6-inch, requiring 3,870 tons of pipe and special castings. The contractors' bid on the basis of the preliminary quantities was $5,473,060; the total cost of the reservoir, it is now estimated, will be nearly $7,000,000.

The methods of excavating and disposing of the earth and rock and the contractors' plants for this work, for crushing stone and for building walls, were described and illustrated in The Engineering Record December 4, 1897, and February 17, 1900. Measured by the payments to the contractors for work done and materials furnished, about 60 per cent. of the undertaking had been completed at the close of active work last season. During the year 1903, in spite of delays and interruptions of various sorts, about $500,000 worth of work was accomplished. Operations were resumed February 29 this season, and there are now about 900 men at work. This force is being increased as men can be hired and put to work advantageously. The maximum force employed in any previous season was about 1,200 men, and it is expected that even a larger number may be employed this season. Very few horses are found on the work, as the materials are handled chiefly in cars



Jerome Park Reservoir: General View of West Basin, Looking North, Showing Breast Wall at Left and Division Wall at Right.

drawn by locomotives on standard-gauge tracks, although some 3-foot-gauge tracks are also used for distributing supplies and for similar purposes. The contractors' railroad equipment now includes eight standard-gauge and three narrow-gauge locomotives, one hundred flat cars, three Lidgerwood rapid unloaders, a number of narrow-gauge dump cars and thirty Goodwin side-dump steel material cars. Two Marion steam shovels with 2-cubic-yard dippers are at work on the excavations; fifty-five Ingersoll-Sergeant steam drills are in use on the remaining rock cuts, and forty large mast and boom-guyed derricks, placed in various parts of the basins, are handling rock, earth and masonry. About a year ago the large air-compressor plant described in a previous issue was removed to the tunnel for the rapid transit subway now being driven from the Battery, Manhattan, to Brooklyn. Consequently all the drills and hoisting engines are now operated by steam, and in the present condition of the work this is believed to be quite as economical as to use compressed air.



Jerome Park Reservoir: Substructure of Central Gatehouse, Causeway to Shaft of New Croton Aqueduct and Portions of Division Wall.

At the beginning of this season, the following approximate quantities of the principal items of excavation and masonry remained to be accomplished: 1,700,000 cubic yards of excavation, of which 1,000,000 cubic yards or more are expected to be earth, the balance rock; 200,000 cubic yards of concrete and 50,000 cubic yards of rubble, and there are about 3,000 tons of cast-iron pipes to be laid. Of the excavated materials now being taken out, 500,000 to 800,000 cubic yards are being placed along the embankment of the old Croton aqueduct, in Van Cortlandt Park, which adjoins the reservoir ground on the north, in order to build the embankment for a park drive; some of the spoil is being used to grade streets and for filling in the botanical gardens in the Bronx Park, east of the reservoir.

All the stone required for the rubble and ashlar masonry in the walls and chambers has been obtained from the excavations in the reservoir, which have yielded gneiss of good quality in good-sized blocks. Much of this stone, when in place in the structures, resembles, when viewed from a little distance, a light-colored limestone and presents a satisfactory and pleasing appearance for the purposes to which it has been applied. For copings and other cut-stone work on the walls and in the gate chambers gray granite from Maine quarries has been used. Some of the gneiss, however, is hornblendic and almost black. Irregular fragments of stone from the quarries and excavations have been sent to the crushing plant, situated near the middle of the easterly side of the reservoir, and broken for concrete material. This broken stone is stored in a large pile near the crusher house, which now contains, roughly, 150,000 cubic yards, or about three-quarters of the quantity needed. Formerly only 1-inch and 2-inch stone was stored for use as concrete aggegate; now the run-of-the-crusher is sent to the pile, only the screenings or "dust" passing a ¼-inch mesh being separated out. These screenings are used as sand in mortar and concrete, and a pile of about 20,000 cubic yards has been accumulated beside the stone pile. Giant Portland cement is used exclusively for all the work.

A superficial glance at a large heap of the screenings gives one the impression that the very fine dust predominates in quantity, but that this is not actually so is made apparent by the results of a careful mechanical analysis made with accurate sand-analysis screens. The tabulation of such an analysis is given below. An examination under a microscope shows that the small particles have the same sharp, jagged shapes as the larger fragments of broken stone, and under a lens of high power this is seen to be true also of even the finest dust. Mortar made of this material and used in the masonry is satisfactory in all respects, as far as observed. Large piles of rock fragments suitable for crushing have also been accumulated in the northwesterly part of the west basin, near one of the embankments which are to be paved with concrete.

Mechanical Analysis of Screenings.

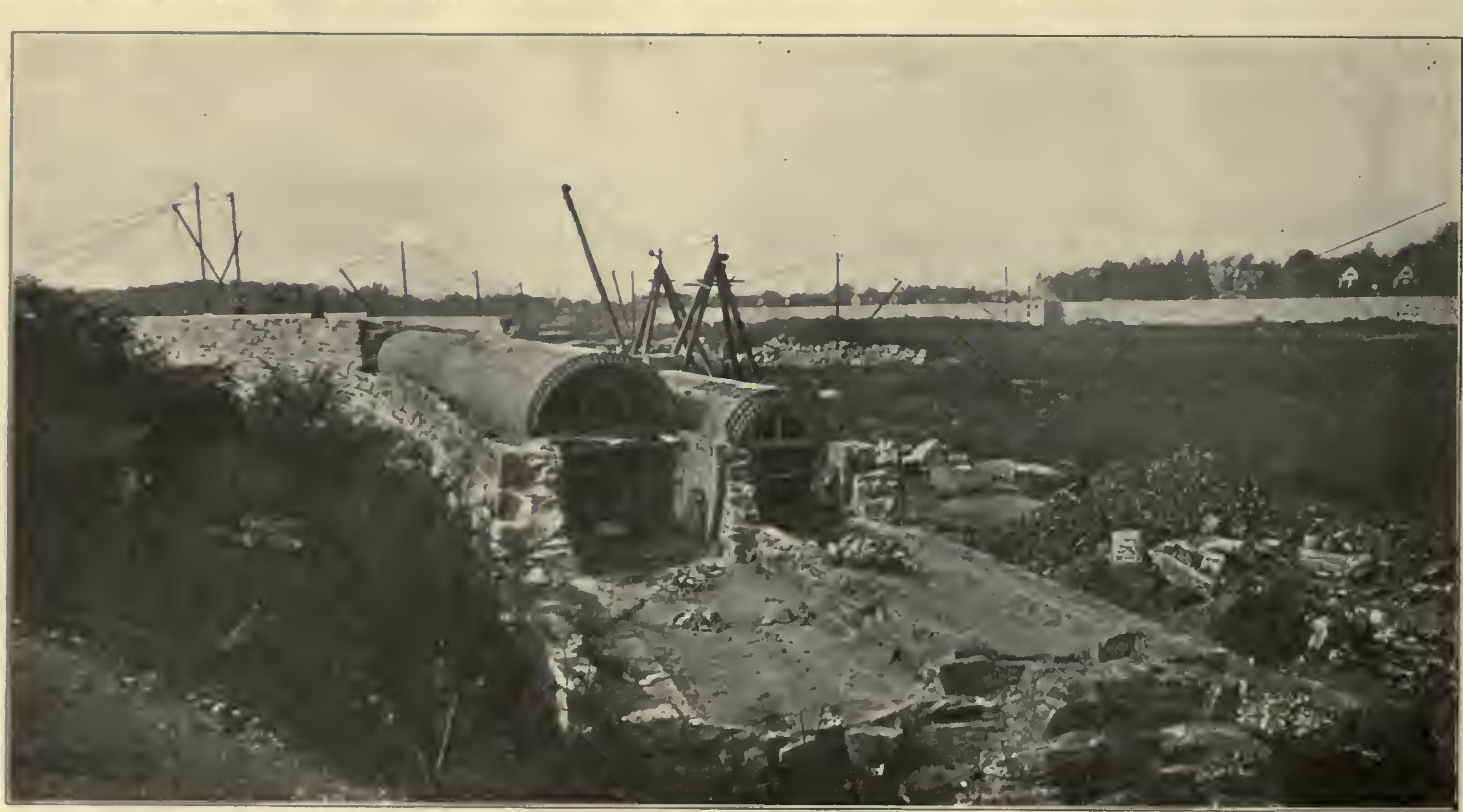
Retained on—	Parts.
.35 inch mesh sieve	4
.27 " "	14
.20 " "	36
.15 " "	42
.10 " "	57
No. 10 sieve	31
No. 15 "	58
No. 20 "	42
No. 30 "	117
No. 40 "	86
No. 50 "	56
No. 74 "	227
No. 100 "	59
No. 150 "	67
No. 200 "	38
Below 200	66
Total	1,000

Four concrete-mixing plants are being installed at convenient points for the delivery of concrete. One of these plants will probably contain two, and each of the other one 2½-cubic-yard concrete mixers made by the Thomas Carlin's Sons Company, of Allegheny, Pa., each driven by a small engine built by the Erie Pump & Engine Company, of Erie, Pa. Tracks will be laid to transport the materials in cars to the mixers and to carry the concrete away to the places where it is to be deposited. The capacity of the four mixing plants is expected to be about 800 cubic yards per day.

For 5,000 feet, where an embankment with core wall was shown on the original plans, a rubble retaining wall with one face exposed to the water has been substituted. This modification has effected a saving of several thousand dollars and a gain of about 26,000,000 gallons in the capacity of the reservoir, which is valued at about one-half cent per gallon, figured on the basis of the cost of the reservoir. These walls are 3 feet thick at the top and have batters of 3 inches per foot on the front, or water face, and 2 inches per foot on the back, to a thickness of 15.5 feet, where the height is sufficient, below which the thickness is uniform. The retaining walls are founded on sound rock throughout their length, which is prepared by removing all loose and soft material and disintegrated rock, cleaning thoroughly with water jets and brooms, and plugging with cement the few open seams which occur.

The backing of these walls is made of selected earth from which stones larger than 3 inches are thrown out. Usually the material has been dumped from narrow-gauge cars along the edge of the trench back of the wall and washed in with streams of water from hose. After the filling and puddling of the lowest part of the trench, steps or terraces about 12 to 18 feet long are formed of the earth filling, rising along the back of the wall. Small earth rams 8 to 10 inches high are then formed across the trench at the edge of each step, and the shallow basins thus made are filled with water, part of which percolates from the upper basins to the lower and part sinks directly downwards into the earth. By this method the filling is thoroughly puddled and washed into all the irregularities of the rough rubble back of the wall.

The old Croton aqueduct traverses the reservoir from north to south following a straight course and being in an embankment for the greater part of the distance; the new Croton aqueduct, which also crosses the reservoir site, is a tunnel at an average depth of 115 feet below the natural surface of the ground. Although the designs contemplated preserving the continuity of the old aqueduct through the reservoir so that it could convey water directly to the city, no part of the portion of this aqueduct within the reservoir could be utilized; to accomplish the purpose a corresponding aqueduct is incorporated in the division wall, as previously mentioned. There are several reasons for this: The old aqueduct was not conveniently located for incorporation in the new work nor was it of suitable construction; it was advisable to maintain the aqueduct for as long a time as possible in such condition that it could quickly be put into service in case of emergency; furthermore, in many places this portion of the old aqueduct is cracked, and portions of it are on foundation embankment. It was necessary to found the division wall on rock throughout its length, and the most economical location does not follow the line of the old aqueduct, so, that the new structure has been built for almost its entire length without interfering with the old aqueduct. For convenience of construction operations, however, the contractors were permitted to cut through the old aqueduct embankment a gap wide enough to lay a construction railway. A wooden flume was provided at this place to connect the two portions. The line of the division wall crosses the old aqueduct, and at this place and two others there are gaps where the wall has not yet been built. These three gaps amount to 900 linear feet and will be closed this season. In these places concrete will be used instead of brick and stone, except for the ashlar faces of the wall.



Jerome Park Reservoir: New and Old Croton Aqueducts in Division Wall North of Central Gatehouse, West Basin in Background.

Connection with the new aqueduct will be made at a point about 4,600 feet north of the northerly boundary of the reservoir, whence an aqueduct of the same cross-section as the new Croton aqueduct will be constructed in trench close beside the old aqueduct embankment, the distance between center lines being uniformly 50 feet, to the northerly line of the reservoir. Originally it was intended to build this aqueduct of rubble and brick masonry, but the plans have been modified to use concrete, because better results can be obtained and time saved. Much of the trench for this section of aqueduct has been excavated and the work of finishing the excavation and placing the concrete is now in progress. From the northerly embankment of the reservoir this aqueduct together with the substitute for the old Croton aqueduct is carried in the division wall to the main gate chamber. One of the open shafts of the new aqueduct tunnel, known as shaft No. 21, is situated in the center of the reservoir, about 227 feet west of the main gate chamber. A second connection with the new aqueduct has been made at this shaft, as indicated by the accompanying photographs.

The first illustration is a general view of the westerly basin looking north from the southerly end, taken about the middle of March, this spring. At the right is the division wall and at the left a portion of the retaining or breast wall ready to receive the earth backing. As indicated, a large proportion of the bottom of this basin has been brought nearly to grade and can rapidly be made ready for the concrete lining.

The second view, looking northward, shows the completed substructure on Gatehouse No. 5, the principal gatehouse, with the base course of cut granite ready for the superstructure. It also shows portions of the division wall and of the arched causeway leading to shaft No. 21 of the new Croton aqueduct. Gatehouse No. 2 is seen in the background, and at the extreme right of the picture is the embankment of the old Croton aqueduct. Beneath the causeway arches is the 11-foot circular brick conduit, by means of which water may be let into the new Croton aqueduct; this conduit is under pressure when in use, and whenever it may be emptied while the reservoir is full the weight of the causeway will counteract any possible buoyancy. The by-pass conduit, carrying the old Croton aqueduct around the gatehouse is under the platform at the west of the base for the superstructure.

The third photograph shows the construction of the portion of the division wall north of Gatehouse No. 5, looking south. This portion of the wall contains, in the left or easterly side, the part of the connecting conduit from the new Croton aqueduct which is within the reservoir and the new conduit to replace the old Croton aqueduct. The former is 11.40 feet wide and 13.53 feet high, and the latter is 7.42x8.46 feet.

The fourth view was taken near the southerly end of the reservoir and shows the construction of the division wall south of Gatehouse No. 5, indicating the character of the ashlar facing above elevation 121.5 and the rubble masonry, used throughout the length of the wall. In the lower part of the wall can be seen the two 12-foot circular outlet conduits leading from the central gatehouse nearly to the southern extremity of the west basin, providing means for discharging water into the reservoir at this end for purposes of circulation. The outlet end of the east conduit appears in the picture. As will be perceived, the west conduit could not be conveniently ended in the same way because the new conduit for the old Croton aqueduct, which it supports, continues on through the reservoir; its outlet is directly opposite that of the east conduit and is shown in the first illustration, being arranged for the water to issue at right angles to the wall. The picture was taken in March, 1900, and the background gives some idea of the heavy cutting required for a considerable portion of the reservoir. Provision has also been made for letting water into each basin at the northern extremity.

The fifth illustration shows the construction of the aqueduct leading from the new Croton aqueduct at Gatehouse No. 1 to the reservoir. The embankment of the old Croton aqueduct is at the right. The Aqueduct Commissioners are preparing an extensive and interesting exhibit of the great water-works system of New York to be shown at the St. Louis Exposition. Through the courtesy of the commissioners and their chief engineer some of the photographs which are to form a part of the exhibit have been reproduced with this article. The St. Louis exhibit will include, also, a large wooden model of the substructure of Gatehouse No. 5.

Mr. J. Waldo Smith is chief engineer for the Aqueduct Commissioners, and the work described is now being done under his general supervision. Mr. Daniel Ulrich is the division engineer in immediate charge of construction, and the designs were prepared under the direction of Mr. F. S. Cook, in charge of the drafting department. Messrs. McDonald & Onderdonk are the contractors.

General Rules for Construction Work, Illinois Central Railroad.

The Illinois Central Railroad Company has recently prepared some general rules to govern construction on its system. The work of this nature is in charge of Mr. A. S. Baldwin, engineer of construction, and comes under the general direction of Mr. John F. Wallace, general manager, and Mr. W. J. Harahan, assistant general manager, who sign the rules mentioned. These are particularly interesting because the Illinois Central lines are kept in a condition of high efficiency, and its new roads, particularly in the South, have attracted a large amount of attention.

In this work of construction the resident engineer reports to and receives his instructions from an assistant engineer, as a rule, and is responsible for the work of the instrumentmen, rodmen, chainmen, track apprentices and axemen assigned to him. He is required to maintain a careful supervision over the work of his subordinates and keep them employed constantly. Cases of negligence, incapacity or insubordination are required to be reported promptly to the assistant engineer. Whenever it becomes possible for the engineering force to be reduced the assistant engineer must be notified in order that there may be a reassignment of forces without loss of time.

All grading and trestle work which is not done by the company's forces, as well as all other work assigned by the assistant engineer, is in charge of the resident engineer under these regulations. Instruments are furnished by the company in accordance with the needs of the work, and the resident engineer is required to furnish a complete list of them, showing their condition, upon taking charge of the work; on his removal or exchange he is required to account for all of them, and when a transfer is made the list must be signed by both parties concerned. A personal inspection of the work must be made as frequently as possible by the engineering corps; the resident engineer inspecting it daily, except when necessarily engaged in the office on estimates or other work of that character. When so engaged the work must be inspected by one of his subordinates.

The first duty of the resident engineer on taking charge of a piece of work is to check it over carefully from one end of the residency to the other, both as to alignment and levels. When the line of check levels is run, permanent bench marks must be fixed at convenient points at least every half mile in level country, every one thousand feet in hilly regions, and in the vicinity of water courses or depressions where bridge structures are likely to be erected. At every bench the elevation must be marked. Where possible, tangents must be run to intersection on the ground. All turning points on tangents must be double-centered, and they must be checked by the foresight method. No excuse is accepted by the Illinois Central Railroad Company for irregularity in the line of tangents.

The beginning and ending points of all curves must be located by measurement from the point of intersection of the two tangents unless it is impracticable to do so. When this cannot be done a traverse line must be run with as long a chord or chords as possible, connecting the tangents, and the P. C. and P. T. located therefrom as a check on the accuracy of the original location. All curves of 2 degrees or over must be connected to tangents by spiral curves. The junction point of all compound curves in which the radius of either is over that of a 2-degree curve and all reverse curves must be connected by spiral curves also. When a tangent between two curves is so short as not to permit spirals of full length, the spirals must be apportioned to the curves in direct proportion to their degrees of curvature.

The point of spiral, point of circular curve and a sufficient number of centers on both curves and tangents to enable them to be easily reproduced, must be carefully referenced. The reference points must be made as durable as possible and must be sufficiently far from the center line to be safe from disturbance during construction. The magnetic bearing must be read on reference lines and a record made of the reading in the note book, with a careful description of the points.

When discrepancies are found between the old and new surveys for alignment, levels or chaining, an immediate correction must be made and a memorandum of it sent to the assistant engineer, with a statement of the changes required. If an adjoining residency is involved the engineer of it is also notified.

All ground on which both excavations and embankments are to be made must be carefully cross-sectioned, such sections being taken and the slope stakes set at full stations and at as many intermediate points as may be necessary to cover fully the irregularities of the surface. The calculations for areas in cubic yards must be checked and their accuracy verified before entering in the final record book. From time to time as the work of cross-sectioning proceeds, the assistant engineer is furnished notes and plats of cross-sections showing their area and cubical contents for both cuts and fills. Two copies of the complete profile of the line are prepared from the field notes, one for office use and one for the assistant engineer; on this profile is marked the quantity of each cut or fill. Where the profile is for a second track, it is prepared from the cross-section notes under the assumption that the center line elevation is the elevation of the ground at the outer slope stake. In submitting profiles the resident engineer puts in the grade lines in pencil; these are merely suggestions, however, and are not acted upon until duly authorized. All grades are compensated on curves at the rate of 0.04 foot for each degree of curvature.

The correct proportioning of waterways to the area drained and the size of streams must be carefully investigated, and where there is reason to believe that the opening is either insufficient in size or unnecessarily large the attention of the assistant engineer must be called to the fact. Where waterways are in the vicinity of an established roadbed the openings in the latter must be carefully examined and the division officers consulted as to their efficiency.

The regulations lay special stress on the need

Jerome Park Reservoir: Division Wall near South End of East Basin, Showing Old Croton Aqueduct, Outlet Conduits, and End of East Conduit.

of drainage in general. Surface and right-of-way ditches must be carefully laid out and neatly finished, great care being taken to keep the water away from the foot of embankments and the slopes of the cuts. The roadbed ditches must be finished in accordance with the company's standard plans as the work progresses. Head walls of culverts and retaining walls must be laid out so as to make a neat fit with the slopes of the embankments. All standard cross-sections and plans are furnished to the resident engineers by the assistant engineers.

The Illinois Central Railroad Company has adopted the following scales for its standard drawings: 100 feet to the inch for all ordinary plats, 50 feet to the inch for plats requiring more details than can be shown on the 100-foot scale, 200 to 400 feet to the inch for plats which would be rendered too bulky by using the larger scales. Smaller scales than these are employed only when absolutely necessary. The object of these drafting rules is to obtain plats which can be scaled with a foot rule with the least amount of calculation, and, for convenience of folding, will be either the size of a sheet of letter paper or multiples of that size. In attaching them to letters the company insists on their being fastened in the upper left hand corner in such a way as to unfold without being fastened.

The following data must be given on every plat made for the company: The points of the compass must be indicated, exactly if possible and approximately in any case, the fact that the location is approximate being so stated. The names of the terminals of the line at both ends must be shown. The title, scale, date and office where the drawing is made must be indicated. On all plans involving tracks the names and numbers by which the tracks are known must be given.

Where changes are proposed the company requires the present arrangement to be shown in solid black lines on tracings and solid white lines on blueprints, while the proposed arrangement is indicated in dotted red lines on tracings and solid red lines on blueprints. When color shading is employed to distinguish between different owners red is always used to denote the company's property.

Where material is to be borrowed, if within the economical reach of a cutting, the cut must be taken out and sloped in the first instance of sufficient width to furnish all that is needed. Irregular and unsightly holes on the company's right of way are strictly prohibited. Where there is excess of material from cuts it must be wasted evenly and in such shape as to form a grade for an additional track, unless considerable expense will be incurred in so doing. Under the latter circumstance the advice of the assistant engineer concerning the disposal of the material must be sought.

Where borrow pits are made they must be regular in shape and graded so as to drain out all water that comes into them. They must be staked out to the width and depth of the cutting required. No borrow pit that will form a pond must be allowed, without express permission from the assistant engineer. Where possible borrow pits must be made in the form of continuous ditches, parallel with the center line, and the side slope must be the same as in cuts.

A berm at least 6 feet in width and 10 feet if practicable is to be left between the top of the slope of the borrow pit and the foot of the slope of the fill.

The surfaces of old embankments or natural slopes in side-hill work must be freed from vegetable matter and well benched, either by plowing or shoveling, before new material is deposited on them.

Great care should be exercised in providing for shrinkage, both horizontally and vertically. The rate of shrinkage varies so greatly in different materials that experience and judgment are necessary in providing properly for it, and on this account the regulations require the resident engineer to consult with the assistant engineer before determining the allowance for large embankments. The slopes of cuts must be taken out close to the proper section as the work progresses, and must be neatly trimmed to the final section before the last estimates are made. Embankments must have an even crown with the surface true to grade. The edges must be neatly trimmed to a line parallel with the center line and the side slopes must be regular. Loose rock must not be allowed to remain on the slopes of cuts or near enough to the slopes to be in danger of rolling into the cut if undermined by water. The resident engineer is particularly directed to anticipate the needs of the contractors in setting necessary center, grade and slope stakes.

The requirements for monthly estimates on this road read as follows: "At the end of each month measurements must be taken and computations made of the amount of work done at the end of the month, and a record of the same sent to the assistant engineer for his use in making up the monthly estimate of the work done. This record must bear the personal signatures of the resident engineer, instrumentman and rodman, if any; if not, that of the engineer who checks the calculations. With this must be sent a profile showing in color the progress of the work during the month, the standard color for each month being used. Under no circumstance must the amount of work done be over-estimated."

Jerome Park Reservoir: Connecting Aqueduct from New Croton Aqueduct to Reservoir.

The regulations regarding the oversight of the contractor's force are very simple. A daily record of the number of men employed on the work must be kept so as to show both their distribution and location. A weekly report of the progress of the work by sections and by miles must be made. This gives the average force employed and the place where the men are located, and an account of all incidents of importance connected with the construction. Care must be taken by the resident engineer to keep in touch with the assistant engineer at all times and to keep him fully posted regarding the progress of the work. The regulations require the weekly report to be sent to the assistant engineer every Saturday evening. Where a contractor is employed to do work on force account the engineer has to direct the work and keep an accurate record of the time. When the bill is submitted, the record of the engineer's check must accompany it.

The rules are quite explicit with respect to the attention to be paid by the resident engineers to property abutting on the right of way. Fences and cattle guards must be properly maintained during the progress of the work so as to avoid damage to stock or crops. Standard boundary posts must be located at all important property corners. If the standard posts cannot be had stout stakes about 4 inches square and long enough to stand 2 feet above ground when planted must be used. One side of these stakes must be trimmed and the letters "I. C. R. R." printed on it. Particular care must be taken to prevent any encroachment on the company's property.

One of the most important methods of obtaining friendly relations between a railway and the owners of abutting property is for the engineers engaged on construction to treat every one with whom they come in contact with all possible courtesy. In the regulations of the Illinois Central Railroad Company this idea is particularly emphasized, as the following quotation indicates: "Endeavor must be made to maintain a friendly relationship with people living along the line of the work, and a feeling of friendliness toward the company must be cultivated. Where sentiment exists adverse to the company a report of the same must be made and an endeavor made to correct it." In the same way instructions are very definite on the necessity of exercising extreme care to avoid the breaking of telegraph wires. In case of any such breakage an immediate report must be made to the assistant engineer, stating the number of wires broken, the cause and time of the breakage, when it was repaired, and the name of the person responsible for the breakage.

The relation between the engineering department and the contractors is defined explicitly by the company's rules. No information must be given to any contractor, sub-contractor or any other person by the resident engineer as to probable quantities of work done or to be done, nor may he allow his subordinates to give any. Inquiries for such information must be referred to the assistant engineer. "Great tact must be exercised by the resident engineer in dealing with contractors. The fact must be borne in mind that not only is it the duty of the resident engineer to see that the contractors perform their work properly, but he must facilitate their work and render them every assistance in his power. Sub-contractors are but the agents of contractors. They must be dealt with as such, and when addressed in writing it must always be as agents of the principal contractors."

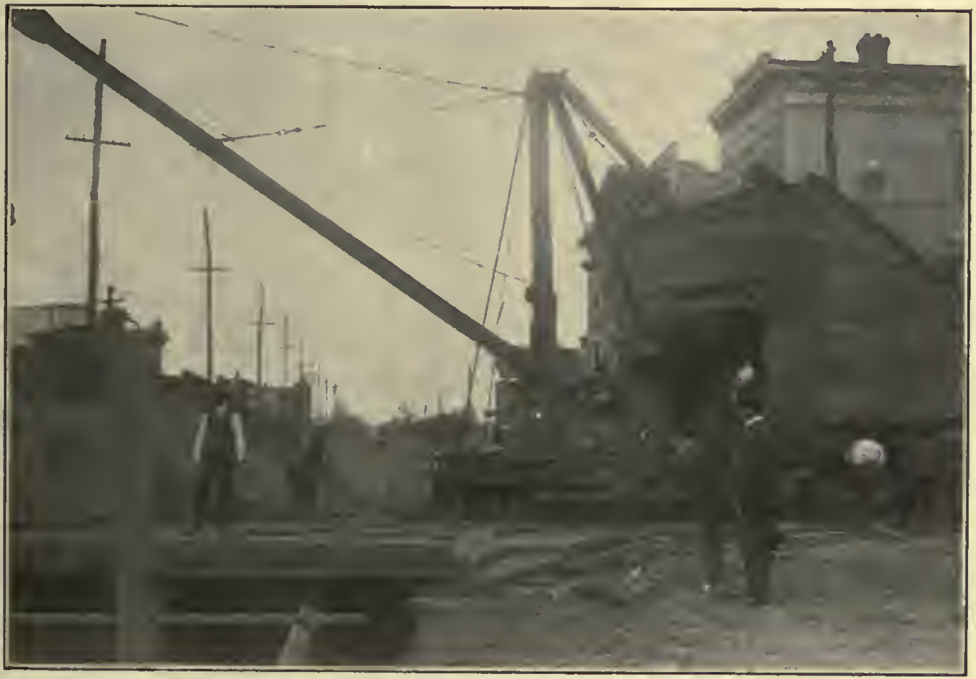
Notes made during the day must be entered at night in ink in the final record book, and all notes must be made with such care and system that in case of a reassignment of the force there will be no trouble on the part of a man new to the work taking them up and understanding them. Copies must be kept of all letters relating to the company's business. The final record and estimate book must contain alignment and level notes for the entire residency; original and final cross-section notes of all cuts, fills and borrow pits, with the final calculations of areas and quantities; descriptions and memoranda of the location of borrow pits, descriptions of all bench marks and their elevations, and the dates of completion of all important work.

The final profile must show grade lines with the gradient given, and all stations at changes, with their elevations indicated; alignment notes of the stations at the beginning and end of all curves; the location of mile posts as computed from the starting point of the line; the width of right-of-way land, names of adjoining property holders, and the stations at which their land lines intersect the center line of the tracks; the stations at all bridge piers, abutments and culverts; the beginning and ending of all trestles; the location of towns and depots, water tanks, side tracks and other similar information of importance.

Extensions of Brooklyn Sewerage System; Avenue G Trunk Sewer.—II.

The upper end of the sewer, from Coney Island Avenue to Avenue G and East Fifty-third street, was constructed last year, excepting a gap at Flatbush Avenue and Avenue G, which was left over the winter to avoid serious interruption of street-car service during a period of particularly heavy traffic in the fall, when large crowds are carried to the race tracks in the extreme southeasterly part of the borough. The principal portion remaining to be built is 2,200 feet of 90-inch circular brick sewer near the outlet, on which work was resumed March 28.

The street laterals connecting with this trunk sewer are 15 and 18 inches in diameter. The positions of the Y-branches placed for future sewers are located from the manholes and marked on tracings by the sewer inspectors, from which they are platted in record books filed in the bureau office for reference. Besides these there are several connections with large collecting sewers. At the intersection of Avenue G and Flatbush Avenue a 48-inch brick sewer built about fifteen years ago is to be connected; this sewer drains the territory known as Flatbush and discharges into the bay, but the city has been ordered by the courts to divert this sewage to another outlet. In excavating the trench across Flatbush Avenue the sheeting used for the trench of the old 48-inch sewer was uncovered. Although it had been in the ground for about fifteen years this lumber was sound, even to the top, which was within 3 feet of the street surface.



Brooklyn Sewers: Moving an Excavating Machine around a Curve.

At this point the new sewer, which is egg-shaped, passed underneath the old sewer, which is circular, so close to the bottom of the latter that there was room for only one complete ring of brickwork in the new arch. As much of the second ring was built as feasible, and then the intersection was inclosed in a box, by placing cross-sheeting, and a block of Portland cement concrete formed around the two sewers from the arch of the new sewer to the springing line of the old. The bottom of this concrete block, at the side of the new sewer, is 14 inches wide and on each side rests on undisturbed material.

In Avenue G at Nostrand Avenue the 60-inch sewer intersects a 36-inch brick sewer from the opposite direction and the two are combined into a 66-inch sewer in Nostrand Avenue. At Avenue F this 66-inch sewer meets the 48-inch sewer from the opposite direction and also the 42-inch sewer from the west in Avenue F; the three are united into the 84-inch sewer, which continues the line eastward. At Utica Avenue the diameter is increased to 90 inches, and at Avenue H provision is made for connecting a 30-inch sewer to be built in that avenue.

The intersection of the four large brick sewers at Avenue F and Nostrand Avenue is the most important junction on this line and embodies the principle adopted, excepting where local conditions prevent, in the construction of all intersections of large sewers. An accompanying sketch plan shows in a general way the layout at this point. The scheme followed is to bring the sewers together so that their center lines will be tangent on the plan and so that there will be no break in the grade of the inverts, the aim being to direct the flowing sewage as nearly as practicable along the center of the large sewer. As indicated, the 42, 48 and 66-inch sewers are egg-shaped and the 84-inch is circular. The 84-inch was made a continuation of the 66-inch by means of a special section 20 feet long, which is followed by a 90-degree curve of 40 feet radius in the 84-inch sewer, making the required change of direction from one avenue to the other. The 42-inch and 48-inch sewers enter on the convex side of this curve. The transformation from the 66-inch egg-shape to the 84-inch circular was built by laying the brickwork to lines stretched between the ends of the regular portions of the sewer.

Surplus material from the trenches, when of proper quality, is used for embanking over and around those portions of the sewer which are partially above the existing surface, thus forming a portion of the filling required to bring the low places in the proposed streets to grade. An embankment at least 3 feet deep above the top of the sewer and, for the 84-inch and 90-inch sewer, 15 feet wide on top, with 1½ to 1 slopes is required. While at some places the embankment has been made somewhat wider than the standard width, the available surplus is not sufficient to build all the embankment required. The deficiency will be supplied from borrow pits and from the trench for the Flatlands Avenue sewer, which is being constructed by the same contractor. For handling this material a narrow-gauge track has been laid along the larger part of the sewer, on which dump cars have been run.

The larger trenches were excavated with the aid of traveling diggers, or excavating machines, described last week. The accompanying view shows one of these machines in detail and indicates the method of moving it around a sharp curve in the line, from one street to another.

A good bottom to support the sewer has been found throughout the trench as far as excavated, excepting for a distance of 300 feet in the marsh, near Albany Avenue, where bents of 10-inch round piles about 25 feet long were used. There are four piles in each bent spaced 3 feet 7 inches on centers, and the bents are 5 feet apart. The piles are capped with 10 x 10-inch longitudinal timbers, on which 6 x 8-inch pieces are laid transversely close together to form a platform for the sewer. The timber used in foundation will be always below the spring-water level. For the portion of the trench not yet excavated there are indications that an excellent bottom will be found all the way to the silt and trap basin, as well as for the basin.

The manholes are mostly of the usual type of brick construction and are placed at each connection with a lateral or other intercepted sewer and at the beginning and end of each curve. If the distance between two of the points mentioned is greater than about 400 feet, intermediate manholes are placed so that in no case on this sewer does the distance from one manhole to the next exceed 300 feet. Experience with the older sewers of the borough has shown that it is dangerous, as well as uneconomical whenever cleaning is necessary, to have the manholes more than about 400 feet apart on large sewers. Numerous cases are on record in which men at work in the large sewers have just escaped with their lives when a sudden heavy shower came up. Some sewers, even as large as 12 feet in diameter, have been filled so that they were flowing full within 15 or 20 minutes after the beginning of a heavy rain, owing to the rapid runoff from the impervious street pavements and roofs covering practically the whole tributary watershed. This is especially the case where there are large areas of asphalt pavement, the runoff from which practically all passes into the sewers within a few minutes after precipitation.

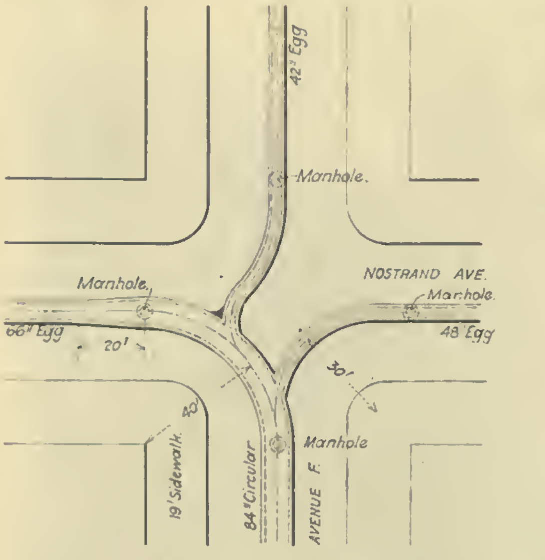
Good clean sand for mortar and concrete has been obtained from the trench in a number of places. No gravel suitable for concrete has been gotten from the excavations and broken stone was used exclusively. All mixing of concrete as well as mortar has been done by hand. Several brands of American and imported Portland cements have been used, among them Giant, Atlas, Adirondack, Stettin-Girstow, Alsen and Reliance. The bricks used are all North River brick. The vitrified pipes were furnished in 3-foot lengths by the Contractors' Supply Company, of New York. The joints in the pipe sewers were filled with mortar made of equal parts of Portland cement and sand. Before laying the pipes at any time, the contractor was required to have 60 feet of foundation concrete in the trench and ready to receive them. A few exceptions were made and shorter stretches allowed to be laid at curves and other special places.

At its outlet this sewer terminates in a temporary purification, silt and trap basin 60 feet wide and 80 feet long. The discharge from the basin will flow through the creek into Jamaica Bay at a point near its entrance, and thence into the ocean south of Long Island. The water of the bay is comparatively shallow and within a few miles of the sewer outlet are a number of popular beach resorts; as there are no strong favorable currents the discharge of crude sewage amid these surroundings would create a nuisance. Provision has been made, therefore, for treating the dry-weather flow in the basin before discharging it into the creek.

This arrangement for treating the house sewage at this point is a temporary expedient; it is anticipated that in the near future the house sewage will be intercepted and pumped through a 30-inch force main over a summit, whence it will flow by gravity through 72, 120, 126, 138, 48, 132 and 187-inch sewers, forming part of the sewer system of that section of the borough, to a large permanent plant for treating the sewage chemically. The pumping station is to be built just across the creek from the silt basin and is to be equipped for the present with pumps of a capacity of about 10,000,000 gallons per day. The permanent chemical plant is in the portion of the borough known as East New York and is situated near the shore, about 5¾ miles distant, as the sewage will flow, from the pumping station. This plant also discharges into Jamaica Bay.

Returning to the silt basin now under construction as a part of the Avenue G sewer—it is located on the southerly side of Paerdegat Basin at the intersection of Paerdegat and Flatlands avenues and is to be also the terminus of a 120-inch sewer recently put under construction in Flatlands Avenue to serve a large district east of the Avenue G sewer. Flatlands Avenue sewer will enter the silt and trap basin on its south side, at right angles to the Avenue G sewer. Accompanying drawings indicate the construction of the basin. It is divided longitudinally into two equal parts, each containing a receiving chamber about 59 feet long and 29 feet wide and an outlet chamber 19 feet long and 29 feet wide. Exterior and division walls alike are of 10x10-inch splined and grooved yellow pine sheet piling and the roof, or covering platform, is of 2-inch splined and grooved flooring on 3x12-inch joists spaced 18 inches on centers and supported on 10x10-inch transverse beams 10 feet apart. The floor is to be of Portland cement concrete 2 feet thick laid directly on the sand and gravel forming the bottom of the excavation.

The floor surface is to be 8 feet below mean high water and the top of the roof platform 7½ feet above this datum, so that the chambers will have a height inside of about 14 feet. The sheet piles are about 28 feet long, and, as the first step in the construction of the basin, all of them were driven to the required depth of about 10 feet below the floor. Afterwards the enclosed material was excavated to the required depth and placed around the walls, being finished with slopes of 1½ to 1. Besides the sheet piles twenty-four 10x10-inch bearing piles were driven at the points indicated on the plan to aid in supporting the roof platform and a system of 10x10-inch intermediate horizontal bracing 5 feet above the floor. The tops of the sheet piles forming the walls are secured in alignment by 10x10-inch waling pieces inside and outside with 1-inch through bolts spaced about 5 feet apart. All the heavy timber construction is thoroughly fastened together by large drift bolts.



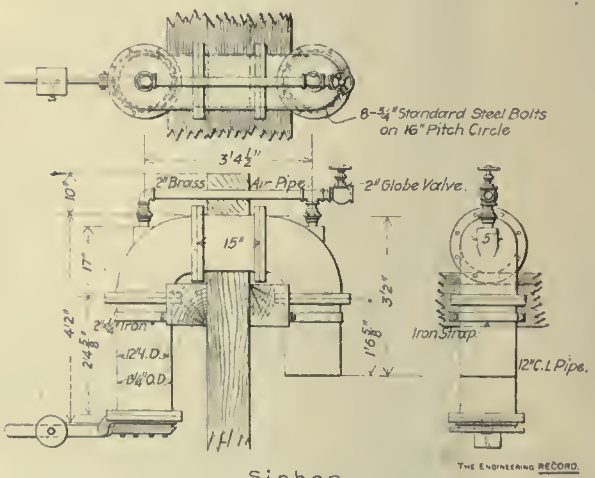
Sewer Intersection at Avenue F and Nostrand Avenue.

The Engineering Record.

Typical Intersection of Large Sewers, Brooklyn.

On the roof platform of the silt basin, over the intersection of the division walls, there is to be a light frame superstructure 35 feet long and 15 feet wide inside, which will house the chemical measuring, mixing and feeding apparatus and a stock of the chemicals. Near this building there will stand on the platform a timber trestle tower about 9 feet high supporting a 3,000-gallon cypress tank 7½ feet in diameter and 9 feet high inside, to contain a supply of clean water to be used for mixing the chemicals. The supply of water is to be gotten from a well to be driven through the floor of the basin to a sufficient depth to obtain a sure and constant supply of at least 3,000 gallons per hour of fresh water. The water is to be drawn from the well and delivered into the tank by a force pump driven by a Mietz & Weiss kerosene engine or one equal thereto, according to the specifications, to be located in the small frame building mentioned above.

Avenue G sewer is to terminate at the west wall of the basin, its center line being at the longitudinal division wall. In its last 15 feet the shape of the sewer will be changed from a 90-inch circle to the section having a rectangular lower part and an arched top shown in one of the drawings. The end of the sewer will be finished by a brick portal wall 3 feet 3 inches thick, 15 feet wide and 11½ feet high, and its waterway partially closed by a concrete wall 2 feet thick and 4 feet high. This concrete wall will be pierced by two openings 24 inches square, each controlled by a Coffin sluice gate operated by a hand wheel on the platform above. By means of these gates the discharge of the dry-weather flow can be regulated and the sewage directed into either one or into both of the receiving chambers. Storm water, of course, can be passed not only through the gates, but also over the concrete wall. The effluent of the dry-weather sewage, after chemical treatment and subsidence, is to be drawn from either receiving chamber into the corresponding discharge chamber through two 12-inch siphons, details of which are shown herewith. Two similar siphons in the easterly end wall will pass the effluent from the discharge chambers to the creek channel, which is to be excavated to a depth of 4 feet below mean high water.



Siphon.

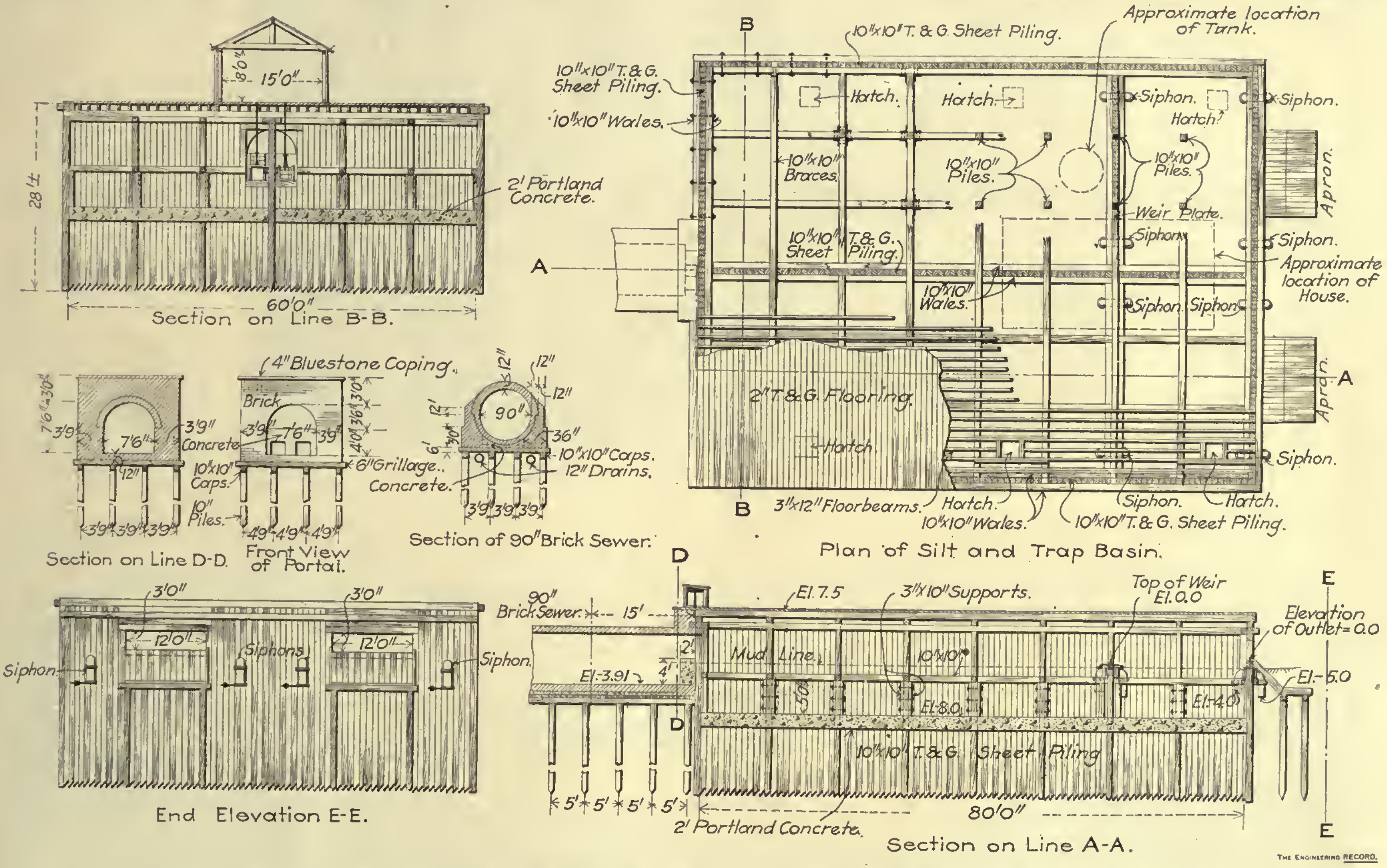
The Engineering Record.

Details of Siphon in Purification Basin.

The top of the transverse division wall is about 9 feet above the floor, and over it storm water can flow in large volume into the discharge chambers, and from them through two openings 3 feet high and 12 feet wide in the easterly end wall of the basin. The water from each of these large openings will fall upon a heavy wooden apron supported on 10x10-inch square bearing piles, as shown. Each siphon is provided with a counterweighted foot valve. Their air pipes and fittings are of brass and the foot-valve seats of composition of 88 parts copper, 10 parts tin and 2 parts zinc. The valves have rubber rings 1 inch wide let into an annular groove to bear against these seats.

The Avenue G trunk sewer was designed and is being constructed under the direction of Mr. Henry R. Asserson, M. Am. Soc. C. E., chief engineer of sewers, Borough of Brooklyn. Mr. George T. Hammond is the division engineer in immediate charge. Mr. John McNamee, of Brooklyn, is the contractor. The total cost of the work covered by the contract is estimated at $315,000. The sewer in Flatlands Avenue, referred to above, is a part of the system, and, although a separate contract, is being constructed under the direction of the same engineering force in connection with the Avenue G sewer. Contractor McNamee, as intimated earlier in the article, has both contracts. The estimated cost of the Flatlands Avenue sewer is $323,000, making the total estimated cost of these main trunk sewers in this system $638,000. This does not include the lateral trunks and the lateral sewers, the estimated cost of which will fully double the figure just given. Several miles of lateral sewers, not included in the contracts mentioned, have already been completed and are ready to be connected with the main trunks as soon as an outlet is secured. The time allowed the contractor for completing the work on each of the contracts for Avenue G and Flatlands Avenue sewers is 300 working days; no working days are counted between December 15 and March 15 of each year.

A 1,000-Foot-Span Power Transmission line that recalls the notable 4,427-foot Carquinez Straits crossing described in The Engineering Record of June 22, 1901, has been stretched between two steel towers for carrying 250-volt direct current to the Homestead steel works, near Pittsburg. It consists of four 800,000-circular-mil aluminum cables attached to the towers through strain insulators. The weight of each cable including a coating of ¼ inch of ice was calculated as 1.125 pounds per linear foot, and the stress of the wind, acting at right angles to this, at 40 pounds per square inch of the cross-section of the ice-covered wire, was shown to be 4.166 pounds, giving a resultant load of 4.31 pounds per foot. With a winter deflection at the center of the catenary of 28.4 feet, the maximum allowable sag being 35 feet, the stress in each cable was found to be 19,000 pounds. Further details are given in a recent article in the "Electrical World and Engineer."



Brooklyn Sewers: Purification, Silt and Trap Basin at the Outlet of Avenue G and Flatlands Avenue Trunk Sewers.

An Indestructible Viaduct.

About twenty-five years ago when the main line of the Canadian Pacific Railway was under construction a remarkable accident occurred on Section B, near Rat Portage, where a trestle viaduct was accidently dynamited under a moving train, and the latter escaped without injury. The fact appears almost incredible, but is circumstantially related and vouched for by Mr. William Robinson, who was then division engineer in charge of construction and directed the repairs to the injured trestle.

Nitro-glycerine had been issued to the contractor for blasting, and was charged to him at $1 a pound, so that when the work was finished and a 60-pound can remained intact he wished to return it to the stores and receive credit. Accordingly he borrowed a velocipede from Mr. Robinson and sent it back by a powder monkey, as the men who handled the explosives were called, who strapped the can to the back of the velocipede and started alone. When in the middle of a long, high viaduct across Moose Lake he met a train coming at high speed around a curve so close that he could not stop it and had no time to turn back or even to remove his velocipede from the track, where he left it and took refuge on the end of a trestle cap. The locomotive knocked the velocipede off the trestle and it fell about 45 feet, striking on the 4-foot ice below, where the nitro-glycerine exploded and completely wrecked the lower story of three bents of the trestle. The train nevertheless passed over unharmed and proceeded without stopping, the crew being unconscious of any accident. When the powder monkey, who was almost frightened to death, recovered his courage he got back on the track and ran for help, and a wrecking crew was sent out and traffic was stopped until the lower part of three bents had been replaced.

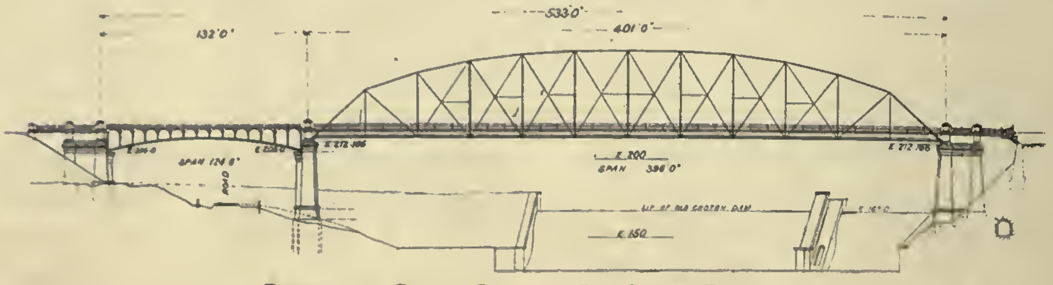
Of course, the only explanation is that the diagonal bracing in the upper stories of the trestle had developed sufficient truss or arch action to form a span across the gap, but this is the more wonderful as this work was built of round timber without framing and was spiked and not bolted at connections. The trestle was three stories, or about 45 feet high, above the water and each bent had two plumb posts and two bater posts. The bents were 14 feet apart and carried four lines of 8x14-inch stringers at least 28 feet long, breaking joints over the caps. There were ledger pieces on the batter posts at every story, which were laid across the caps and sills and were spiked to them and to the batter posts, and all panels in the planes of the batter posts were X-braced longitudinally by round timber diagonals 5 inches in minimum diameter. There were also diagonal braces through the centers of each one-story section of the viaduct included between successive tiers of horizontal caps and adjacent transverse bents, which thus had combined longitudinal, transverse and vertical reach in each brace. All the timber was green, and it was almost impossible to draw the 8x⅝-inch wrought-iron spikes with which all intersections and connections of the timbers were thoroughly spiked. It would seem that if the present liberal use of high explosives in international warfare is to be continued that the builders of such dynamite-proof construction should find their services highly appreciated at a point several thousand miles west of the terminus of the railroad where this incident occurred.

Wooden Water Pipes dug up in the streets of London, England, about four years ago, after having been in the ground for about two centuries, were in an excellent state of preservation. They were mostly elm logs, and none of the pipes exceeded 7 inches bore. In one instance two lines of wooden pipes were connected together by cast-iron bends. Some pipes made of fir and some of oak were found.

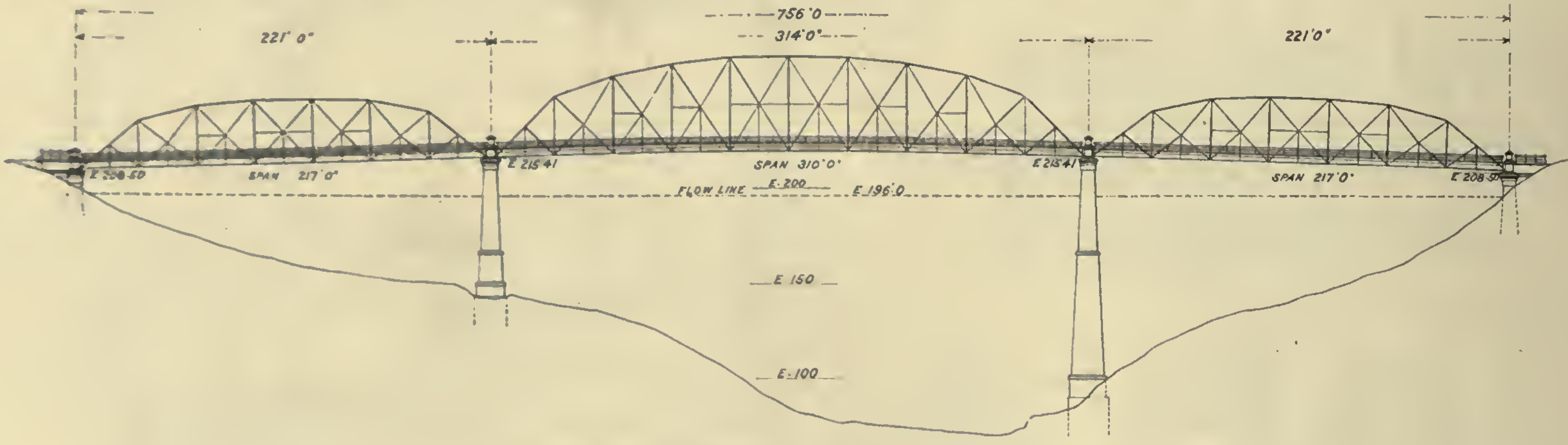
Highway Bridges in the Croton Valley.

When the new Croton dam for the increased water supply of Greater New York is completed the water impounded will submerge a portion of the valley about 15 miles long. This is a fertile agricultural district, with farm houses, residences and other buildings which have been condemned and removed. It is traversed by a number of public highways which will be submerged. In some cases new roads are being constructed to replace them above the flow line, and on these and other roads where the water will rise above their present locations the Aqueduct Commission is building a number of steel bridges, part of which are under contract and some of them fabricated and now being erected. There are fifteen principal structures, including twenty spans of from about 52 to 384 feet. All of them are made with two trusses or girders spaced approximately 22 feet apart on centers and carrying a single roadway without sidewalks. The superstructures are built entirely of soft steel, except the pins, eye-bars, roller bearings and sliding plates, which are of medium steel. The steel is specified to conform to the usual requirements of high-grade structural steel and to be subject to mill and shop inspection, and it is provided that full size eye-bars shall be annealed and when broken in a testing machine shall develop an ultimate strength and elastic limit of 54,000 pounds and 30,000 pounds per square inch with an elongation of 10 per cent. in a length of 20 feet. All floors are proportioned for live loads of 100 pounds per square foot in tension for their own weight, and for that of a road roller with a 10-ton rear axle and a 5-ton front axle. The specifications and details conform generally to the ordinary standards for first-class country highway bridges proportioned to carry live loads of 2,000 pounds per linear foot.

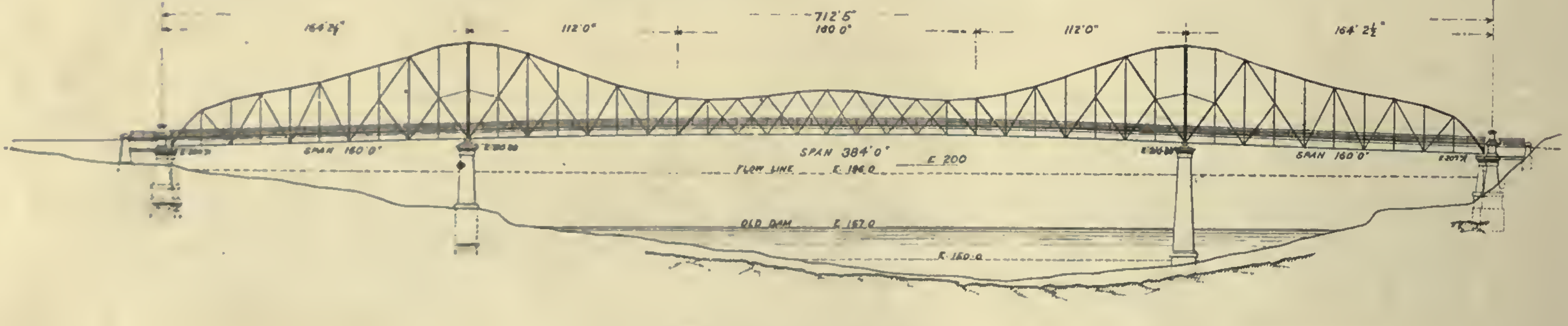
When the designs were made it was thought possible that the reservoir would be full of water when the bridges were erected, and therefore all of them were designed so that they could easily be erected at a distance from their sites and floated into position, an expedient especially important for the Hunter's Brook bridge, which is about 150 feet high above the ground surface. Unexpected delays have hindered the completion of the new Croton dam and all these sites are yet exposed so that the bridges will be erected on falsework.



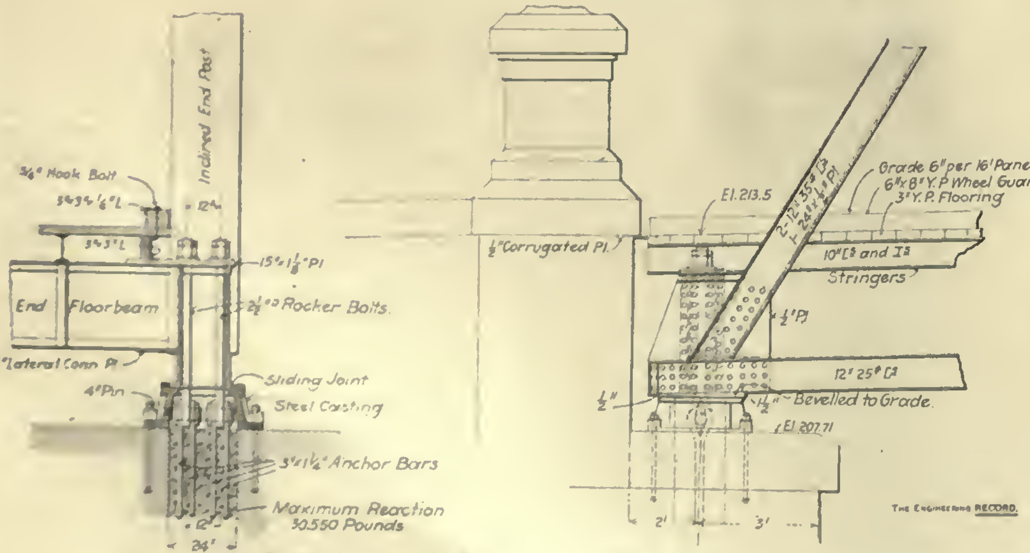
Bridge over Croton River at Old Croton Dam.



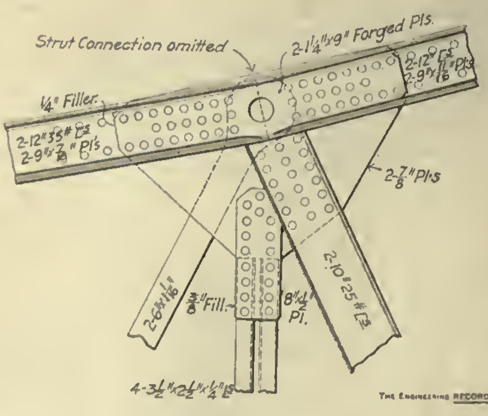
Hunter's Brook Bridge over Road Number Seven.



Pines Bridge over Croton Lake.



Support and Anchorage of Shore End of Truss.



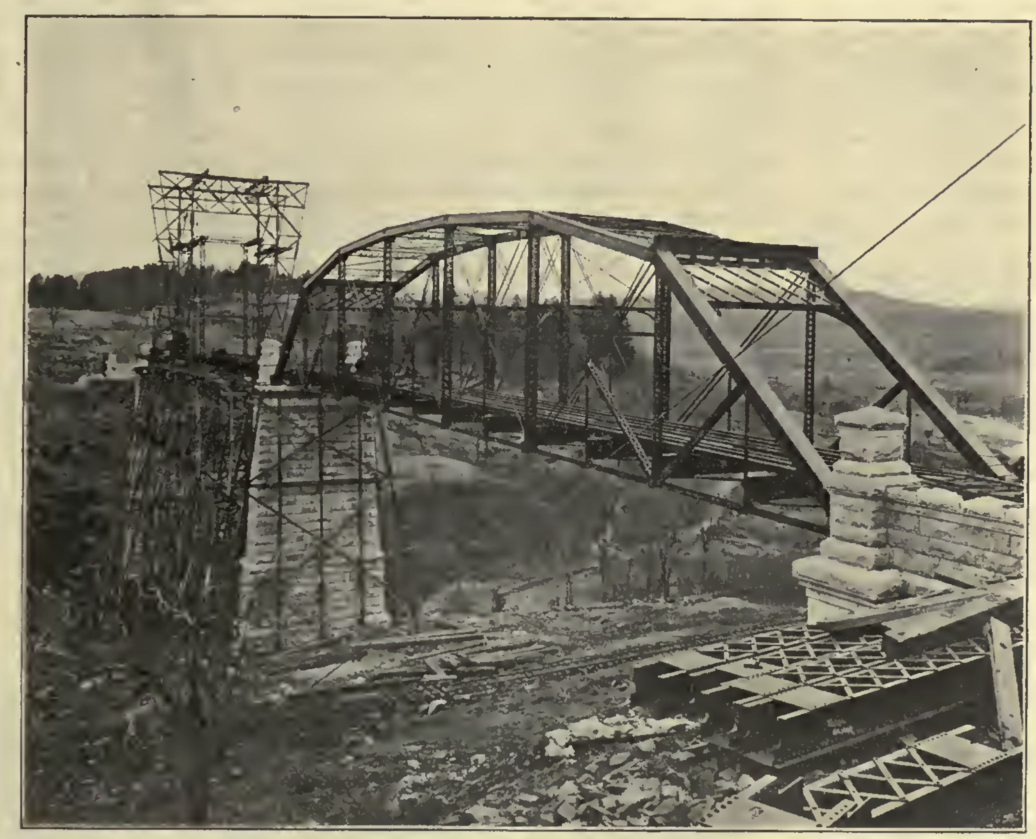
Typical Panel Point of Anchor Arm Truss.

DIAGRAMS AND DETAILS OF HIGHWAY BRIDGES IN THE CROTON VALLEY, NEW YORK.

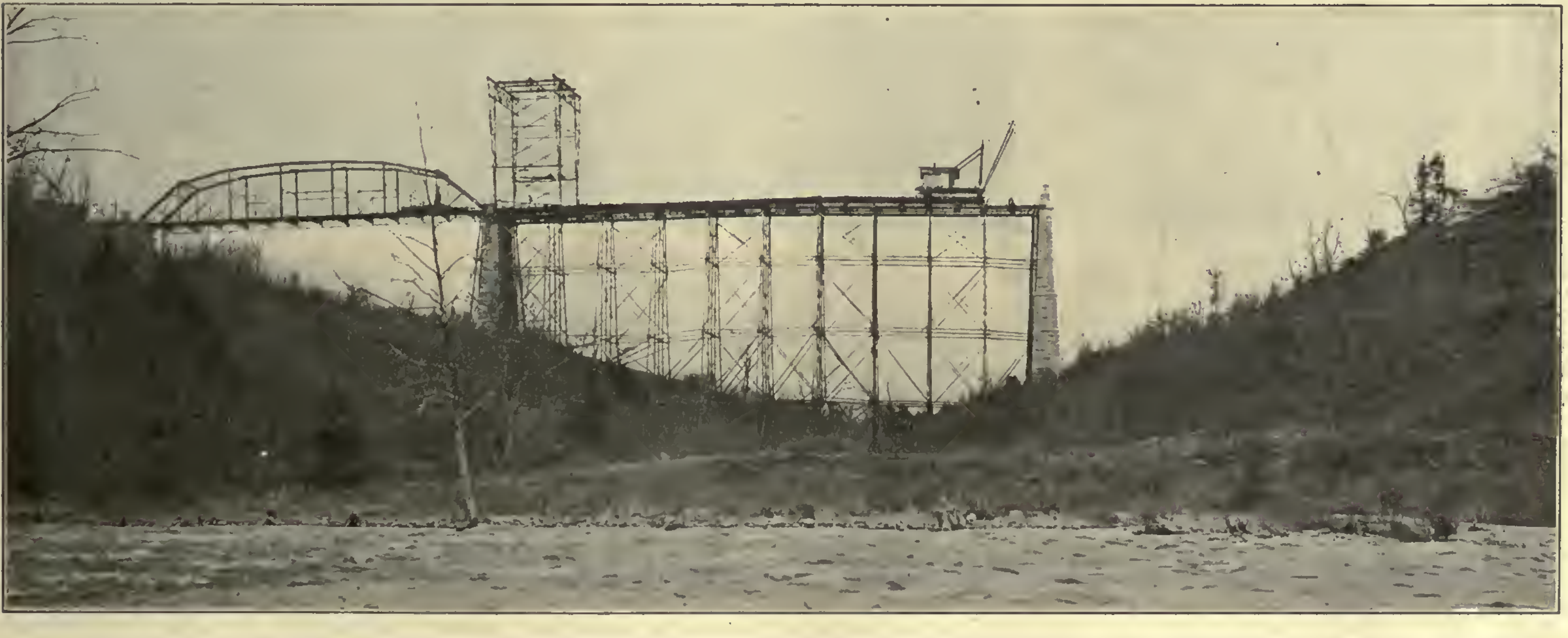
The most important structure is Pines Bridge, which is a cantilever bridge. The trusses are 51 feet 7½ inches deep over the main piers, 19 feet deep at the hip joint of the anchor arm and at the extremity of the cantilever arm. They are divided by vertical members into 16-foot panels, which are crossed by the zigzag main diagonals which are alternately tension and compression members. The top chord from the end of the anchor arm to within two panels of the main vertical post is composed of a pair of 12-inch channels latticed. It is peculiar in that the last panel which corresponds to the inclined end post is curved so that the bottom flange has a versed sine of about 10 inches. It is proportioned for a maximum compression of 341,400 pounds. The remainder of the top chord is composed of 4, 5 and 6-inch eyebars, and is proportioned for a maximum stress of 538,600 pounds. The bottom chord is composed throughout of a pair of built channels with 12-inch webs and 3x3-inch flange angles, except in the end of the cantilever arm, where 12-inch rolled channels are used. It is proportioned for a maximum compression of 426,600 pounds and a maximum tension of 321,400 pounds.

The main vertical post has a rectangular cross-section composed of four 4x3½-inch angles latticed. The other vertical posts have I-shape cross-sections made of two pairs of angles back to back latticed. The compression diagonals are made with pairs of rolled or built channels with latticed flanges, and the tension diagonals are made with 5 or 6-inch eye-bars. All of the main truss members are pin-connected to the connections of the sub-verticals, and where the verticals alone meet the chords without diagonal members at the same point the connections are riveted. The top lateral system consists of transverse struts and pin-connected diagonal rods. The main vertical posts are connected by a horizontal strut and a lattice girder portal at their middle points, and the panel above is sway-braced by diagonal angles. The upper parts of the other principal vertical posts are sway-braced by horizontal struts just above the clearance of the roadway. These have sleeve-nut diagonals which are pin-connected to wing plates on the main truss pins.

The lower lateral diagonals are pairs of angles riveted to the lower flanges of the floorbeams. The entrance portals are lattice-girders which are riveted to the hip joints of the top chord and have solid web kneebrace brackets with curved flanges connecting them to the end verticals. The girders are about 30 inches deep, and their flanges are curved so as to give them an arch effect with a rise of about 10 inches. The top flange angles are continued across the top chord cover plate to which they are field riveted. Where main tension and compression diagonals intersect the connection is made with gusset plates riveted to the chord webs and bored for the main pins of tension members, the ends of the compression members being cut to clear the pins and field-riveted. Where all of the members are in compression the pins are omitted and the ends of the diagonals form jaws riveted to the outsides of the connection plates while the ends of the verticals are riveted between them on the insides of the plates.



Completed End Span of Hunter's Brook Bridge and Traveler Erecting Center Span.



Highway Bridges in the Croton Valley: Falsework for Erection of Center Span of Hunter's Brook Bridge

The 160-foot suspended span is a riveted truss, 24 feet deep at the center and 18½ feet deep at the second panel points from the ends. The top chord and end post are of the regular trough section made with 10-inch web plates, 22-inch cover plates and 3x3-inch angles. The bottom chord has an I-shape cross-section with pairs of 4x3-inch angles and a 14-inch solid web plate. The diagonal members are single and double pairs of angles riveted to the top chord webs and at the lower end to jaw plates riveted across the flanges of the bottom chord.

The top lateral system consists of I-shape horizontal struts connected to the top chords at panel points and of single intersecting diagonal angles in each panel. At the hip joints the trusses are braced together by an arched lattice-girder portal strut, similar to that at the ends of the anchor arms, except that it has no kneebraces. The bottom lateral diagonals are single angles riveted to connection plates on the lower flanges of the floorbeams. The connection plates at the feet of the inclined end posts are riveted to the insides of the post webs and to the outsides of the lower chord flanges and project above the latter sufficiently to receive the end connections of the floorbeams and the riveted connections to the feet of the vertical members, which suspend the span from the top chord pins of the cantilever arms.

The lower chords of the cantilever arm and suspended span are entirely disconnected, and there is abundant clearance between them. The lateral stresses are transmitted from one truss to the other, and transverse rigidity is secured, while longitudinal motion is permitted by means of a thick horizontal plate, which is riveted to the end of the bottom flange of the center span floorbeam and projects across the bottom flange of the cantilever floorbeam, where it is enclosed in a bent cover-plate, through which it slides freely, with a close fit on the edges. The top chords of the cantilever and suspended spans are really discontinuous, but a connection is made between them by a pin-connected strut reaching from the end of the cantilever arm to the hip joint of the suspended span. There are, however, no diagonal members in this panel, and the lateral stress from the top chord of the suspended span is carried down the inclined end post to the bottom lateral system.

The shore ends of each anchor arm truss are anchored to reaction platforms, built in the abutment piers, by four 3x¼-inch eye-bars, 19 feet long, at each end pin. The lower ends engage cast-steel shoes with their horizontal base plates bearing on the lower flanges of four 20-inch I-beams, 24 feet long, transverse to the bridge axis. The upper flanges of these I-beams bear on the lower flanges of fourteen 8-inch I-beams about 10 feet long, which extend entirely through the pier parallel with the bridge axis. These beams and the eye-bars are all sealed in a solid mass of concrete, which fills the masonry cavities in which they are seated. The upper ends of the eye-bars engage the lower ends of two 2½x2½-inch vertical rods, about 5 feet long, with upset screws on their upper ends. These rods pass through the stiff bottom chord and the foot of the inclined end post, and their nuts take bearing on the horizontal cap plate riveted to the upper edges of the connection plates at the end of the lower chord. These plates also receive the end of the end floorbeam and form the sides of a stiff box, the lower flanges of which take bearing on a cast-steel bolster anchor-bolted to the masonry. The anchor eye-bars have clearance inside the bolster. The upper surface of the bolster is planed to receive the bed plate on the end of the lower chord and has guide flanges engaging its edges so that the latter can slide back and forth longitudinally to provide for temperature movements, which cause the screw rods to rock slightly on the pins through their lower ends.

At the foot of the main vertical post the gusset plates which connect it and the main diagonals are continued below the lower flange of the bottom chord and are stiffened by vertical angles to form the webs of a pedestal, which has a base plate seated on a cast-steel bolster anchor-bolted to the masonry, and carrying a calculated maximum load of 665,500 pounds.

The floorbeams are 30-inch plate-girders, with 5x3x⅜-inch flange angles, without cover plates. Their ends are field-riveted through vertical flange angles to the flanges of the vertical posts. They carry eight lines of 10-inch I-beam stringers seated across their top flanges and two lines of 10-inch channels, one at each end, to carry the 3-inch yellow pine transverse floor planks. Planks 10 inches wide are bolted to the webs of the channels, to act as spiking pieces for the floor planks. Two other lines of 3x10-inch planks are laid edgewise between the second and third stringers from the ends of the floorbeams to make spiking pieces for intermediate points on the floor boards. All floor joints between adjoining spans or between the ends of the spans and the abutment masonry are covered with 15x½-inch corrugated steel plates set in flush, with the top of the floor planking and sliding at one end, to allow for expansion and contraction. Although Pines bridge is designed for service as a cantilever, it is proposed to erect it entirely on falsework, and it will be assembled in the usual manner on timber trestle bents. The trusses will be wedged up for erection camber, and no special provision is necessary for adjustment at the connections between the cantilever arms and the suspended span.

The next longest trusses are those of the 396-foot span over the old Croton dam, which are divided into 33-foot panels by vertical posts. Each panel has a single main tension diagonal and a counter diagonal, the former being made with four 4½, 5, 6 and 7-inch eye-bars, and the latter with two 2½, 3 and 3½-inch eye-bars. Each diagonal bar is made in two pieces, pin-connected, at their intersection in the center of the panel. All of the truss connections are pin-connected. The top chord is made with built channels, having 27-inch web plates, 30-inch cover plates and 3½x3½-inch top flange angles and 5x3½-inch bottom flange angles. The maximum section is 61.67 square inches, and they are proportioned for a maximum compression of 802,800 pounds. The bottom chord is composed of 7-inch eye-bars, of which there are in the center panel six 1 3/16-inch pieces, proportioned for a maximum tension of 786,300 pounds. The vertical posts are made with pairs of built channels latticed, except the end tension members, which have I-shaped cross-sections made with 4x3-inch angles. The pins through the intersecting diagonals in the center of each panel receive one end of a light horizontal strut, which is riveted at the opposite end to the middle of the adjacent vertical post.

The top lateral system consists of transverse struts, with I-shape cross-sections, made with two pairs of angles latticed and attached by horizontal connection plates to the top and bottom chord-flanges. The diagonals are single round sleeve-nut rods with pin connections. A system of lower transverse struts is riveted to the vertical posts, so as to give a clearance of about 16 feet above the roadway. These struts have I-shape cross-sections, with two pairs of angles back to back latticed, and their ends are knee-braced by pairs of curved angles, back to back. Between the top and bottom struts each pair of vertical posts is sway-braced by single 1¼-inch pin-connected diagonal rods, which, at the upper ends, engage bent wing plates on the top chord pins and at the lower ends are forked to engage the web plates of the struts. The portals are deep lattice girders in the planes of the end post, with kneebraces similar to those for the intermediate struts. The bottom lateral system has two sets of diagonal members. The lower one consists of single sleeve-nut rods pin-connected to wing plates on the ends of the lower chord pins. The upper set, which is about 18 inches above them, consists of single angles riveted to horizontal connection plates on the lower flanges of the intermediate floorbeams.

The floor system is special, on account of the unusual length of the main panels. The main floorbeams are 36-inch plate-girders, with the usual riveted web connections to the vertical posts. Each flange is made with a pair of 6x4x⅜-inch angles without cover plates. The floorbeams carry two lines of main stringers 36 inches deep, which are 18 feet apart and are web-connected to the floorbeams in the usual manner. Each panel of these stringers supports two intermediate floorbeams 11 feet apart and are 24 inches deep, with pairs of 3x4x5/16-inch flange angles. The floorbeams and sub-floorbeams support eight lines of 8-inch I-beam stringers resting on their top flanges, and two lines of 8-inch channels, which carry the deck of 3-inch transverse floor boards, spiked to four 3x8-inch pine planks, laid edgeways on top of the beams. The channels support the outer edges of the roadway and are carried between the main floorbeams on solid web cantilever brackets riveted to the outer faces of the stringers in the planes of the sub-floorbeams.

Highway Bridges in the Croton Valley: Site of Old Croton Dam Bridge.

The Hunter's Brook Bridge has one span of 310 feet and two of 217 feet which correspond in general with the Croton Dam Bridge. The main span trusses are 50 feet deep at the center and 31 feet at the hips. The side span trusses are 34 feet deep at the center and 25 feet at the hips. The camber of the bridge is continuous from one abutment to the other, the side spans having a grade of 3.182 per cent. and the center span having both ends at the same height and the bottom chord curved to a radius of 4,930 feet, which gives it a versed sine of 30 inches. The trusses are 22½ feet apart on centers and all of their members are pin-connected. The top and bottom lateral diagonals are all made with single angles. The lower transverse struts are made with pairs of channels latticed and the sway-brace rods are pin-connected at the upper ends between pairs of vertical web plates which connect the top chords, vertical posts and upper lateral struts. At the lower ends they engage pins passing through the webs of the transverse struts.

The sub-verticals in the middle of each panel from which the intermediate floorbeams are suspended are made with pairs of angles riveted together, back to back, to form a T-shape cross-section pin-connected to the main diagonals at their intersection and to the bottom chord bars. The lower chord pins at these points engage 1-inch vertical plates, which are riveted between the end flanges of the floorbeams and the lower ends of the sub-verticals. The erection of this bridge was somewhat difficult and expensive on account of its height of 150 feet above the water, which at this point has a considerable depth, and made the construction of the falsework expensive. The erection of it is now nearly completed, and the falsework which was used to support it will be taken down and used for the erection of other bridges in this series. All of the piers which support the adjacent ends of the center and side spans are built with small towers at each end, which rise about 4 feet above the roadway and have moulded courses forming ornamental pillars in the lines of the hand rails. These towers are recessed at the bottom to receive the end bearings of the trusses.

Wood's Bridge has a span of 330 feet and resembles the Hunter's Brook Bridge in nearly all particulars. The trusses are 22 feet 6 inches apart on centers and are 49 feet deep in the center and 29 feet at the hips. The principal differences are in the portal struts, which have, above the lattice girder, a 27-inch plate girder. The web of the latter is vertical and it is connected to the top chord and end post by bent plates. Its web projects below the bottom flange angles to receive bent plates connecting it with the top chord of the lattice-girder, which lies in the plane of the inclined end post. The top lateral struts have rectangular cross-sections made with four 3x2½-inch angles latticed vertically and horizontally.

The 210-foot span at Purdy's Station is also of similar construction and has trusses 33 feet deep at the center and 23 feet at the hips. The panels are 15 feet long and the lower chord is cambered to a radius of 3,675 feet. The portal strut consists simply of a lattice-girder, with curved kneebraces in the planes of the end posts, with a clearance of 15 feet above the roadway. The top lateral struts are like those in Wood's Bridge, but the upper ends of the sway-brace rods are connected to wing plates on the top chord pins.

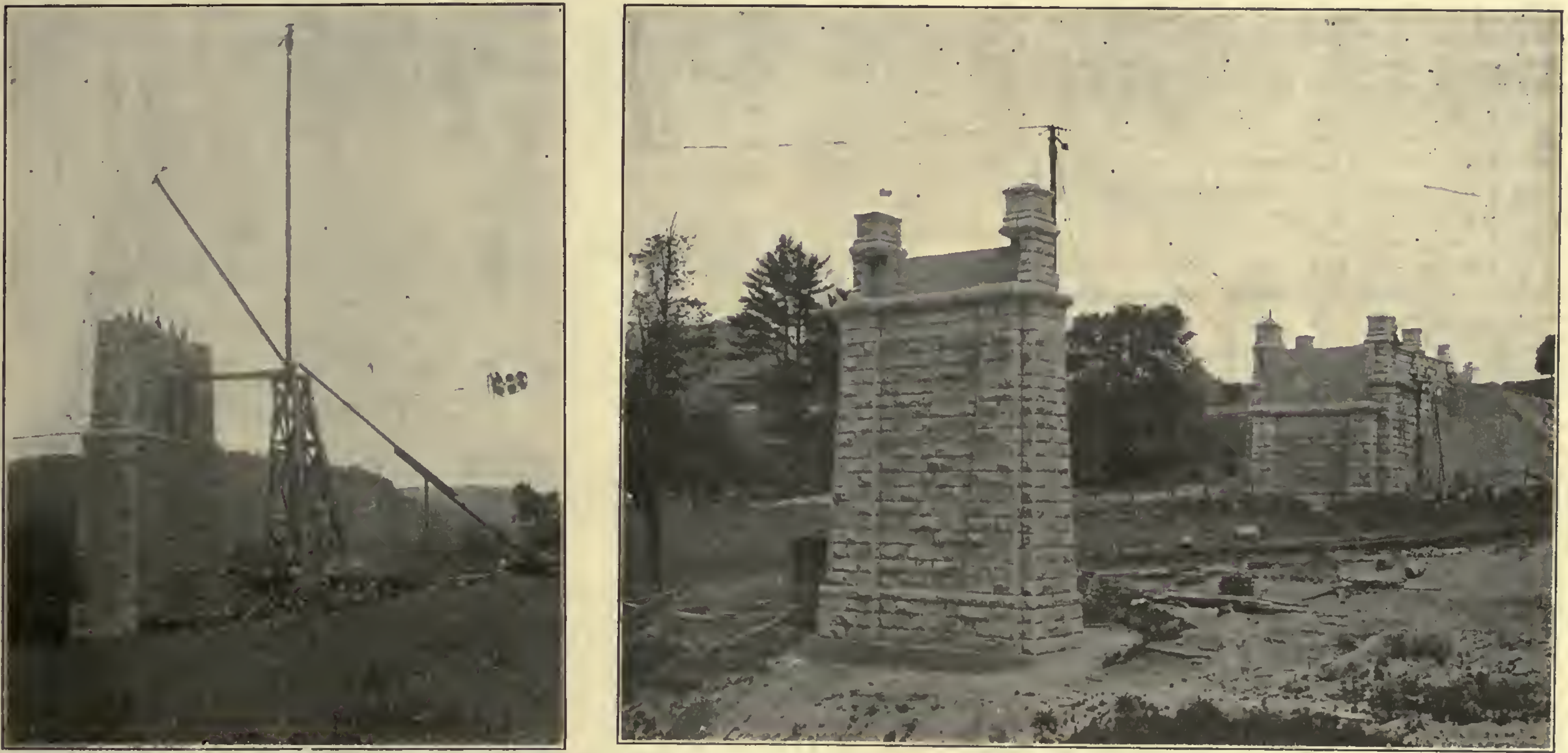
Most of the shortest span bridges are simply through Pratt trusses, the largest of which are two 153-foot spans at Goldens Bridge. These have pin-connected trusses, 21 feet 9 inches apart, and 27 feet deep, on centers. They have I-shape top lateral struts, made with pairs of 3x2½-inch angles latticed and field-riveted to the top and bottom flanges of the top chords. There are no sway diagonals or lower lateral struts, but the top struts are kneebraced with pairs of 3x3-inch angles riveted together, back to back, to make T-shape cross-sections, and having their ends bent tangent to the struts and to the vertical posts. The portal struts are lattice-girders, with curved kneebrace angles. The bottom lateral struts are single angles riveted to the lower flanges of the floorbeams. The floorbeams and floors are like those already described.

Beaver Dam Brook Bridge has half through riveted trusses 48 feet long, 7½ feet deep over all and 21 feet 3 inches apart on centers. They are divided by vertical members into 12½-foot panels, in each of which there are two diagonals reaching from the center of the panel of the top chord to the ends of the panel in the bottom chord. All members are made with pairs of angles riveted together back to back to make T-shape cross-sections with connection plates riveted between the vertical flanges. The floorbeams are 24-inch plate girders with pairs of 5x3½-inch flange angles and are seated on horizontal angle clips riveted to the lower chords and are field-riveted to the vertical posts through their end web stiffener angles. At each panel a bracket projects from the end of the floorbeam to support the foot of a transverse diagonal brace running to the top chord. The ends of the trusses are seated on flat bed plates, which allow one end to move with temperature expansions. Two horizontal lines of 3x⅜-inch flat bars are riveted across the web members above the floor level to serve as guard rails protecting the roadway.

The Kisco Bridge has a clear span of 74 feet which is covered by two spandrel-braced arched trusses with horizontal top chords. They are divided into nine equal panels of which two at each end are open with vertical and diagonal members and the five remaining panels in the center have solid webs. The bottom flange is composed of four 6x4-inch angles riveted together back to back to make a cruciform cross-section. The top flange is composed of two 6x6-inch angles making a T-shape cross-section. At the ends of the lower chord the web connection plates project and have flange angles riveted to them so as to give horizontal bearings and bearings normal to the lower chord tangent. The lower chord is curved to a radius of 128 feet and has a rise of 6 feet 1½ inches. The truss is about 18 inches deep at the crown and 8 feet at the skew-backs. The floorbeams are 15-inch I-beams about 21 feet long, which are seated across the top chords of the trusses and cantilever a few inches beyond them with their ends riveted to the webs of fascia girders 21 inches deep. They carry seven lines of 6-inch I-beam stringers, two lines of 6-inch channels and four lines of longitudinal spiking joists on which the 3-inch transverse floor plank are laid as described for the long-span bridges.

The Upper Plum Brook, Cross River and Muscoot Bridges have spans of 104 feet 5 inches and are similar to the Kisco Bridge. At the old Croton dam there is a plate girder-span of 124 feet 6 inches at one end of the truss span already described. This span is peculiar in that the bottom flange is curved to give an arch effect, and the web-stiffener angles are bent in semi-circular curves from one panel to another.

The bridges were designed under the direction of the Aqueduct Commissioners; Mr. W. R. Hill was then chief engineer and Mr. F. S. Cook assistant engineer in charge of the drafting bureau. Mr. Albert Lucius was retained for special work on the superstructures. Messrs. Coleman, Breuchaud & Coleman, who are the builders of the new Croton Dam are the contractors for and have built the substructures. The American Bridge Company is the contractor for the superstructures.



Highway Bridges in the Croton Valley: Building Pier for Hunter's Brook Bridge; Pier and Abutment for Old Croton Dam Bridge.

The Extension of the Imperial Hotel, New York.

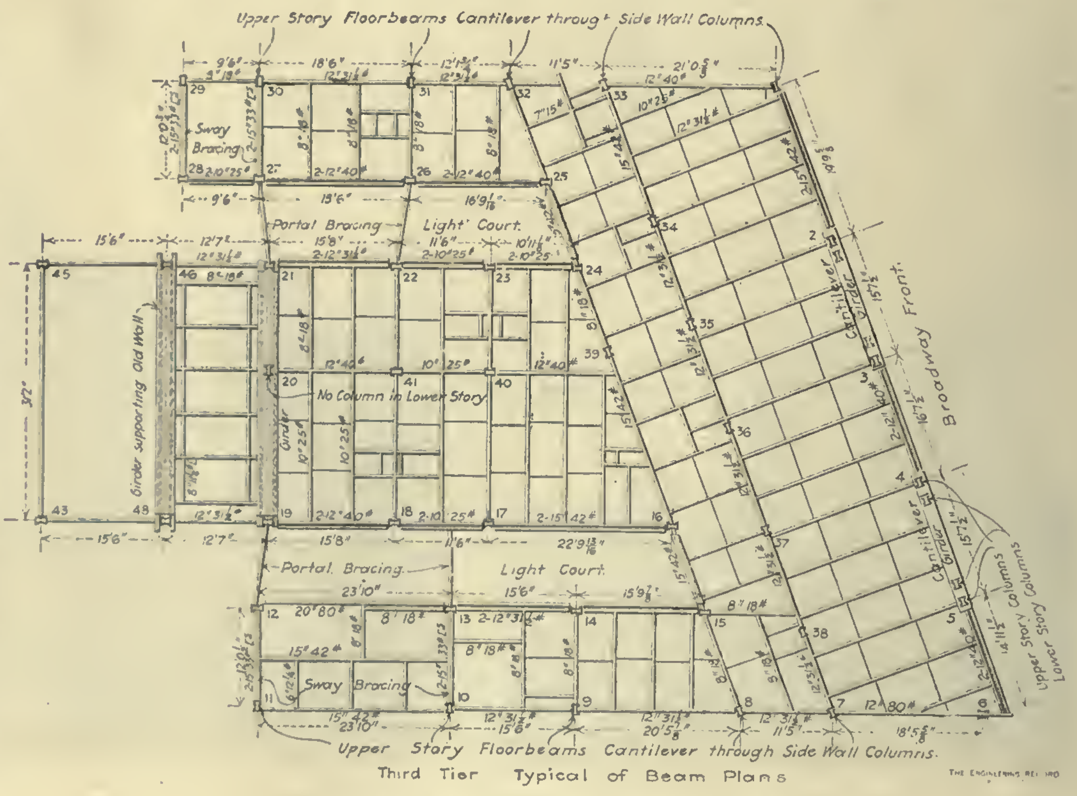
Part II.—Cantilever Floor Girders and Wall Columns, Double Plate and Box Girders, Steel Smokestack, Flagpole and Cornice.

On the sides of the extension of the Imperial Hotel the upper stories of the wall columns are made special to support the floor girders, which cantilever beyond them to carry the stories which overhang the adjacent roofs. These columns are made with pairs of channels with reinforced webs parallel to the girders. The column channels are latticed together, and at floor level are connected with deep tie plates having horizontal angles across the upper edges. The horizontal flanges of these angles are supported by vertical reinforcement angles and serve as fulcrums for the floor girders, which project through the centers of the columns and are riveted to the shelf angles and also to corresponding horizontal angles engaging their upper flanges.

Wall column 31 is typical of the columns supporting the cantilever girders, and the elevation of it shows the standard connections for the regular floorbeams to the columns. It also shows a column splice made with horizontal shims or packing plates, which give an adjustment for the seven story upper part of the column. In order to allow the cantilever girders to pass through the columns above the ninth floor it was necessary to separate the webs of the column channels, and that was accomplished, as shown in the elevation of column 7, by dividing the ninth-story section of the column into two pieces and making the 8½-foot upper part special. Its channels were offset beyond those of the lower section so that their flanges were almost entirely outside the others, and were connected to them by three pairs of flange cover plates. A horizontal diaphragm composed of two ¾-inch plates was also inserted between the ends of the eccentric channels to distribute the load from the upper to the lower ones, and the projecting edges of these plates were supported by bearings on the finished ends of pairs of vertical reinforcement angles riveted together back to back to make 4x8-inch tees, riveted to the channel webs to distribute the load over a length of nearly 3 feet of the channel webs. This drawing also indicates the careful proportioning of the connections to the computed stresses by the difference in the supports for the lower beams, all of which have seats on the horizontal shelf angles. These shelf angles have their horizontal flanges reinforced by bearings on the ends of vertical angles, which are made single or double according to the loads provided for. The design of the column is such as to involve the least possible amount of field riveting, and the floorbeams are carried wholly by the shelf angles without any web connections. In the column splices the cover plates are field riveted to both column sections so as not to form jaw plates, and the horizontal diaphragms are riveted to flange angles on the lower column sections only.

Up to the third tier the columns are arranged as indicated in the foundation plan, and the arrangement of beams and girders corresponds essentially to that shown in the third tier, except for the plate-girders which are introduced there to provide for the openings in the lower stories and the offsets in the column lines. In the street front there are two duplicate heavy double-cantilever girders, 12-13 and 14-15. Each of them is supported on the lower sections of a pair of columns about 10½ feet apart on centers, and carries the upper sections of the same columns about 15½ feet apart on centers. Each girder has a closed box section, made with solid webs and flange plates and extends continuously across the tops of the supporting columns. On the opposite side of the building girder 19-21 extends across the full width of the wing between the light courts and carries the fifteen upper stories. It is supported at the extremities on the lower sections of columns 19-21, which are about 31 feet apart on centers, and carries their upper stories in the same vertical lines and the intermediate column 20. It consists of two separate single-web plate-girders, connected by field-riveted flange tie plates.

Adjacent to this girder is girder 46-48, which is supported on three-story columns and carries the upper part of the brick wall of the old portion of the building. This girder is double, each half of it having a 54x½-inch web and single 6x6x¾-inch flange angles. The flanges are seated on the extended caps of the columns and the webs are connected together by vertical transverse diaphragm plates, put in position after the wall had been removed. This girder is of interest on account of the manner in which it was erected, as described in The Engineering Record of January 16. In order to make it carry the existing wall and allow for the removal of the latter below it, slots were cut in the brickwork to receive the columns which were seated on their grillages. Then the two halves of the girder were set on the column caps and bolted together through the wall, enclosing a portion of the latter between them. Afterwards a horizontal strip of brickwork, 21 inches high and about 33 feet long, was cut through the wall in alternate short sections just above the top flanges of the girder. As each section was cut, the brickwork was replaced by pairs of cut stones bearing on the girder, and the wall was thus transferred to the girders and columns, and the portion of the wall between the columns and underneath the girder was removed, leaving the girder in service under the upper part of the old brickwork.



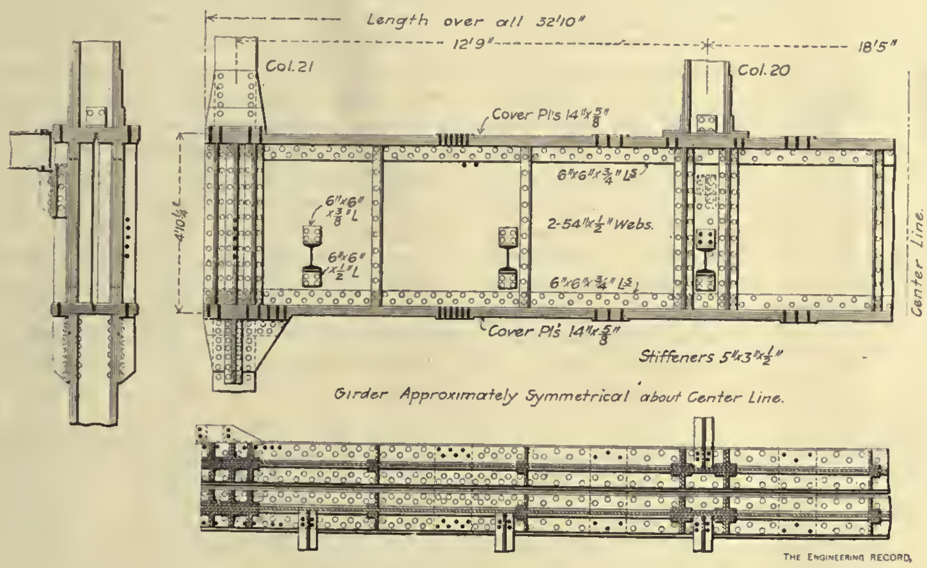
Imperial Hotel Extension: Floorbeam Plan.

Girders 2-3 and 4-5 were necessary to adapt the framework to the architectural requirements in the front of the building. Each of them is a simple massive member weighing about 7½ tons and supporting the ends of the 15-inch floorbeams from brackets on its inner web. The upper columns cantilever 2 feet 4¾ inches and 2 feet 3¾ inches from the centers of the lower columns, and these distances are reversed in the two girders so as to make them right and left-handed. The loads carried by the upper columns are respectively 375 tons by column 2, 329 tons by column 3, 329 tons by column 4, and 308 tons by column 5. Under the upper columns the webs are reinforced to resist the heavy shear with vertical angles in the lines of the column flanges and with web plates between the angles. Similar reinforcement is provided on the center lines of the supporting columns, and at each end of the girder the web plates are doubled, for a length of nearly 11 feet. These plates are fillered out from the webs, leaving closed cavities each side of the column reinforcement plates. All of the web reinforcement plates and stiffener angles are milled to bearing on their upper and lower edges.

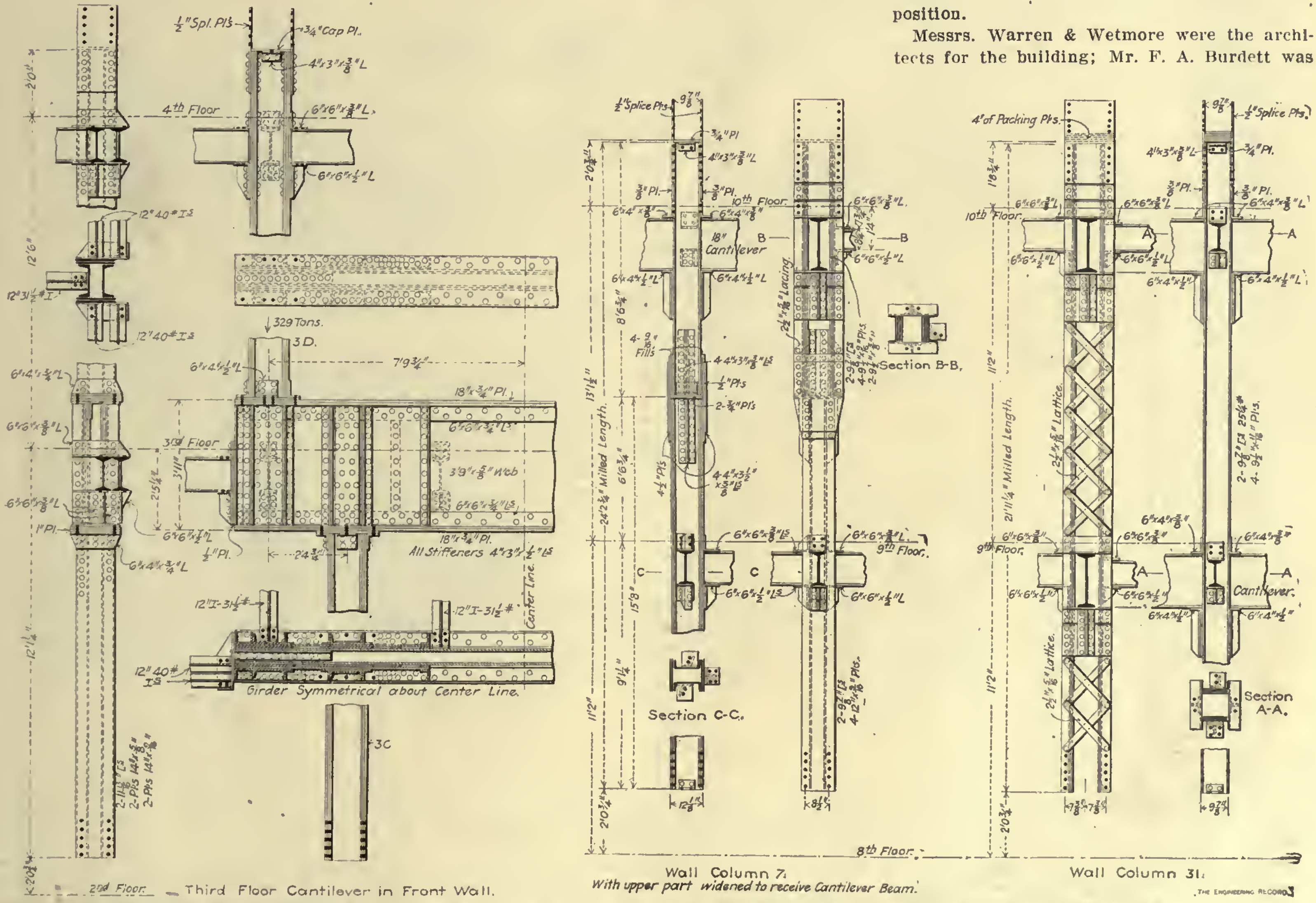
Girder 19-21 is made with two separate halves, each of them weighing about 17,500 pounds. At each end the web is reinforced by a single narrow plate, and three pairs of angles on each side to take up the shear over the supporting columns. Near the center, where column 20 imposes a load of 254 tons, the webs are similarly reinforced by single plates and two pairs of angles on each side.

The upper story of the building is surmounted by a wide cornice, having an overhang of nearly 8 feet on one side and about 6½ feet on the other side. This consists of a steel framework supporting a copper moulding and a tile roof covered with copper. The framework is built chiefly of single angles, and was supported entirely from the roof beams. The front columns extend about 3 1-3 feet above the roof and support at their upper ends a horizontal 10-inch channel, to which are connected the inner ends of the top chords of cantilever brackets, about 4 feet apart. These brackets are normal to the walls of the building and have their lower chords attached to the upper tier of wall girders. Their lower chords are made, as indicated in the cross-sections, to conform to the required outlines of the finished cornice. Their top chords are horizontal and carry lines of transverse T-bars about 2 feet apart to support the roof blocks. At the intersection of the side and front cornice the angle is carried by a bracket nearly 9 feet long, located in the diagonal, from the corner of the cornice to the corner column.

The smokestack is a rectangular steel flue, 240 feet high. It is built in courses 5 feet high and the plates are spliced together with single outside 5x⅜-inch horizontal cover plates with two rows of rivets, except at the expansion joints, where the plates are 6 inches wide and have only one row of rivets, which are driven through the upper edge of the cover plate. The plates are 5-16-inch thick up to and including the eleventh tier. Above that they are only ¼ inch thick. The smokestack is concentric with one panel of the floor and is supported from the beams and girders at each story by means of six solid-web bracket lugs, two of them projecting from each long side and one from the center of each short side. Each set of lugs supports one section of the stack, which is 14 feet long. At the lower edge each section has projecting splice plates, which engage the side plates of the section below it, but are not riveted to it, thus allowing each section to expand and contract independently.



Girder carrying Fifteen Stories.



Third Floor Cantilever in Front Wall.

Wall Column 7. With upper part widened to receive Cantilever Beam.

Wall Column 31.

Special Upper Story Columns Acting as Fulcrums for the Cantilever I-Beam Girders Supporting Overhanging Wall and Floor.

The building is provided with two duplicate steel flagpoles, extending to a total height of 42 feet above the top of the cornice. The upper section of the pole consists of a 6-inch, 19-pound pipe, 17 feet long, telescoped at the lower end 18 inches into an 8-inch, 28-pound pipe, 19½ feet long. This again telescopes into a 10-inch, 41-pound pipe, 18 feet long, which, at the lower end, is connected to an 18-foot length of the same size pipe. The total length of the flagpole is about 70 feet. The base is seated in a flanged casting, bolted to the fifteenth-story floor girders, and at the seventeenth story the pole passes through a steel guide ring. Both poles are exposed for their full length on the outer wall of the building and pass through the main cornice. There is about ½-inch clearance between the pipes in the telescope connections, and in this space they are accurately centered by four pairs of ½-inch vertical steel wedges, 18 inches long, which are secured by tap screws engaging both pipes. The annular space between the 8 and 10-inch pipes at the joint which is not filled by the wedges is run full of lead and calked.

The joint between the two sections of 10-inch pipe is made with three horizontal cast-iron diaphragms, or separators, which are provided with octagonal vertical flanges on one side only. These flanges are about 3½ inches wide and have a maximum clearance of about ¾-inch from the inner surface of the pipe. A 3½x¾-inch flat bar is planed convex on one side to match the interior of the pipe and is carefully fitted to each face of the diaphragm so that with the diaphragms they build up a hollow core, 3 feet long, which projects 18 inches into each pipe. The ends of the pipe are finished and abut over the center diaphragm. They are connected to the diaphragms and to the side strips by tap bolts drilled in position.

Messrs. Warren & Wetmore were the architects for the building; Mr. F. A. Burdett was the consulting engineer, and the general contract was awarded to Messrs. M. Reid & Company. Messrs. Clark & Company were the contractors for the foundations. The J. B. & J. M. Cornell Company was the contractor for the 1,700 tons of structural iron and steel; and Mr. H. A. Forsyth was in charge of the detailing and designing.

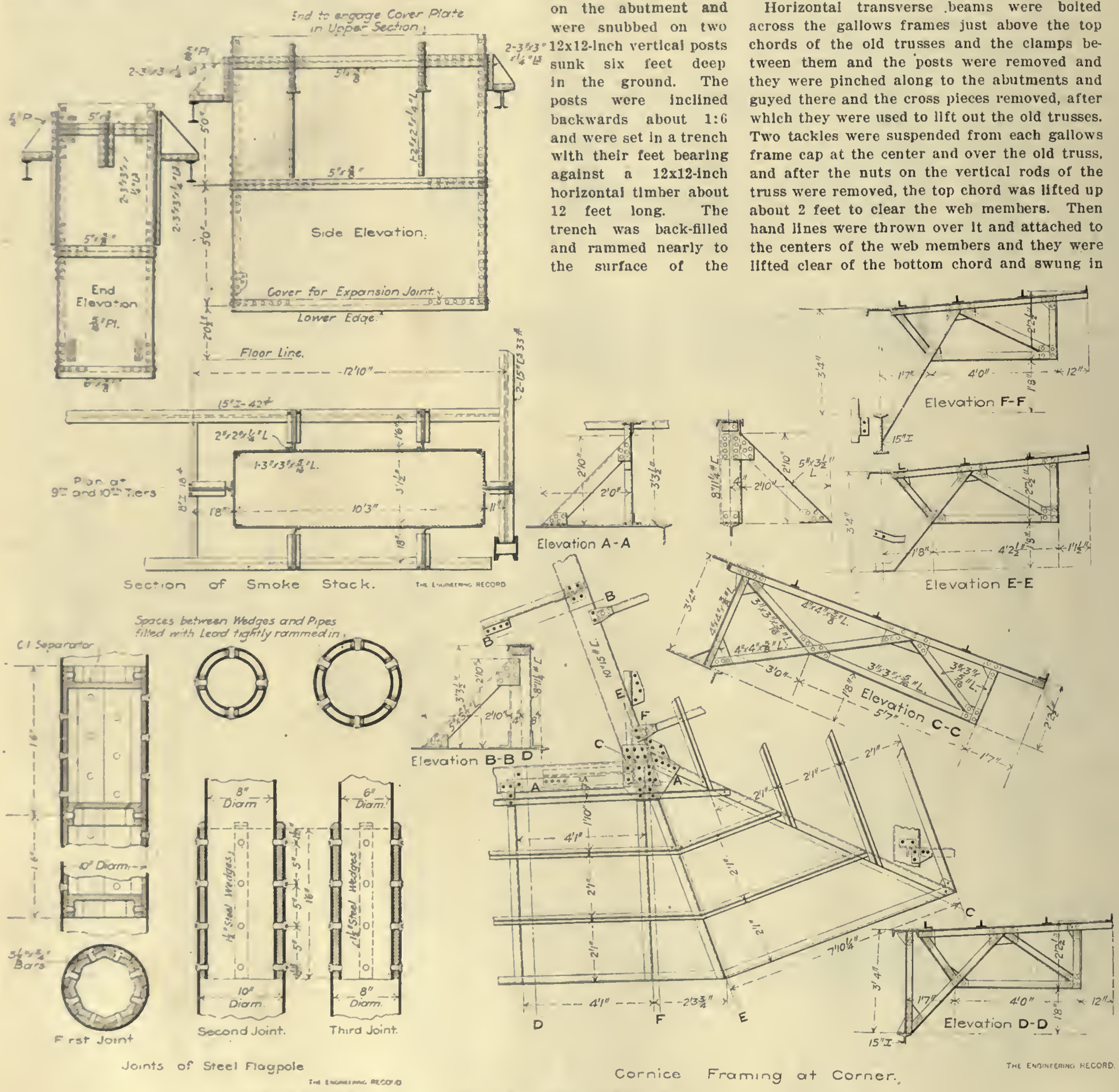
Replacing a Lattice-Girder Bridge with Plate Girders.

The single track bridge of the Rutland Railroad across the Little Otter Creek, Ferrisburg, Vt., originally had a single wooden through Howe truss span 147 feet long, which has recently been replaced by a 114-foot deck plate-girder span and two 15-foot 8-inch approach spans supported by the old abutments and by two intermediate steel towers on new masonry piers. The 50-ton main girders were delivered on three cars each, which were run across the creek on the old span. Two gallows frames with vertical and horizontal clearances of about 40 and 20 feet respectively were set up about 50 feet each side of the center of the old span and supported from it. As the trusses were only about 18 feet apart over all 1-foot fillers were bolted to the insides of the gallows posts and they were clamped to the top and bottom chords of the Howe trusses with their feet about even with the lower chords. Two four-part tackles rigged with 1¾-inch manilla lines were suspended from each cap of the gallows frames about 6 feet each side of the center, were attached to the ends of a girder and lifted it clear of the cars, which were then run off the bridge.

All the lead lines were run to one four-spool hoisting engine seated on the abutment and were snubbed on two 12x12-inch vertical posts sunk six feet deep in the ground. The posts were inclined backwards about 1:6 and were set in a trench with their feet bearing against a 12x12-inch horizontal timber about 12 feet long. The trench was back-filled and rammed nearly to the surface of the ground; another horizontal timber was set in it on the opposite side to give bearing for the upper reaction, and the fill completed.

One tackle at each end of the girder was made fast and the other was slacked off so as to fleet the girder over close to the old truss, where it was lowered to rest on the floorbeams clear of the track. The other girder was then brought in and unloaded in the same manner, and set nearly over its final seats. At the next sufficient interval between trains, the old floor between the new girders was cut out and then they were lifted a few inches by the tackles and the floor under their ends was cut out also, and they were lowered to bearing on the tops of the steel towers, the sway bracing and laterals assembled and bolted up and the ties laid and rails spiked on as fast as possible so that trains were able to cross again in about four hours after the removal of the old floor was commenced. Afterwards the riveting was done and the short approach spans were put in at leisure.

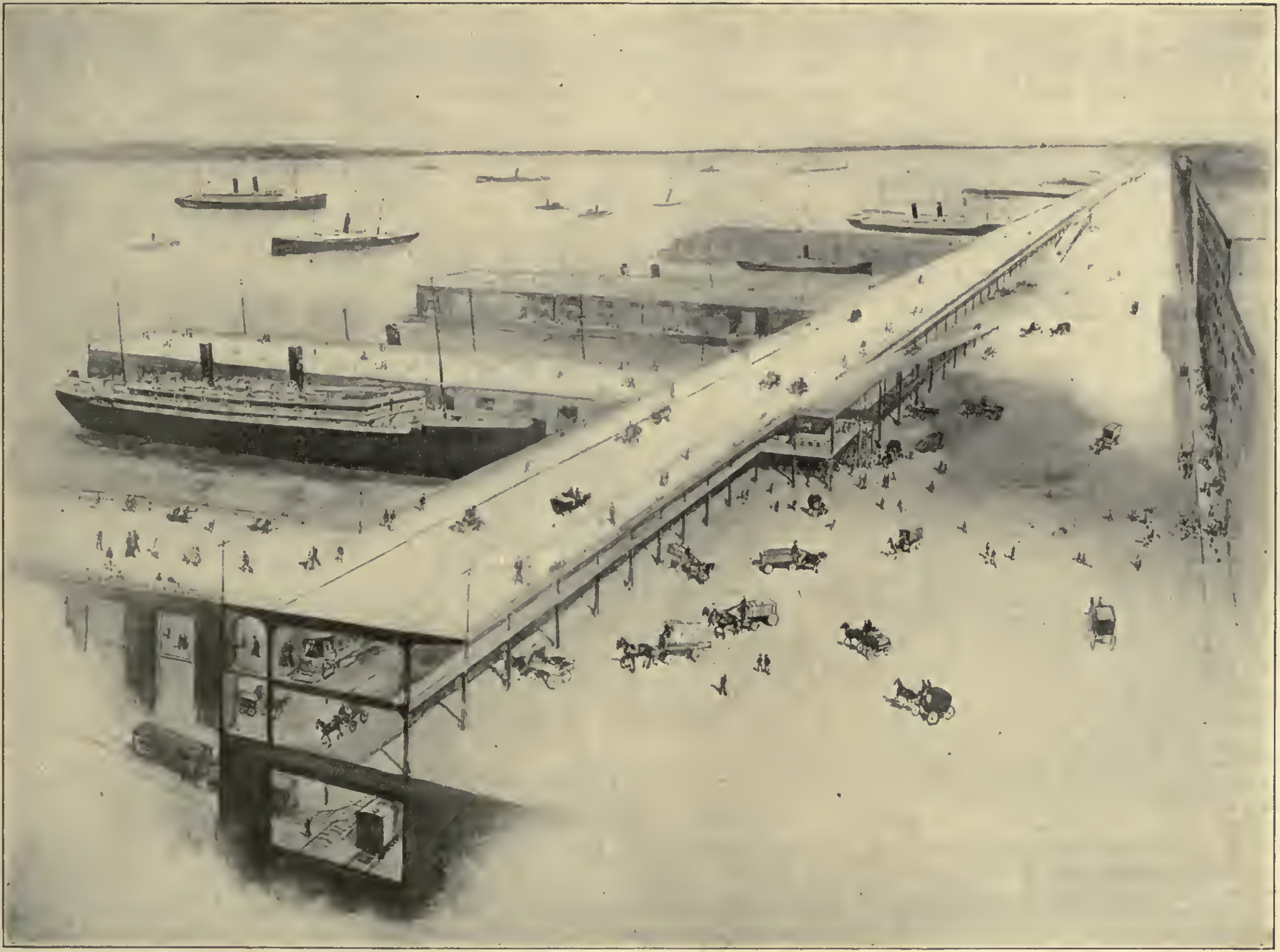
Horizontal transverse beams were bolted across the gallows frames just above the top chords of the old trusses and the clamps between them and the posts were removed and they were pinched along to the abutments and guyed there and the cross pieces removed, after which they were used to lift out the old trusses. Two tackles were suspended from each gallows frame cap at the center and over the old truss, and after the nuts on the vertical rods of the truss were removed, the top chord was lifted up about 2 feet to clear the web members. Then hand lines were thrown over it and attached to the centers of the web members and they were lifted clear of the bottom chord and swung in and loaded on hand cars. The top chord, entire was fleeted in by the tackles, loaded on cars and run off the bridge, and then the bottom chord was lifted out and disposed of in the same manner and the operations were repeated for the other truss. Both girders were seated on their towers within three hours after fourteen men commenced to unload them from the cars. The work was done by the American Bridge Company, contractor, under direction of Mr. C. J. Parker, chief engineer of the railroad company.



Imperial Hotel Extension: Details of Smoke Stack, Steel Flagpole and Cornice Framing.

A Suggested Improvement of the Water Front of New York.

Along the New York frontage on the North River toward the middle of Manhattan Island the municipality has gone to considerable expense to construct a boulevard which is one of the most fashionable drives of the city. On the other side of Manhattan Island a speedway for fast driving has been built at great public expense. The lower end of the island, which in one district has the most densely populated section to be found in any city in any country, has been provided with a few little parks, a few asphalt streets for the children to play on, and two or three recreation piers. The west water front of the lower portion of the city, known as West Street, is a broad thoroughfare capable of being developed into a street far more useful for teaming than at present, better adapted for street railway purposes and, what many people consider more important, a place of sufficiently pleasing appearance to impress the people who first reach the United States from the steamship docks lying along this water front. A very strong feeling has manifested itself of late concerning the improvement of West Street. The proposition to allow trolley cars to operate on the street aroused an opposition which probably surprised even those people who are moderately opposed to the use of the overhead trolley in any large city. This opposition was so vigorous and determined that no city council would dare to consent to a trolley system in the face of public protest against it.



A Suggestion for the Improvement of West Street, New York.

A number of readers of The Engineering Record have requested it to print the accompanying sketch for the treatment of West Street by means of an elevated boulevard and observation piers in connection with an elevated railway and a freight subway. This sketch is one of a series made by Mr. Charles R. Lamb, as chairman of the Committee on Thoroughfares of the Municipal Art Society of New York. These suggestions were made to point out possible improvements in the transit facilities of the city which would at the same time add to its beauty. The sketch which is reproduced has attracted particular comment because there is nothing in its suggestions which will cause any injury to existing franchises and property, were it carried into execution. It would be a benefit to nearly every one, although a costly scheme to execute.

The idea of a double elevated structure which would give not only tracks for electric cars on a level with the first floor of the steamship piers, but at the same time an open boulevard for automobiles and bicycles with a footway for pedestrians, is suggested by Mr. Lamb primarily because of its distinct advantage to all people doing business in lower New York or desirous of going south on the island to any of the North River steamship or ferry piers. The street entrance to the docks on the main level is not interrupted by the elevated structure, while the freight problem is solved by an inclined railway spur from the deck of each dock to a subway under West Street. At the present time the operation of freight cars in lower New York only occurs at night and merchants are seriously hampered in consequence. The subway would entirely change this condition. It will be noticed that the boulevard connects with observation piers all along the water front, these platforms being formed on the roofs of the steamship docks. As explained in the report of the committee, these roof platforms are for the use of the thousands of residents of the district, and will be without cost to the city, as their construction in no way interferes with the rental value of the piers. When it is considered that the so-called recreation piers have been provided only at a great expense for construction and a continuing annual loss of rental, the value of Mr. Lamb's suggestion is apparent.

While the expense of any such structure will be very great and the adoption of such plans will meet the opposition of the lessees of some of the docks, the sketch is nevertheless full of interest as an indication of a possible method of providing a summer resting place for the overcrowded population of lower New York, an admirable driveway for reaching that portion of the city where wholesale business is conducted, and plenty of room for street cars in a position where they will not interfere with the heavy teaming along the water front.

A Steel Tower 85 feet high carrying four reservoirs superimposed one above the other serves the Rixdorf gas works near Berlin. The uppermost tank is cylindrical, and holds 5,300 cubic feet, while those beneath it are hemispherical, each of 1,585 cubic feet capacity.

Sewage Disposal Works and Experiments at Andover, Mass.

The town of Andover, Mass., is located on the line of the western division of the Boston & Maine Railroad, 23 miles from Boston. The town is principally residential in character; its population in 1895 was 6,145, and had increased in 1900 to 6,813. The town is made up of the main village and several small settlements. The natural drainage of the place is into the Shawsheen River, which empties into the Merrimack River at the boundary line between the city of Lawrence and the town of North Andover. The main village lies mostly on high land. The water supply is drawn from Hagget's Pond, about three miles from the town, and the waterworks, which were built in 1889-90, are owned by the town.

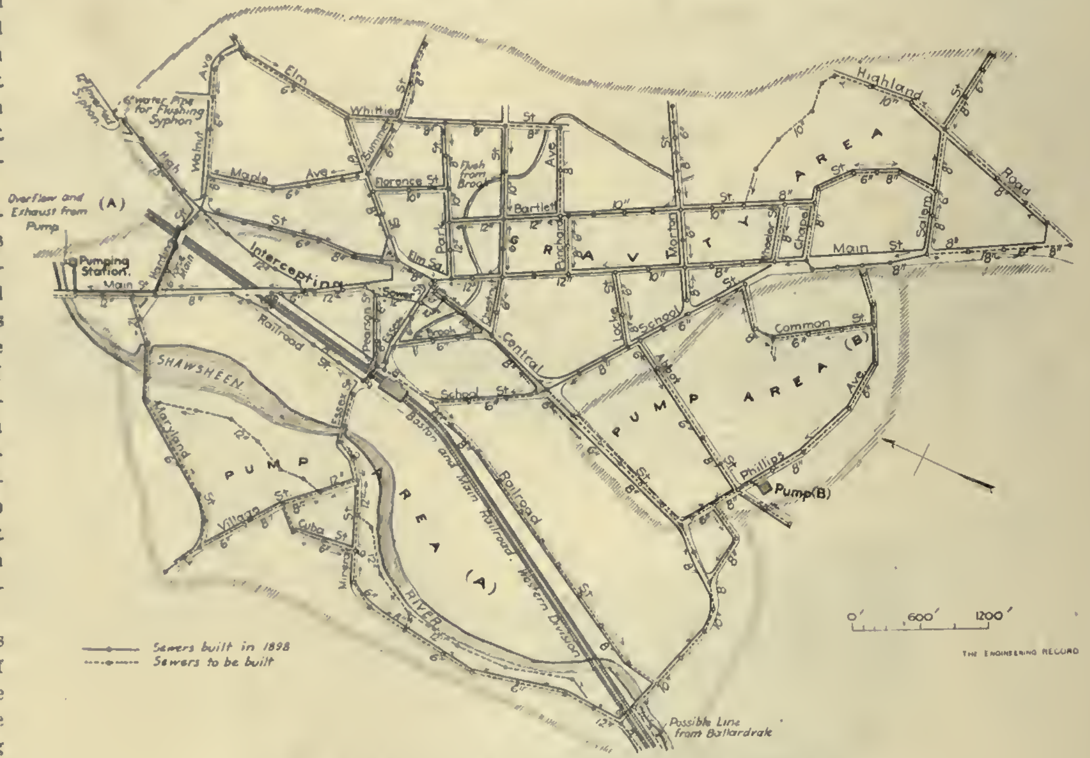
In 1894 the sewer commissioners engaged Messrs. McClintock & Woodfall, of Boston, to design a system of sewerage. The engineers in their report suggested two methods of disposing of the sewage, first, to treat the sewage on land located within the limits of the town, and, second, to discharge the sewage into the Merrimack River near the mouth of the Shawsheen River. The first method was finally adopted by the town and construction was started in 1898, the works being largely built during that year. In order to deliver the sewage to an area which was suitable for filtration works it was necessary to divide the town into a high-level and two low-level districts.

On the accompanying map of the town showing the sewerage system these three districts are indicated, one being designated as the gravity area and the others as pumping areas A and B. The main pumping area includes, besides the territory which is shown on the map, the village of Ballardvale, located on the line of the railroad southwesterly from the main village. The sewage of Frey village, located on Main Street, northwesterly from pumping station A, will also have to be pumped. The location of the two pumping stations for the two low-level districts are shown on the map, but not the location of the disposal works, which are situated nearly a mile north of the northerly limit of the area included in the map.

The larger pumping station, designated as pumping station A, is situated on the bank of the Shawsheen River, at the north end of the village. It is a small and extremely simple structure, as indicated by the accompanying drawings, which show its arrangement. The building is of brick, about 12x15 feet inside, one story and basement, with hip roof. The basement is 10 feet deep below the main floor, which is of wood and at the ground level, and serves as a receiving tank and pump well. It has a bottom of Portland cement concrete 1 foot thick, graded to the center, where a length of 20-inch vitrified sewer pipe is sunk into the floor concrete with the top of its bell flush with the surface of the floor, as shown. The bottom of this pipe is filled with concrete, leaving a space at the top about 18 inches deep to serve as a sump for the end of the pump suction pipe. The intercepting sewer discharges into this tank through an inclined screen of steel bars turned edgewise, and an overflow prevents the depth of sewage from exceeding 4 feet. At the top of the screen there is a wooden platform suspended from the main floor and 4 feet below it, to provide access to the screen for cleaning it.

The pump is a 4½x6x10-inch Worthington water-motor pump with 5-inch suction and 4-inch discharge. The discharge pipe, however, is increased to 6 inches near the point where the force main leaves the building. This pump is set with its base at the main floor level on a 2½x5½-foot block of concrete supported by two 12-inch I-beams extending through the walls of the building so that their ends are carried on two concrete buttresses with rubble masonry foundations built against the walls, as shown. The water for the motor end of the pump is drawn from a water-works main under a pressure of 125 pounds per square inch and is exhausted into a small well in one corner of the basement, which acts also as the overflow chamber. A pipe extends from this chamber to Shawsheen River. The pressure pipe is 3 inches in diameter and the exhaust 4 inches. The force main is about 1,800 feet long and the lift is about 90 feet. The capacity of the pump is about 75 gallons per minute. The pump is automatic and starts when the tank is full, but stops when the tank is empty. The ball float shown on the drawing opens and closes the regulating valve, thus starting and stopping the pump. The sewage from the force main is discharged into a manhole on the gravity pipe line to the disposal works.

The second pumping station, designated as pumping station B, is very similar to the one just described, the only difference being that in this instance no superstructure was built over the tank and pump. The tank is covered by a platform roof and entrance is made by a manhole. At station B the operating water pressure is 80 pounds per square inch, the lift for the sewage is about 26 feet and the force main is about 2,000 feet long. The pumping station at B was built because sewers were needed in pumping area B, but were not needed at present along the Shawsheen River. It was thought to be cheaper to pump the sewage at B rather than to build a long and expensive outlet sewer to pumping station A.



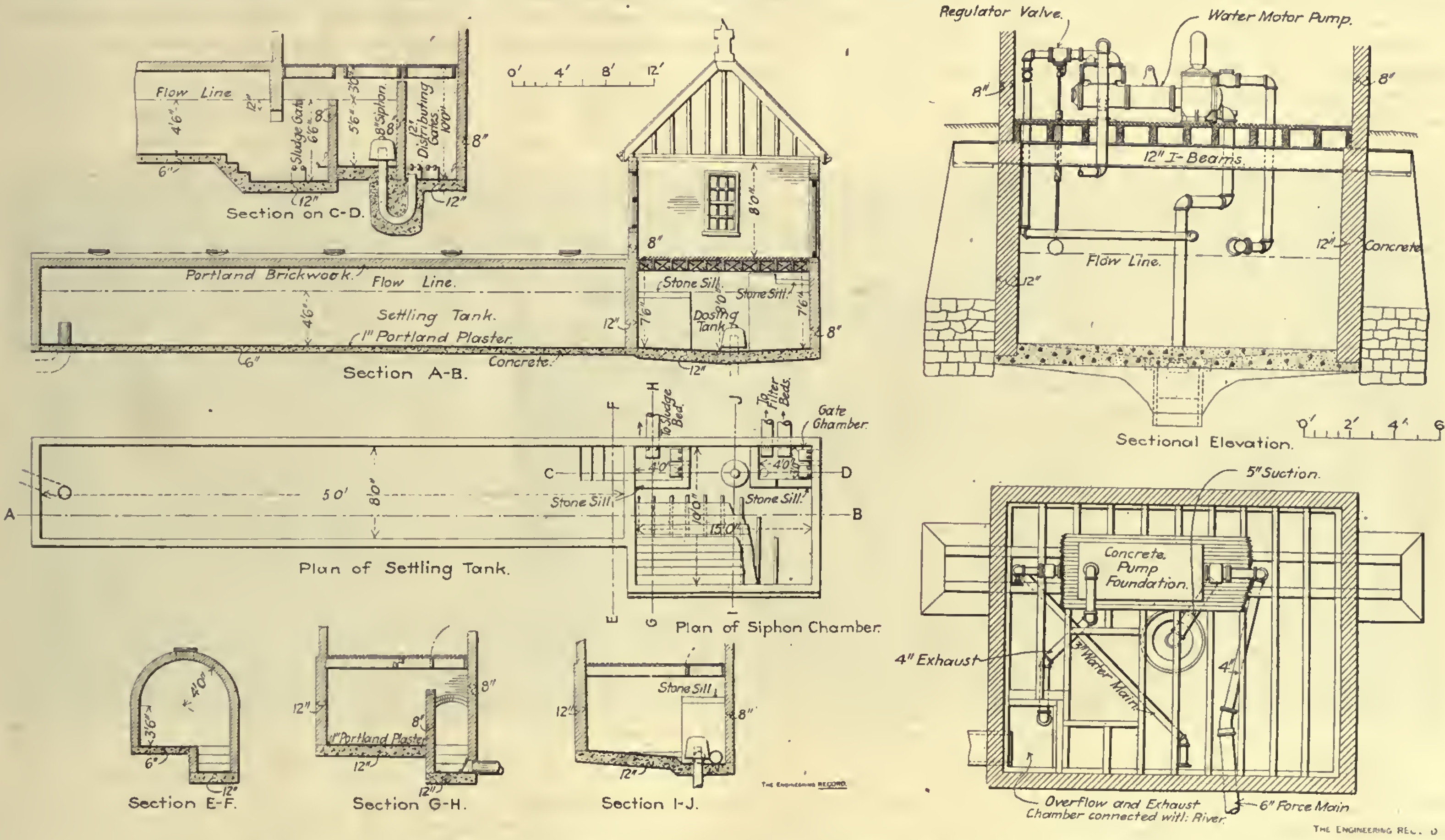
Map of Andover, Mass., Showing Sewerage System.

The disposal works comprise a settling tank and siphon chamber, twenty filter beds for treating the tank effluent and two sludge beds, the effluent from the filters being discharged into a brook entering the Shawsheen River, which is only about 600 feet distant, along the brook course. The settling tank is located on a hillside about 50 feet above the lowest filter bed, the beds being at the bottom of a small valley and terraced.

The sewage is delivered to the settling tank through an inverted siphon which crosses a valley between the village and the disposal area. This inverted siphon is a 12-inch cast-iron pipe 4,960 feet long, and its low point is 53.5 feet below the surface of the sewage in the settling tank. At the low point there is a gate valve and pipe which allows the sewage to be discharged from the siphon on to a ½-acre filter bed, the effluent from which flows into a brook nearby. At the high end of the inverted siphon near the village there is a 12-inch gate valve in the pipe line, and just below this gate a 6-inch connection controlled by a valve was made with the water system. By closing the 12-inch gate and opening the 6-inch the siphon can be flushed.

At the disposal works the sewage first enters the settling tank through the upturned end of the 12-inch siphon pipe, as shown in one of the drawings, at one end of the tank, the top of the pipe being about 2 feet above the floor. After passing through the settling tank the sewage flows into the adjacent dosing tank, and from the dosing tank is discharged by means of a Miller automatic siphon to the filter bed. Accompanying drawings show the arrangement and principal dimensions of the settling and siphon tanks which together form one structure. From the settling tank the sewage flows, as shown in section C-D, under a baffle wall into a small chamber in one corner of the dosing tank, and spills over the walls of this chamber into the dosing tank or siphon chamber. The dosing tank is 10x15 feet inside, and the Miller siphon discharges the sewage from it into a small gate chamber built in another corner of the dosing tank. From the gate chamber the sewage is discharged to the filter beds through a 12-inch pipe. The sludge is drawn from the small chamber first mentioned by opening a gate on the end of a 12-inch pipe leading to the sludge filter beds. By opening two other gates in one of the walls of this small chamber, thus connecting it directly with the dosing tank, the settling tank also can be emptied through the Miller siphon. The walls of the settling tank and its arched roof are of brickwork laid in Portland cement mortar; the floor is of Portland cement concrete. There are five manholes in the roof. The settling tank is wholly underground, but there is a small brick superstructure over the dosing and siphon chamber.

The filter beds are long and narrow and arranged to fit the topography of the site. Each has an area of 1/5 acre, so that the twenty beds now in use have a combined area of 4 acres. The two sludge filter beds each have an area of 1/10 acre. The town owns sufficient land to permit the construction of other beds in the future whenever they may be needed. The material of which the filter beds are made varies from quite fine sand to coarse gravel. The beds are underdrained by 4, 8 and 10-inch vitrified pipes laid from 4½ to 5 feet below the surface and extending, usually, lengthwise of the bed. On the main distributing sewer which passes between the two rows in which the beds are arranged, there are several small brick distributing chambers containing the valves which control the pipes leading to the individual beds. Corn is raised on the beds in the summer.



Andover Sewerage System: Details of Settling Tank, Siphon Chamber and Pumping Station.

In 1898, while the Andover sewerage system was under construction, the State Board of Health of Massachusetts decided to take advantage of the favorable opportunity which the conditions seemed to afford for studying the septic process of sewage treatment on a somewhat larger scale than that on which experiments had previously been conducted in the experiment station at Lawrence. Consequently the Board constructed a septic tank of about 9,000 gallons capacity and two experimental filters of 1/200 acre area each. The following description of this experimental plant and the work done with it have been taken from the recent reports of the Board.

One of the filters was filled to a depth of 5 feet with fairly coarse sand of an effective size of 0.23 millimeter, while the other filter was filled to a depth of 5½ feet with coke, most of which would pass through a sieve with a ½-inch mesh. The coke contained a considerable proportion of large pieces, but was free from coke dust. These filters were put into operation the first week in July, 1899, the sand filter being started as an intermittent filter at the rate of 40,000 gallons per acre daily, and the coke filter as a contact filter at the rate of 860,000 gallons per acre daily. The rate of the sand filter was increased in October to approximately 110,000 gallons, and in November to 220,000 gallons.

The quantity of sewage reaching the town filters averaged about 70,000 gallons per day during the year 1899, and was a very strong sewage, as is indicated by the following averages for the last six months of the year: Temperature, 55 degrees Fahrenheit; free ammonia, 9.75; albuminoid ammonia, total, 1.29, in solution 0.98, in suspension 0.31; chlorine, 15.62; oxygen consumed, 7.42; bacteria per cubic centimeter, 3,772,000, the quantities being stated in parts per 100,000. With the comparatively small volume of sewage flowing during the period mentioned, the sewage was practically twenty-four hours in reaching the filters and was stale when it arrived at the septic tank. The sewage, in the condition in which it reaches the disposal plant and flows upon the town filter beds, not operated at a high rate, is fairly well purified by these beds. When flowing to the experimental filters, however, after having been practically twenty-four hours in the settling tank, it was in a condition very difficult to purify. When operating the experimental sand filter at a low rate, fairly good results were obtained in warm weather, although the amount of free ammonia in the effluent was larger than would be expected, notwithstanding the strength of the applied sewage. When the rate of operation of this filter was increased, nitrification became much less active and had practically ceased by the end of November.

During this period it was impossible to obtain any nitrification whatever in the coke contact filter, although this filter was not operated at a rate greater than that at which filters had been operated at the experiment station in Lawrence with strong sewage, with satisfactory results. The sewage applied to these filters did not average stronger in albuminoid ammonia or oxygen consumed from permanganate than had the sewage at the experiment station for some years, but the amount of free ammonia present was more than twice as great as the average amount in the experiment station sewage. The amount of chlorine, while greater than that in the Lawrence sewage, was not enough to impede nitrification, as various investigations with tannery sewage, etc., had shown.

It seemed probable that the anaerobic action had been carried so far before the sewage reached the filters that various bodies were generated in the sewage which prevented the development of the nitrifying bacteria in the filters. The sewage had an odor more nearly resembling that of the wastes from a cesspool than that of ordinary fresh, stale or septic sewage. It is certain that, if the anaerobic process is carried too far, there may be a formation of distinctly poisonous bodies, which might prevent nitrification.

During the year 1900 the experiments were continued, the small intermittent sand filter being kept in operation at rates varying from 50,000 to 220,000 gallons per acre daily, and the coke contact filter at rates from 100,000 to 2,000,000 gallons. There was considerable nitrification within the sand filter during a portion of the year, but poorer results were obtained than would have been expected if treating a fresher sewage, containing a quantity of organic matter equal to that in the sewage from this septic tank.

During a considerable portion of the winter, the coke filter was operated as a continuous filter, a stream of sewage being passed through it continuously during a large part of the twenty-four hours, at the rate of 2,000,000 gallons per acre per day, this stream being fairly well distributed over the surface of the filter, and the surface not intentionally covered with sewage during any portion of the day. During this period there was no nitrification, the effluent did not contain dissolved oxygen and it was very ill smelling. Beginning May 8 it was operated for a few days as contact filters are usually operated at Lawrence, the outlet being closed and the filter filled by four applications of sewage one hour apart, allowed to stand full two hours and then drained slowly. The rate for a few days was 600,000 gallons, but without any better results than previously obtained. The rate was then reduced to 100,000 gallons, and the filter operated as an intermittent filter, sewage being applied very slowly during a period of one hour, this method being followed for twelve days, at the end of which the rate was increased to 200,000 gallons, and two weeks later to 400,000 gallons per acre daily. This was in warm weather, but even at these low rates nitrification did not occur, and the effluent did not contain dissolved oxygen. After August 21 it was again operated as a contact filter at a 600,000-gallon rate, a small amount of sand being mixed with coke, but this expedient also failed to furnish conditions favorable to nitrification. A second coke filter was put into operation during the last three or four months of the year, containing coke of a different character, but with no better results. The coke in this smaller filter was 4 feet deep.

The experimental septic tank at Andover was operated during the first six months of 1901 at such a rate that the sewage was about 14 hours in passing through it, then for six weeks it was 17½ hours in passing through, and during the remainder of the year it was 20 hours. At the end of the year the liquid in the tank had a hard tenacious scum from 1 to 3 inches thick over a large portion of the surface, and the accumulated sludge on the bottom of the tank occupied about 11 per cent. of the tank's capacity. All three of the experimental filters received a large part of the year the sewage that had passed through the septic tank. The sand filter was operated at rates varying from 56,400 to 116,000 gallons per acre daily, and gave an effluent containing little or no sediment or turbidity; good nitrification occurred, although the free and albuminoid ammonia in the effluent were high. The large, or older, contact filter was operated at rates varying from 380,000 to 600,000 gallons per acre daily. The sewage passed through this filter practically without change; there was practically no nitrification within the filter, and the effluent contained no dissolved oxygen. To the small coke filter the effluent of the large coke filter was applied at rates varying from 352,000 to 522,000 gallons. From the beginning of the operation of this filter until the middle of October, 1901, the effluent of the large coke filter passed through the small filter practically without change, and nitrification did not occur in the filters to any extent. Beginning on this latter date, however, the large coke filter received Andover sewage which had not passed through the septic tank, and, although nitrification did not occur in the large filter, yet when its effluent was applied to the small filter fairly good nitrification ensued.

The cause of the non-nitrification of the septic sewage, when applied to first one coke contact filter and then to another, was undoubtedly that the gases were of such a nature or the carbonaceous organic matter in the sewage that had passed through the septic tank was in such an unstable or easily oxidized condition that even the oxygen introduced by double contact filtration was not sufficient to enable nitrification to occur. When, however, the stale Andover sewage was applied first to one contact filter and then to another, without having first passed through the septic tank, nitrification occurred in the secondary filter.

The septic tank was kept in operation until July, 1902, and, while fairly successful as a sludge destroyer, the exceedingly strong and very old sewage passed through it was rendered difficult to purify by intermittent or contact filtration without preliminary aeration. During its period of operation it removed or destroyed about 55 per cent. of the nitrogenous organic matter of the entering sewage, as shown by albuminoid ammonia determinations, the period of passage averaging about fourteen hours.

The three filters were operated until the end of June, 1902. During these six months of 1902 the sand filter was run at a rate of 105,000 gallons, and at this rate a very poor effluent was produced. The large coke filter was operated at the rate of 380,000 gallons, and, although some organic matter was removed, little nitrification occurred and the effluent was of very poor quality. The effluent of this filter was applied to the small contact filter at a rate of 352,000 gallons, and a considerable improvement in its quality resulted, nitrification being fairly active during the period of operation.

The experiments proved conclusively that, with the old and somewhat stale sewage reaching the Andover disposal works, septic-tank action was not favorable to subsequent purification. The descriptions of these experiments are stated more fully in the reports of the Board for the years mentioned. These reports contain a number of tables giving results of the analyses made regularly in connection with the experimental work.

Notes on the Sewerage System of Worcester, Massachusetts.

The chemical precipitation and filtration plant for treating the sewage of Worcester, Mass., has made that city widely known among engineers and others interested in the subject of sewage disposal. But Worcester's sewerage system has other points of interest, a number of which have been described in this journal in times past. The following notes on some of the construction work carried on during the year 1903 and on the maintenance and operation of the disposal plant have been taken principally from the recently issued annual report of the superintendent of sewers, Mr. Harrison P. Eddy.

Cofferdam for Sewer Inside Millbrook Conduit.

Millbrook is a stream flowing through the city into the Blackstone River. From time to time portions of the channel of this brook were walled and arched with masonry, and for years it has served as a combined sewer. The dry-weather flow of water in the brook amounts to about 5,000,000 gallons per twenty-four hours and there is a very rapid increase in flow as soon as there is any appreciable rainfall, as the street and roof water from a large portion of the city is drained into this brook. The pavement of the artificial brook channel for about 4,250 feet, from Franklin Street to Lincoln Square, was in unsafe condition for several years, but early in 1903 an appropriation of $25,000 was made for the repaving with Portland cement concrete of such a length of the channel as could be accomplished with this sum. Through this portion of the city Millbrook runs in a stone arched conduit which is about 20 feet wide and 8¼ feet high from the bottom of the circular invert to the crown of the arch. This masonry is about thirty years old, but with the exception of one short section under a railroad, the arch was found in good condition; the defective portion has been pointed with Portland cement mortar, and is now considered to be safe for many years to come.

The original paving was composed of moderate sized quarry stones 10 to 12 inches thick, laid dry. As large a number of these stones as possible were embedded in the new concrete paving and part of the surplus was used on other work being done by the sewer department; the remainder was sent to the stone crusher at the street department yard. Under the existing conditions special methods of handling stock and caring for the water were necessary. These methods were similar to those employed in the construction of the conduit for sewage which was built inside another part of the Millbrook masonry channel, in 1897 and 1898, and described in The Engineering Record October 30, 1897. Before taking out the old pavement, a continuous cofferdam, made up in 16-foot sections, about 200 feet long and 4 feet high, was erected and securely fastened to posts resting on the pavement and tightly wedged against the crown of the arch. These cofferdams were set a little to one side of the center of the channel so that one-half of the original paving could be removed. By these means the water was easily kept away from the concrete which formed the new paving until it had opportunity to harden.

One of the accompanying illustrations shows the method of building the separating sewer inside the Millbrook conduit in 1897 and 1898, and helps to make plain the operations of the later work. Another illustration shows the method of propelling the scows carrying materials for the paving work done in 1903, and the third view shows the inside of the cofferdam used for placing the pavement.

The new pavement is 8 inches thick at the center of the invert and 12 inches thick at the sides. It is composed of one part Dragon Portland cement, 2½ parts sand and 4 parts No. 2 crushed stone. As the skewback stones under the bottoms of the walls extended under the arch, thus forming a part of the pavement of the invert, the average width of the new pavement is only about 17 feet. Light was furnished inside the channel by incandescent electric lights on a 500-volt continuous-current circuit. Materials were transported inside the channel on scows, either poled or pushed by laborers, holes being cut in the arch at convenient places for receiving the supplies. No artificial ventilation was necessary in this case. About eight hours were required for taking down the string of cofferdams and erecting them again in an advanced position. Work was commenced May 27, 1903, and up to December 1 about 2,340 linear feet of the channel had been repaved at an actual cost of $9.48 per linear foot, all work being done by the employes of the sewer department and the minimum price of labor being $2.00 per eight-hour day.

The district of the city situated on the shore of Lake Quinsigamond could be connected to the sewerage system only by means of pumping over a hill intervening between this district and the nearest part of the city in which sewers existed. The total lift required is about 180 feet. This district has a permanent resident population of about 700, which, on holidays and at other times, is frequently augmented by thousands of visitors to the lake resorts, thus causing considerable fluctuation in the quantity of sewage to be dealt with. The district includes the hillsides sloping to the lake and so, instead of draining all the sewage to one pumping station in the lowest part of the area, the district was divided into three sections, each of which could be drained to one point, the lift from the highest station being only about one-third the total and that from the middle section about two-thirds. At each station Shone pneumatic ejectors of suitable capacity have been installed in underground concrete chambers, the lowest station having a 150-gallon ejector with room for another 100-gallon ejector, and each of the other stations having one 100-gallon ejector with room for another of the same size. Power is furnished by two 15-horse-power electric motors, made by the General Electric Company, belted to two 10x8-inch single Ingersoll-Sergeant Drill Company's air compressors. The necessary current for the motors is taken from the electric light wires, and the motors are controlled by automatic pressure regulators actuated by the pressure of the air in the pipe line. The air is transmitted through a wrought-iron pipe having diameters of 5, 4 and 3 inches, leading to the various ejectors, the total length of the line being about 3,600 feet.

Worcester Sewerage: Scows Carrying Materials in Millbrook Conduit; Inside of Cofferdam for Renewing Pavement of Conduit.

As is well known, Worcester's sewage is treated before being discharged into the Blackstone River. The total flow of sewage received at the disposal works during the year 1903 amounted to 5,676,000,000 gallons, of which 5,251,000,000 gallons were treated by chemical precipitation, 158,000,000 gallons by the septic process and 267,000,000 gallons by simple sedimentation before being filtered. The average daily flow of sewage was 15,550,000 gallons. The quantity of water supplied by the water department averaged 9,670,000 gallons per day. The cost of maintaining the purification works for the year was $53,891.17, which makes a net cost of 41 cents per capita, based on an estimated population of 132,000 people. The chemical treatment, as in past years, has consisted of the addition to the sewage of milk of lime. In this treatment 871 pounds of lime have been used per million gallons of sewage treated during the year, and this does not include the lime added to the sludge directly before pressing. The net cost of chemical treatment has been $4.01 per million gallons treated. To this should be added the cost per million gallons of sewage treated for disposing of the sludge, $4.91, making a total cost of $8.92, including the expense of pressing the sludge from the septic and sedimentation tanks. All sludge has been pressed in a G. H. Bushnell Press Company's filter press and the resulting cake hauled over a narrow-gauge trolley road to a dump, as in previous years. The total volume of sludge pumped from the settling basins to the storage tanks was 25,260,000 gallons. It was allowed to remain in the storage tanks as long as possible, and then the clear water was drawn from the top before pumping the sludge to the presses. The clear water drawn off amounted to 733,000 gallons, or 2.9 per cent. of the sludge pumped.

New filter beds have been prepared from year to year and the plant now includes twenty-three beds with a total area of 23.2 acres. The sand and sludge removed from the surface of the filter beds since they were first put into operation in 1899, measured in the filter, has averaged, during the five years the filters have been in operation, 3.2 cubic yards per million gallons of sewage and effluent filtered, or 961 cubic yards per acre. This is equivalent to about 7.15 inches in depth over the entire area, although the general elevation of the surface has been lowered but about 3 inches.

Commenting on these figures, Mr. Eddy writes in his report as follows: "The comparatively large quantity of dirty sand removed from these filters in view of the fact that comparatively little crude sewage has been run on to them leads to the serious consideration of the advisability of giving the sewage any preliminary treatment. It is a well-known fact that crude sewage carries a considerable quantity of coarse suspended matter and that this forms a sort of mat over the surface of the sand which, after it accumulates somewhat, becomes almost impervious to water. In the effort to raise the capacity of the filters it is very commonly advocated that the sewage be treated by sedimentation, the septic process or chemical precipitation and thus remove all but the most finely divided suspended matter.

"It is obvious that the more finely divided the material is, the deeper it will penetrate the sand of the filter and it has been found that the portion which remains on the surface does not interweave into a fabric as does the coarse material, but remains as a powder after drying. When wet it appears to be just as impervious to water as the coarse mat.

"To remove the coarse mat it is only necessary to rake or fork it off the sand. This cannot be done with the fine accumulation. When this first becomes sufficiently thick to prevent the rapid passage of water through the sand there is only a thin film of it. The most practical way of removing this has been found to be by scraping with the back of an iron rake. This method, however, makes it necessary to remove much of the sand in proportion to the sludge. On this account the surface of the sand has been regularly scratched to a depth of about an inch with a horse weeder. Of course this mixes the organic matter with the sand, and so it is found necessary to remove a layer of substantial thickness at intervals of perhaps six months. These scrapings have generally averaged about one-half inch in thickness; but there has also been a gradual increase in the amount of organic matter below the layer removed, and this fall it was found necessary to give the beds a thorough cleaning, and an average of 4.4 inches was removed from the surface of the beds.

"That the iron and lime which have been carried on to the filters have not played an important part in this problem is not yet demonstrated. Further studies are in progress which, it is hoped, will throw additional light upon this question."

The cost of cleaning the beds this year was 36.8 cents per cubic yard of material removed, amounting to $236.08 per acre. The cost of operating and cleaning the filters has been $7,061.97, making the cost of filtering $13.85 per million gallons. The quantity of sewage and chemical effluent filtered per acre per day averaged 108,000 gallons. It should be stated that the cost per million gallons filtered is much more and the quantity filtered greatly less than would have been the case had the filters been cleaned in the spring rather than the fall.

By the chemical treatment an average of 51.69 per cent. organic matter, as shown by the albuminoid ammonia, has been removed from the sewage. Suspended organic matter was removed to the extent of 91.58 per cent. By the chemical treatment and the filtration combined in proportion to the amount treated in each way, the net result shows a removal of 55.31 per cent., while the result of filtering the sewage and chemical effluent was 87.92 per cent. organic matter removed.

Besides the usual tables relating to finances, materials, cement tests, rainfall, sewers constructed and cost of maintaining and the results obtained from the disposal works, Mr. Eddy has added to his report for the past year a "Summary of Purification Statistics," consisting of groups of brief statements under the headings:

Chemical Precipitation, Sludge Pressing, Intermittent Filtration, Sedimentation, and Septic Tank. Mr. Eddy's idea is to get the many engineers and superintendents in charge of sewerage works to report along the lines suggested, or others which may be adopted as a standard form, as many water-works superintendents have for years been using the standard form for Summary of Statistics promulgated by the New England Water Works Association. This suggestion has been taken up by the Sanitary Section of the Boston Society of Civil Engineers, and a committee has been appointed to draft a set of standard items for report covering both maintenance of sewers and disposal plants. Co-operation in the manner proposed should prove beneficial to all concerned in this department of public works. Communications of inquiry or suggestion will, doubtless, be welcomed by Mr. Eddy or by Mr. William S. Johnson, secretary of the Sanitary Section of the Boston Society of Civil Engineers.

The Wood Block Roadways for the Williamsburg Bridge.

In paving the roadways of the Williamsburg bridge with creoresinate wood blocks, which was done by the United States Wood Preserving Company, of 29 Broadway, New York, it was found that the provisions of the specifications calling for either spreading the upper surface of the steel channels with hot asphaltic paving cement, or dipping the blocks in it before setting them, were both impracticable, owing to the fact that the work was carried out during the period of low temperature which prevailed during the months of December, 1903, and January, 1904. The paving cement hardened so quickly on the cold steel and had such an irregular surface that it was impossible to set the blocks on it with a bearing firm enough to sustain the traffic without splitting them. This floor construction was described in this journal April 9. It was found that the original steel surface of the channels formed a smoother surface for laying the blocks than could be secured by paving cement, and so the specifications were modified by the omission of the cement.

It was originally proposed to caulk the joints between the rabbeted blocks with alternate layers of gravel and hot paving cement. Four-fifths of all the blocks have rabbeted joints the plain blocks only being used on the level sections at the center of the span. Owing to the extremely cold weather it was found impracticable to pour thin streams of paving cement from a can to fill these joints and after several consultations between Commissioner Lindenthal and the contractor it was decided to fill the rabbeted joints to within about ½ inch of the top with hot fine gravel, heated on the structure. Immediately thereafter the paving cement was flooded over the entire surface of the paving, being poured from two-gallon buckets and immediately swept into the joints with squeegees, which are a form of rubber-edged wooden scrapers with long handles similar to those used for roofing purposes. The objection to using the cement in this way was the fear that it would not penetrate to the bottom of the joints, but owing to the fact that the gravel was used hot, the cement cooled slowly and flowed well. Subsequent tests showed that it thoroughly penetrated the joints and spread under the blocks so that in some cases it leaked through the steel under floor and dripped on to the street below.

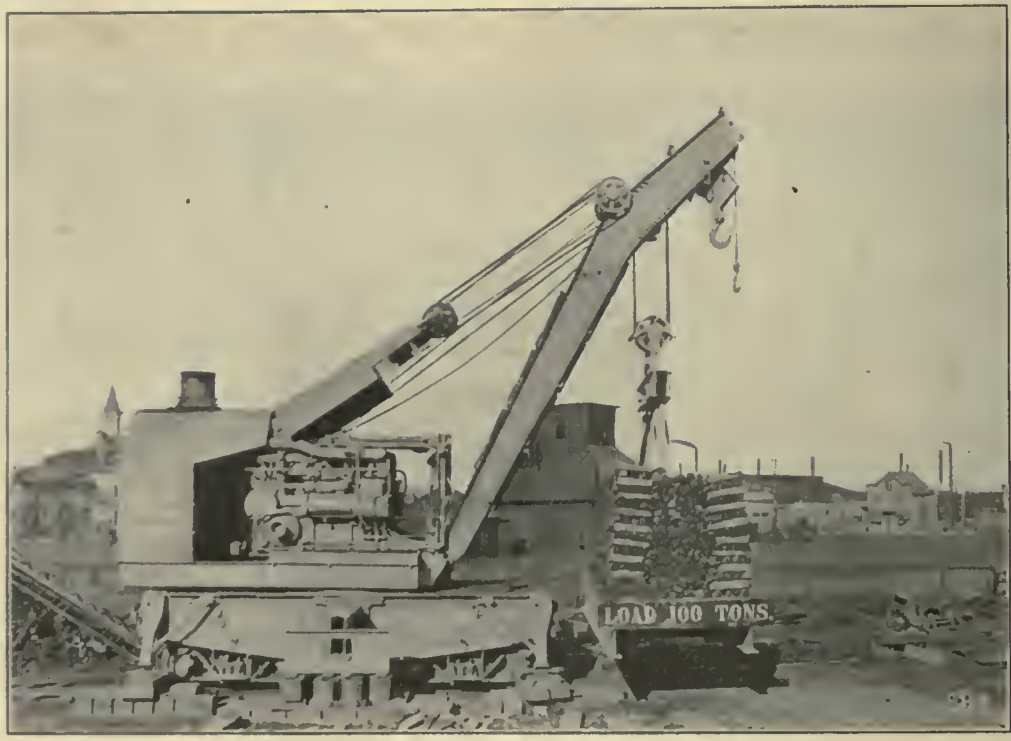
After the work was under way it was found that it could be carried forward on each 20-foot roadway at the rate of about 200 feet per day. Considering the cold weather, and frequent snows, as well as the impossibility of storing material on the bridge, and the necessity of delivering most of the material to the roadway by derricks the rapidity with which this work was executed and the fact that it was completed within the contract time, is worthy of note. The south roadway was completed and opened for travel on December 12, 1903, and the north roadway was finished about the last week in January, 1904. Work on the south roadway was begun in the latter part of October and on the north roadway about the middle of December, as soon as their respective steel underfloors were ready.

Mr. Holton D. Robinson, engineer in charge of the bridge when the pavement was laid, reports that during the winter there was little or no complaint of slipping on the grooved wood block. Mr. K. C. Martin, now assistant engineer in charge of the bridge, adds that sometimes in heavy fogs and at the beginning of rains there is trouble from slipping until the surface is washed, when the trouble disappears. The grooved wooden blocks were treated at the contractors' Perth Amboy Works by a modification of the well known creosoting process, whereby melted rosin and other ingredients are incorporated with the creosote oil with the purpose of preserving the blocks against decay and rendering them waterproof and very much harder and therefore more durable. As an example of the waterproof qualities thus secured, it may be said that the specifications for the city of Brooklyn under which five streets were paved with these blocks last year, called for an absorption by them of not more than 3 per cent. after 24 hours drying followed by 24 hours immersion in water. Under this test, conducted by the Department of Highways, the absorption was only 0.98 of one per cent. in 24 hours and a continued test for three days did not at the end of that time bring up the absorption to the 3 per cent. allowed by the specifications.

The Cost of Power at the works of the municipal station of Chesterfield, England, is 1.64 cents per kilowatt hour. The power equipment includes 600 kilowatts in four direct-current units and a storage battery of 300 amperes capacity for one hour. In the last two years 208,316 kilowatt-hours were sold.

An Unusually Heavy Wrecking Crane.

A 100-ton wrecking crane recently built for the Denver & Rio Grande Railroad by the Bucyrus Company, South Milwaukee, Wis., is shown in the accompanying illustrations, which, however, afford but an imperfect idea of the massive construction of this car. The body is a system of crossed girders with the turntable so arranged that the cross strains in the framing, caused by a heavy side load on the jib, are taken up as directly as possible by these girders. This design of body is new and covered by patents. The body is fitted with quick-acting Westinghouse air brakes and M. C. B. automatic couplers, and is only 21 feet long with a wheel-base of 17½ feet. This short length for such great capacity enables the crane to swing an exceptionally bulky load on a 16-foot radius. Attention is also called to the special arrangement of pendulum bearing arms at the ends of the sills and the jack girder which can be run out transversely from the center of each side so as to afford an additional point of support when lifting heavy weights. The arrangement of the bearing arms and jack girder is such that an unusually large area can be covered by the blocking below them if it is considered desirable.

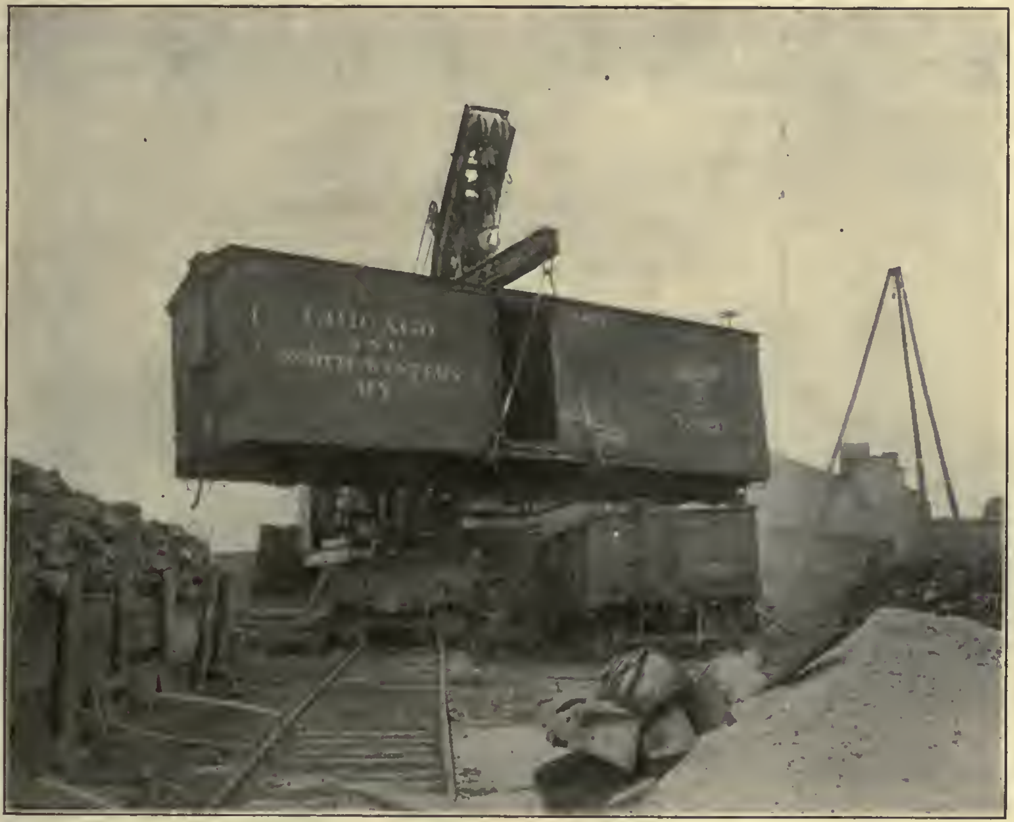


A Test Load for a Wrecking Crane.

The turntable carries a 56-inch boiler for a working pressure of 125 pounds per square inch, a water tank holding 400 gallons and a hopper with a capacity of 2,500 pounds of coal. Power is furnished by an engine with two 10x 12-inch cylinders, with piston valves and outside crank disks. The frame of the engine is cast steel, made with particular care and specially annealed. The hoist has a friction brake, but the lowering operations can also be controlled by means of a port in the steam passage of each cylinder near the valve chest. With the steam valve closed and the brake loose, the load can be lowered at any desired rate by opening or closing this port, the engine acting as a power compressor during the operation. When it is desired to lower the jib with a heavy load, it is only necessary to throw in the jib-hoisting clutch and the hook hoisting clutch at the same time. All brakes may then be removed and the load will hang suspended, owing to the arrangement of the two drums, until its position is moved by starting the engine.

The turntable is swung by a train of spur gearing driven through two friction clutches, of which only one is used at a time. When both clutches are thrown off, a friction brake is applied automatically so as to hold the turntable in place. In wrecking work, heavy side strains are sometimes put on the jib, and in case such a strain should threaten to strip the gears, the friction brake is designed to slip and allow the turntable to swing. It should be added that there is no worm gearing on the crane. The operator's station is at the foot of the jib, where he has full sight of the work in hand.

The construction of the jib and the means of raising and lowering it are fully shown in the illustrations. The main block will handle loads of 100 tons on a radius of 17 feet. The auxiliary hoist at the end of the jib has a capacity of 40 tons on a 30-foot radius while the hook is rated at 14 tons and is arranged for high-speed lifting. The hooks and some of the pinions are nickel-steel and it should be added that some of the large rack gears are cut in weldless locomotive tire blanks. The main block is held out of the way by a latch when it is not in use.



Handling a Box Car Body From the Peak of the Jib.

The operation of the crane in wrecking service is well illustrated by one of the accompanying views, showing it handling a large car body. The car was originally standing on a track parallel with the wrecking car and separated from it by a gondola car. The jib was lowered over the latter, the box car body slung from the auxiliary block by means of an equalizing lever, and the jib was raised and swung as shown until the car was brought around to a position on the other side of the track. The swinging of the jib is accomplished quickly, as the turntable can be completely revolved in 40 seconds or less.

The car weighs about 170,000 pounds.

The Tunnel of the Albespeyre, 258 square feet in area, is ventilated by a 19.7-foot fan, discharging 5,250 cubic feet per minute.

Book Notes.

The Association of Railway Superintendents of Bridges and Buildings has a membership representing over 141,000 miles of railway in the United States and Canada, and was the first of the national engineering organizations to organize a comprehensive system of committee work. Its representative membership and strong committees make its meetings of unusual interest, and the volumes of "Proceedings" in which the reports are printed are indispensable to anyone who desires to keep fully informed concerning railway bridges and buildings. The volume for the meetings held last October is a well-illustrated book of 420 pages, which is particularly noteworthy for committee reports on falsework for bridge erection in rapid currents over rocky bottoms, and on the best method of making annual inspections of bridges and culverts. There are many other reports, moreover, with discussions of them, which are nearly as important. The volume can be obtained from the secretary of the association, Mr. Samuel F. Patterson, Boston & Maine Railroad, Concord, N. H.

About a year ago two Illinois medical journals made some very severe criticisms of the results of the operation of the Chicago drainage canal. They asserted that the works were a failure, from a sanitary standpoint, and that the system was designed in ignorance of scientific sanitation. In order to show how unfounded are such comments, Dr. Arthur R. Reynolds' report on the chemic and bacteriologic examination of the streams between Chicago and St. Louis, before and after the opening of the canal, has been published by the Trustees of the Sanitary District of Chicago. It is a very interesting volume of 360 pages, containing a great number of tables of analytical results, showing the degree of pollution and the amount of self-purification at various places in the waterway between the two cities.

One of the most valuable reference books to users of machine tools which has appeared in a long time is the beautifully printed 750-page catalogue of the Niles-Bement-Pond Company, 136 and 138 Liberty Street, New York. This company manufactures such a great variety of tools and supplies at its different works that its catalogue is encyclopedic. The first division relates to railroad shop equipment, particularly driving-wheel, car-wheel and axle lathes. The second division is devoted to lathes in general, ranging in size from the delicate Pratt & Whitney bench type to the great tool for turning 125-inch crank shafts; this division also contains illustrated descriptions of a number of special types of lathes, such as turret machines and automatic screw machines. The third section is given up to planing machines, and various methods of driving them by magnetic clutches and motors are illustrated. The large portable rotary planers are among the most interesting machines described in this section of the book. Slotting and milling machines receive many pages, and some interesting full-page illustrations are given of the work done on Pratt & Whitney thread milling machines. Among the most useful pages in the catalogue are those devoted to boring machines, turning mills and tools of an allied character, which are now made in a great variety of forms and sizes. After these pages of classified tools, there is a large section for miscellaneous equipment for machine shops, and then follows a division relating to the machinery for boiler shops, including plate planers, bending rolls, punching and shearing machines, hydraulic presses, steam and hydraulic riveters. The book closes with an illustrated description of the full line of Bement steam hammers, typical installations of Niles travelling cranes and the small tools made by the Pratt & Whitney Company. The book has a good index, metric, as well as English dimensions are given throughout, and the general appearance is excellent. The Engineering Record is requested to state that while the catalogue is privately printed and is not for general distribution, it will be gladly sent to users of heavy machine tools.

Reminiscences Of General Herman Haupt. An Autobiography. With Notes and a Personal Sketch by F. A. Fowler. New York, John R. Anderson Co., 60 Bible House; cloth, 10x7 inches, 372 pages, illustrated, $1.75.

It is an unfortunate fact that the information concerning military engineering undertakings during the Civil War is extremely difficult to obtain, and on this account engineers will be glad to know that an opportunity now exists to secure a large amount of data on the subject. From April, 1862, until September, 1863, General Haupt was at the head of the United States military railroads, and his "Reminiscences" relate to the construction and maintenance of them. The book is mainly a collection of official reports and orders, with explanatory text binding the whole into a narrative of great interest. The illustrations are from war-time photographs, and among them are pictures of the famous Potomac Creek and Chattahoochee River Bridges. The first of these structures, about 400 feet long, having tracks 80 feet above the water, was built in nine days by ordinary troops. The second, 780 feet long and more than 90 feet high, was built by trained engineer troops in only four and a half days, with timber cut nearby. Both structures were timber trestles.

It has been given to few men to hold so many places of great responsibility as General Haupt. Like many graduates of his time from the United States Military Academy, he left the army after a few years' service, to take part in the railway construction then recently begun. His work was in Pennsylvania, and while engaged on it, he built a home at Gettysburg, where, about eight years later, he became professor of mathematics and engineering in Pennsylvania College. In 1847 he joined the Pennsylvania Railroad as division engineer, and rapidly rose to be principal assistant engineer, and finally general superintendent. In 1853 he resigned, to become chief engineer of the Southern Railroad in Mississippi, but returned to the Pennsylvania Railroad after six months as its chief engineer, a position he held until the road was completed to Pittsburg.

In 1855 he undertook the construction of the Hoosac Tunnel, and was engaged on this enterprise when he was commissioned in the army, as before mentioned. After the battles at Gettysburg, his local knowledge proved particularly useful, for on the second day after the fighting the railroads and telegraph lines to Washington and Baltimore, which General Lee had destroyed, were again working, although over twenty bridges had to be built to accomplish this feat.

After his military service, General Haupt conducted a general engineering practice in Pennsylvania for some time. In 1874 he became general manager of the Richmond & Danville Railroad, and in 1878, as chief engineer of Pennsylvania Transportation Company, built the tidewater pipe line, the novel method of transporting crude petroleum to the seaboard, about which so much has recently been written in "McClure's Magazine." In 1881 he became general manager of the Northern Pacific Railroad, a position he held for three years, and in 1884 he was elected president of the Dakota & Great Southern Railroad, and became one of the ten proprietors of the townsite of West Superior.

Tables for Roof Framing. By G. D. Inskip. Published for the author by W. P. Gumpert, 4328 Lancaster Avenue, Philadelphia. Flexible leather, 7x6 inches, 448 pages.

This book of tables is apparently written for structural draftsmen engaged on building work. The first table gives the number of thirty-seconds of an inch in any distance up to 50 feet and the number of sixteenths up to 100 feet, with the squares of these numbers. The second table gives the logarithms of feet, inches and thirty-seconds up to 60 feet, and the third table gives the logarithms of pitches per foot run from 1 to 18 inches, advancing by 32ds. The remaining tables present no features of novelty.

The general draftsman has occasion to employ such tables so rarely that it is questionable whether the time spent in acquiring facility in their use is well spent. In large offices, where roof work is in hand all the time, the case is different, and it would probably be a good investment for the manager of such offices to purchase a few of these books for a thorough test. If they prove satisfactory and time-saving, which can only be settled by a test under the working conditions of each office, their introduction should mean an increased amount of work from each man able to use them readily, for the data they give is not arranged so handily in any other book with which The Engineering Record is familiar.

Tractor Trains for Industrial Establishments.

The handling of packages and heavy objects about an industrial establishment is an expensive operation. This has been so well recognized by superintendents and managers of such works that for many years various forms of overhead tramways, traveling cranes and industrial railways have been put in service. All of these devices depend for their serviceability on some form of track and are therefore not flexible systems of transportation. In order to supply this hitherto unfilled field, the Gibbs Engineering & Manufacturing Company, 43 Exchange Place, New York, has brought out what it calls tractors for handling material in and around large shops and plants. The accompanying illustrations show one of these tractors in use at the wharves of the Bush Company in Brooklyn, and the system of haulage for which it was substituted.

Loads Hauled by a Tractor and a Horse at Warehouses of the Bush Company, Brooklyn.

The tractor is a storage battery automobile built for traction purposes. While the cars which it hauls may be run on tracks if desired, it is believed that the best method of haulage with these tractors is to run them directly over the floors, except where they are too rough. The purpose of the tractor makes it desirable to have as great adhesion on the wheels as possible and for this reason the storage batteries are not designed like those for automobiles, in which great lightness of weight is essential. The motors on the tractor are of the General Electric Company type, with a series-parallel controller with which no resistance is used.

The two driving wheels are separately driven and are furnished with solid rubber tires which are believed to increase the adhesion greatly over any other form of construction. These wheels are provided with a powerful brake. The steering is done by a hand wheel which will enable the tractor to turn in a circle of 8 feet radius. This enables the car to be manoeuvred around machine tools and through winding passages.

The tractor weighs complete about 3,900 pounds and is 9½ feet long and nearly 4 feet wide. The draw-bar is 1 foot 4 inches above the ground, and on account of this low height it has been found desirable to design a special line of shop cars to be hauled by the tractor, although the regular type can be used if desired. The draw-bar pull is about 600 pounds and a speed of 6 miles can be attained. The batteries are charged with a 110-volt current, 36 amperes being needed.

Letters to the Editor.

The Broken Valve at Boonton Reservoir.

Sir:—As there seems to be some confusion regarding the manufacturer of the valve which has recently been found out of order at Boonton, we would request that you insert in your columns the following statement: "Owing to the many inquiries which we have received concerning the accident at the Boonton dam we wish to state for the information of our friends that the gate valve referred to was not of our make, our installation having been confined entirely to the sluice valves." Such favor will be much appreciated.

Yours very truly, Coffin Valve Company.
Boston, April 15.

[The accident at the Boonton dam was described in this journal last week. The broken valve was repaired and the body of the unfortunate diver recovered on Friday, the fifteenth.]

Preservation of Steel in Concrete.

Sir:—I note a confirmation of the well established fact that steel embedded in concrete will not rust: In constructing the Subway in lower Broadway, the Degnon Contracting Company has found it necessary to tear up the sidewalk around the Bowling Green Park. This walk was laid in 1883 by Matt. Taylor. There are embedded in the slab a number of steel rods which in tearing up the old walk have been exposed. These rods are in perfect condition today.

Very truly yours, Ernest L. Ransome.
New York, April 12.

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The Failure of a Water Tower at Abilene.

One night some time ago a steel water tower at Abilene, Texas, collapsed when no one was present to observe the manner in which the structure failed. At the time of the collapse the wind was blowing at a rate of over 30 miles an hour, according to government records. Although the actual facts concerning the manner of the failure will probably never be known, the structure has such a history and is of such a character that it is worth while referring to it in some detail. It was designed in a Texas architect's office and built by the Means & Fulton Iron Works, of Birmingham, Ala. When the latter had checked over the design in the usual manner of good builders of structural steel work, they protested against following it but were ordered by telegraph to build both the tank and the tower precisely according to the plan. This plan, it might be stated, was a pencil drawing. The preliminary history of the structure being therefore so peculiar, it may be interesting to state a few facts concerning its design. The tower proper is 70 feet high. In plan it was square, with eight columns. The foundations of these eight columns were located at the corners of a 34-foot square and at the middle points of each side. The columns, each consisting of a 12-inch 40-pound I-beam, were divided into five panels, the panel points being connected by peculiar systems of horizontal and diagonal cross-bracing. At the top the columns were connected by an 18-foot square formed of 15-inch 42-pound I-beams. On the top of the I-beams was a most extraordinary system of girders to support the tank, which was 25 feet in diameter and 20 feet high.

For a number of years The Engineering Record made a practice of printing structural details of standpipes and water towers that failed. Some of these accidents were due to other causes than poor structural design, but most could be traced to the fault of the men who prepared the plans for them. As examples of what not to do, these faulty towers may have been of interest. But although for many years such poor construction has been held up to criticism in The Engineering Record and other journals, there is no appreciable decrease in the casualties among such works. If the readers of The Engineering Record desire to have the details of this Abilene tower printed, space will be afforded to them, but through the courtesy of the Means & Fulton Iron Works, it is possible to give information much more valuable than the drawings themselves. This information is furnished by a report on the design of this tower made by Messrs. Wilson & Alber of Birmingham, who made a careful, though approximate, analysis of the stresses in the various portions of the structure. They find that the bottom plate of the tank was subject to a maximum fiber stress of over 90,000 pounds. In view of the fact that the plates were riveted in such a manner that they were probably weakened about 30 per cent., it is not surprising that the tank itself should fail. This was not the only feature of the structure which manifestly invited disaster. Two of the 15-inch I-beams connecting the tops of the columns were subject to fiber stresses of 27,000 pounds. Some of the columns were likewise far overstressed, even without any wind pressure. The wind-bracing was of little value. As for the structure as a whole, Messrs. Wilson & Alber report that if the material used in it had been properly employed, the tower would have been sufficiently strong.

This tower has a history, therefore, which is very familiar to those who are acquainted with the past records of standpipes and water towers in this country. For some unknown reason, any one having a passing acquaintance with the contents of a structural steel roller's handbook has been rated as competent to design a water tower. Most of the failures in this country can be traced directly to a lack of knowledge of structural steel design. Unfortunately the publication of one bad example of such towers after another seems to have had no effect in producing better work. With the gradual increase in the public appreciation of the value of good engineering, it is possible that the conditions will improve, but the destruction of the water tower at Abilene indicates that the education of the public is still necessary. In this case the conditions are particularly flagrant because the builders of the tank specifically protested against its construction as planned. The drawings show that it was a monstrosity. A further proof of the fact that it was designed by some one without any knowledge of such work is afforded by the presence in the interior of the tank of completely useless vertical 6-inch channels spaced 6 feet apart.

The design and construction of watertanks and standpipes should be placed in the hands of men thoroughly competent to work out steel work in an economical and safe manner. The failure of such a structure may not only deprive a water works system of an important portion of its plant, but also cause serious local damage. The tower proper has to carry not only the heavy dead weight of the water tank at its top, but must also resist wind pressure, which, in many cases, amounts to a large figure. It naturally would be supposed that any one able to understand an engineer's hand book could design a tank to place on top of one of these towers, and yet the Abilene structure shows that this is not the case. Bottom plates stressed nearly to their ultimate resistance and side plates reinforced vertically with entirely useless channel bars of large size, show how dangerous it is to entrust the design of such an elementary structure as an ordinary tank to some people. As before stated, the lesson of this accident will be appreciated probably only by those who know enough to avoid such work without any failures to warn them. This is really the most important aspect of the affair and one which ought to have some remedy, although it is difficult to see what effective preventative can be put on the statute books.

The Work of the New Isthmian Canal Commission.

As the title to the property of the new Panama Canal Company has now been transferred to the United States, and as the Isthmian Canal Commission has organized and begun work both on the Isthmus of Panama and at Washington, it may be stated that the construction of the Panama Canal has actually been begun. No statements have been issued by the new commission touching the work it has undertaken, but various statements by the public press, apparently authenticated, and such information as can be gathered from parties who have recently returned from the Isthmus, indicate that the final plans for the construction of this ship canal are now being carefully considered. The former Isthmian Canal Commission left behind it a monumental work remarkable both for the amount of ground which it covered and for the direct and effective treatment given to the great problem before it. The final report of that commission, however, shows clearly that its members contemplated much further study upon a number of main features of the work before its ultimate lines could be definitely settled. Obviously, the first step to be taken by the present commission is the completion of the requisite examinations and final studies contemplated by its predecessor.

It is clearly impossible at this time to indicate closely the lines of investigation to be followed to close the great questions which were advisedly left open by the former commission, but a careful consideration of its admirable report, together with such information as can be obtained at the present time, makes clear what at least are some of the greater questions to be first undertaken by the new commission. The recent paper by Mr. C. D. Ward, Mem. Am. Soc. C. E., on the possible Gatun dam, five or six miles from the Colon end of the canal, gives point to these observations and raises much engineering interest as to what may be the best plan to be followed in the building of the Panama Canal. It will be remembered that the old commission contemplated a dam across the Chagres river at the point called Bohio, about 17 miles from Colon, to form the summit level of the canal at an elevation of 85 or 90 feet above sea level. This summit level would extend for a distance of nearly 21 miles, making three locks necessary on the Pacific side of the isthmus to reach the Pacific Ocean. Mr. Ward suggests the possible feasibility of building a dam across the Chagres river at Gatun, 10 or 11 miles nearer Colon than Bohio. Although the Bohio summit level might remain unchanged with a lower level between Gatun and Bohio, it appears practically certain that if the Gatun dam should be built the resulting elevation of lake surface should render unnecessary the costly construction of Bohio, thus displacing not less than 10 miles of restricted canal navigation by the same amount of open lake navigation. In this latter event the site of the summit level lock on the Pacific side of the isthmus would remain unchanged but its maximum lift might be materially reduced. Although there appears to have been no borings made at the Gatun dam site by either of the French companies or the former Isthmian Canal Commission, a close examination of such maps as exist seems to indicate that the construction of the dam at that location would be exceedingly costly in consequence of its great length and probable depth to bed rock. This is one of those questions, however, on which it is idle for engineers to speculate and which can be treated rationally only after adequate examinations have disclosed the actual conditions to be encountered. It is fair to assume that the new commission will complete such examinations as may be necessary to settle conclusively whether the construction of the Gatun dam be feasible or not.

Again, there are great problems to be solved connected with the control and handling of the Chagres river floods, which are of such a sudden character and of such violence that many engineers in the past have considered them as almost if not quite insuperable obstacles to the successful completion and maintenance of the Panama Canal. The report of the former commission shows conclusively that any such fears are absolutely groundless. The report further shows that an exceedingly simple and effective method of safely receiving into and discharging from Lake Bohio those flood waters may be arranged by means of the Gigante spillway, even without the construction of a great controlling dam either at Alhajuela or at Gamboa, the latter location being a short distance upstream from the point where the canal line leaves the Chagres river on its way toward Panama. Although this latter controlling construction was not considered immediately necessary by the Commission, and possibly not at all, it is understood that some of its members at least entertained the opinion that its effect might be desirable at the outset of the operation of the canal even if not actually necessary. The old French company seriously considered the construction of such a dam at Gamboa rather than Alhajuela. Although the Gamboa site was thus seriously considered in connection with the sea level plan only, it is just possible that the changed conditions now existing, taken in connection with the future water supply of the canal and other questions of power and affiliated requirements of a great ship canal, may make it desirable to give still further consideration to the creation of a controlling lake on the upper Chagres, either at Gamboa or Alhajuela or at some other point.

There are other problems perhaps of less magnitude than those indicated above which appear worthy of study to a careful reader of the report of the old commission. The construction of such a great waterway carries with it the consideration of a number of closely affiliated matters which, while not absolutely imperative for the bare construction and operation of a ship canal, are of great importance in connection with it, especially in this case where the water supply of the cities at its two extremities and of the towns between must be constructed. It must also be remembered that the strip of territory through which the canal passes has experienced practically no development as an aggregation of communities since those communities were founded, but which, under the new governmental condition, will necessarily be developed with rapidity hereafter. The construction of the canal under the treaty between the United States and the Republic of Panama, read in a broad way, means far more than the digging of a great navigation ditch. A great waterway is to be constructed, and so constructed as to contribute to the industrial development and civilization of the country through which it passes. The problems before the new Isthmian Canal Commission, therefore, are broad ones, and their treatment should be characterized by the most enlightened policy and one which will reflect credit upon the part which the United States Government is to play in the matter. The tentative plans contemplated by the former commission were admirable in their scope and were worked out sufficiently to serve all the purposes for which the commission was created, but the new commission must go further, complete all the examinations plainly contemplated by its predecessor and reach the broadest and best solution of this great interoceanic problem, even if the former estimates are exceeded in cost by a few millions more or less.

Typhoid Fever Epidemics.

Every sanitary engineer is interested in the prevention and remedy of typhoid fever epidemics. Formerly such visitations were looked upon as calling for the aid of physicians alone, but the growth of knowledge concerning this disease has proved that the engineer can be of great assistance not only in preventing the fever but also in checking its spread. One of the members of the American Society of Civil Engineers, Dr. George A. Soper, has already won a reputation as an epidemic breaker which bids fair to make him as well known in the community as the famous strike breaker who prevents or overcomes troublesome mutinies of street railway employees. In the last few years he has been in charge of a number of such epidemics and the information he has acquired is most interesting. At a recent conference of the health officers of the State of New York he made some very interesting remarks concerning features of this unusual specialty he has adopted. The breaking of epidemics is, of course, not so important as their prevention. The cause of the disease can generally be traced to the pollution of water through the careless manner in which a typhoid fever patient has been cared for. Sometimes, as at Ithaca, the water supply of a whole city is affected and the disease causes terrible loss of life as well as material injury through sickness and loss of business. In other cases a milk supply becomes infected and users of the milk are stricken with the disease. The latter case is not so serious as the former if its cause is detected early enough. Theoretically, there should never be an epidemic in American communities, for the laws provide for boards of health with ample powers to prevent such outbreaks. Unfortunately a board of health is rarely an efficient organization for such a purpose, and even when its members have sufficient knowledge to act intelligently in case the typhoid fever sick rate rises abnormally, they often lack the strength of character as a body to compel the adoption of the precautions necessary at the time. If every physician were to report promptly all suspicious cases, and Boards of Health were to treat such cases, as soon as reported, in accordance with an efficient program, typhoid fever would soon lose much of its present terror.

The statements of Dr. Soper are mainly interesting for the suggestions they give concerning the handling of an epidemic as soon as it is detected. The disease is frequently hard to diagnose and gains a foothold before its character is definitely determined. For this reason it is important that suspicious cases should be watched with great care. Patients so ill as to be confined to their beds do not cause so much trouble as those who suffer from a mild form of the disease, who are able to go about and may spread the fever in this way. As soon as the possibility of an epidemic is detected, Dr. Soper advises immediate steps to investigate its history so that the original cause may be discovered. In this way it may be possible to check the outbreak when it appears, although it is too often the case that many cases occur and a number of foci of disease are established before a careful investigation is considered necessary. Fortunately local authorities are often able to call on a State board of health for assistance when such an epidemic is threatened, and in this way they secure the advise of an expert in the handling of such cases.

When the authorities of a town have secured such expert advice and made a careful census of all the cases, particularly those of a mild form, their work is chiefly along the line of a rigid yet tactful enforcement of the laws which enable them to safeguard the people. They are able to control the purity of the food supply, to bring about the proper use of suitable disinfectants and to clean up the city generally. It is necessary for them to make provision for the extraordinary expenses which may be necessary to stamp out the fever, and in doing this they will often have to exercise much care. They will have to arrange quite often for an extension of their privileges outside the limits of their authority, in order to compel a proper observance of sanitary regulations on the drainage basin of a reservoir or on the premises of a milk dealer furnishing an infected supply. In all this work it will frequently happen that the most expeditious and economical conduct of affairs will be possible by securing the complete co-operation of the State board of health. Dr. Soper states that from his experience in work of this nature he is convinced the State should always send a representative to the scene of an epidemic to insure the adoption of measures which will bring it under control, whether this takes three days or three months. This suggestion is really the keynote of his remarks, and The Engineering Record is glad to learn that he has so publicly advocated a step of this nature. Means of communication between towns is now so good in all parts of the country that an epidemic of typhoid fever can no longer be regarded as a local matter. The danger of carrying the disease from one town to another is so great that the State is fully warranted in exercising a supervision over the work of the local authorities. The prevalence of typhoid fever in an American city is largely unnecessary, and the engineer and sanitarian should work hand in hand at all times and in all places to insure the purity of the water supplies of towns and cities and the proper treatment of any sporadic cases of the disease which may be detected. Epidemics are so frequent that the importance of such work is becoming appreciated, slowly but surely.

Electricity in Cotton Mills.

Among the cotton mills operated electrically in this country, the Columbia mills at Columbia, S. C., the Pelzer mills at Pelzer, S. C., the Ponemah mills at Taftville and others, the use of electric motors seems to be entirely satisfactory. The troubles which some people predicted have never occurred, so far as can be learned from inquiry. Occasionally some slight defect may be noticed temporarily, but absolute perfection cannot be expected in anything so complicated as the system of power generation, distribution and application in a great industrial establishment. While this dearth of unfavorable reports has been gratifying to those who have hoped that the electric drive would prove an advantage over systems of greater age, the lack of definite information concerning what were the real results of electric operation has been almost equally disappointing. It has been known for some time that very careful watch was being kept on the power system at two of the largest mills in the South, and when the New England Cotton Manufacturers' Association announced recently that among its papers for the convention of this week there would be one by Mr. E. W. Thomas of Columbia, it was hoped that the silence would be broken. These expectations have not been fulfilled, because his tests at the two mills are not finished. He promises to give their results in a later paper, and for the present supplies only general statements concerning some of the advantages of electric operation which have been demonstrated by the plants under his observation.

One of these advantages is the readiness with which one department of such a mill can be run independently of the others. When a certain section, such as the opener room, picker room or cloth room, has caught up with its work, the overseer has only to throw a switch to stop all the machinery, withdrawing all demand for power without affecting any of the other rooms. In addition to the switch in the room, the motor is also controlled by one in the engine room, and it is possible to apply on the switchboard an automatic registering instrument which will show the fluctuations in power supplied to each department. This is an important advantage, for records have been obtained showing that when the starting time of the mill was 6:30 in the morning the full amount of machinery was not in operation until 7 o'clock. Other records indicate that there has been a dropping off of power from 11:30 to noon, showing that the employees were neglecting their work preparatory to leaving for the noon hour. The switchboard may also have instruments that will indicate when any motor is being run with an excess load.

The technical information which it is possible to acquire with automatic registering instruments connected with the electric equipment is often of considerable direct value. The study of the variations in the power demand and their connection with differences in temperature and humidity have proved very interesting. The investigation of the value of different lubricating oils which has been possible is also worthy of note. Another class of data furnished by such records is useful in planning additions, namely, the information concerning the amount of power actually needed to operate different types of machinery. With such data and complete freedom from the restrictions of line shafting, the design of an addition to a mill loses its main difficulties, even when the existing mills are badly situated according to old ideas of arrangement.

The above statements summarize practically all the information which the author has considered it desirable to print at the present time. He will doubtless agree that it really amounts to little as a presentation of definite data, and as such is disappointing to those who expected he would give figures showing just what is the efficiency of the two noted mills under his observation. As a general statement of what can be done with the electric drive, as compared with the old system of extensive and expensive line shafting, it is of considerable value and increases the anticipation of good things which will be afforded by the results of his tests.

The Renaissance of the Dummy.

One of the most interesting features of steam railway affairs in Great Britain and on the Continent at the present time is the endeavor of the managers of numerous main lines as well as branches to introduce some substitute for the present system of suburban traffic by locomotives. Mention has been made several times in these columns lately of the adoption of complete third-rail equipments for main line service on two English railways. For some unknown reason this logical solution of the problem is avoided by many companies to whom electricity seems an abhorrent thing, and instead dummy cars are being introduced on several lines. Something like twenty-five years ago these were regarded as the salvation of local traffic on railways in the United States as well as abroad. Many readers of this journal will doubtless recall the uncomfortable, wheezy trips made by such cars. The little engine in the front was a source of admiration to the small boys along the line and of objurgation by the engineer who had the fearsome task of making it run. These dummy cars were often the basis of most astonishing projects. The Engineering Record once saw a local railway built for operation by them between two seashore resorts. The track was laid and the rolling-stock delivered. The dummy car with a trailer attached was filled with directors of the company and local dignitaries. When everybody was ready, the order to start was given, the little engine gave a snort, the wheels went round on the track, but the only movement was the shifting of some of the passengers so they could look out of the windows to see what was going on. The trailing car was uncoupled and the dummy car itself was put in motion; by a most careful watch of the steam gauge the engineer was able to run the car over the track above as fast as a man could walk. More powerful dummy cars were ordered, but they also proved unsatisfactory and light locomotives had to be purchased to operate the line. This was the history of several of these enterprises that came to the notice of The Engineering Record, and they must have very generally proved unsuccessful because there are very few such lines in the United States now.

It is on account of the unsuccessful history of such cars, even when built by reputable manufacturers who were not hampered by a low price limit, that the introduction of them in England seems so surprising. For some time there has been running between Fratton and Southsea in England, a local service of this nature. It has proved very successful in comparison with the less frequent but longer trains handled by steam locomotives, which formerly provided very inadequate for the traffic. It is possible that the success of these cars has induced the management of the Taff Vale Railway to order dummy cars for its line. These are 62 feet long and are carried on two four-wheel trucks. The wheels of one truck are driven by the engine, which, with its boiler, is installed over it. The middle of the car has room for forty third-class passengers, while over the rear truck there is a compartment for twelve first-class passengers. There is also room for about one ton of baggage. Several other railways in Great Britain have introduced these dummy cars, some steam and others furnished with petroleum engines, and still others have endeavored to give a similar service by placing automobile omnibuses on the highways.

This use of automobiles in connection with regular railway service will also be adopted on some of the Bavarian lines. The Royal Department of Traffic has also called for tenders for two types of motor wagons for main lines. One of them is to be used for postal and passenger service and the other for the delivery of freight and express matter. This project is particularly interesting because it is practically an extension of the dummy car service on the regular railways in the Rhine Pfalz that has been operated for about seven years. This service has been so satisfactory that it will shortly be extended to other parts of the Bavarian State Railway. It is proposed to use two classes of passenger cars, one carrying eighty passengers with some baggage and able to draw a trailer, and the other carrying sixty passengers and capable of hauling a correspondingly small trailer. These cars are for the main lines; for the smaller branch and local lines still smaller cars are proposed. Such cars have been operated by storage batteries in the past and it seems probable that the new equipment will be of this character.

The introduction of such cars for local traffic on lines previously operated by steam is a subject that will repay careful watching. Unquestionably the equipment has been selected in the belief that it would afford satisfactory service as economicaly and safely as a regular electric equipment. It is not proposed to use this class of cars as a substitute for regular trains, as the intention is to run the cars at frequent intervals for local business. The success of interurban trolley lines has demonstrated that a large local traffic can often be built up provided cars are run often enough so that people will acquire the habit of considering a trip an expeditious affair. Where it is necessary to wait long periods for cars, travel is never encouraged.

These facts are mentioned because they indicate a feature of railway operation which must inevitably receive attention in the United States. Sooner or later a large amount of printed matter will reach this country concerning these dummy cars. At the present time the information concerning such equipment is a quarter of a century old and may just as well remain buried under the dust of oblivion. Until foreign railway officials are ready to give out reliable data concerning the operation of these cars, The Engineering Record believes that American railway managers who are finding it difficult to handle their suburban traffic, will find the most valuable information for their purpose in the columns of "The Street Railway Journal," which explains nearly every week how suburban or interurban electric lines are caring for the passengers who have deserted the steam roads for the more convenient trolley car. The line of demarcation between the suburban steam road and the interurban electric road is rapidly becoming obliterated, and the electric railway is to-day furnishing about all the important novelties and advances in the way of handling local business.

General View of the Fenimore Sulphite Pulp Mill.

THE FENIMORE SULPHITE MILL.

The New Plant of the Union Bag & Paper Company, near Sandy Hill, N. Y.

The Union Bag & Paper Company is the owner of plants at Sandy Hill and Ballston, N. Y., Watertown, Mass., and Kaukauna, Wis., where it produces various grades of manilla and wrapping paper, and manufactures paper bags of an infinite variety of forms and sizes. The Sandy Hill mills furnish a large amount of stock pulp, which is shipped to the other mills for working up into finished product. The new sulphite mill which is to be described is located at Fenimore, on the west bank of the Hudson River, opposite Sandy Hill. A short distance to the north is a cutting-up mill and a ground wood mill operated by water power obtained from a dam crossing the river at this point. On the east bank of the river at the opposite end of this dam is another ground wood mill, while on the same side of the river and about three-quarters of a mile nearer the town, is a group of paper mills where the finished product is made. These are located at Baker's Falls, where an abrupt fall of over fifty feet exists in the river bed. At this point the natural head has been increased by building a second low dam on the crest of the Falls giving a total of sixty feet, which is utilized in a new hydraulic power plant generating high-tension electric current for transmission to the various factories and mills in the immediate district. The equipment will ultimately comprise three units of 1,200 horse-power each, but only 2,400 horse-power is available at the present time. This hydraulic plant operates the entire power equipment of the new sulphite mill at Fenimore, paper machinery in the group of mills at Baker's Falls and all the bag machinery of the bag factory.

At the Fenimore mills there has been installed for increased security against interruption of service, an auxiliary steam plant of 1,000 kilowatts capacity which receives steam from the boiler plant serving the sulphite mill, and during dangerous periods of high or low water this plant is kept continually in readiness for immediate operation. The plant consists of a single 1,000 kilowatt direct-connected unit, generating current at 660 volts, which completely relays the hydraulic service at the Fenimore mills. The power system is also arranged so that current may be generated at Fenimore and transmitted back to the hydraulic station at Baker's Falls in cases of extreme emergencies.

Preparing Chips.—With the exception of the steam supply to this auxiliary plant, the entire steam service of the Fenimore mill is utilized in connection with the sulphite process of wood pulp making. The pulp is made from spruce from the Adirondack region, which is floated down the Hudson River in the log. At the cutting up mill these logs are reduced to 2-foot lengths and transported by a conveyor on an elevated wooden trestle either directly to the wood room or to a storage pile. The delivery of 2-foot sticks is confined to those months when the logs may be driven down the river. The height of the conveyor trestle is 40 feet and it is 2,500 feet in length, furnishing a large storage capacity for the blocks beneath. In the winter time the wood in storage is elevated to the trestle conveyor by movable vertical conveyors, similar to those used in handling barrels. The vertical conveyor is driven by an electric motor which is connected by flexible wires to a power circuit extending along a trestle. The trestle conveyor was furnished by Garland & Company, Bay City, Mich.

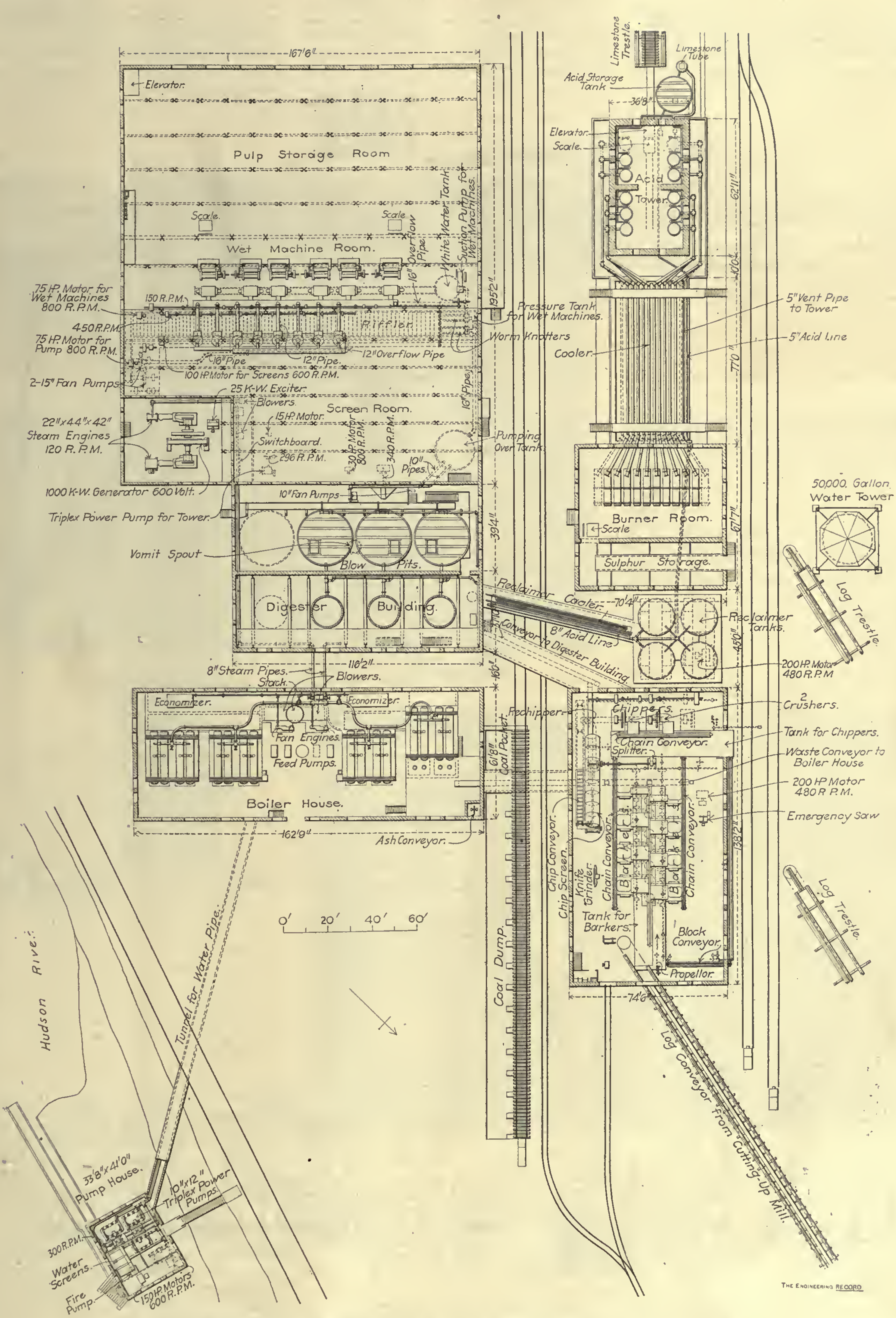
On reaching the wood room the blocks are dumped into a water tank which is heated in winter to remove the snow and ice. The blocks are floated through the tank, much of the dirt being washed off, and are then carried by a conveyor over the tank to the barkers, which are fourteen in number and built by the Sandy Hill Iron & Brass Works. The barked blocks are thrown on a flat chain conveyor and delivered into a second tank, from which they are delivered by a similar conveying apparatus to two Holyoke chippers in which they are reduced to pieces of suitable size for cooking. The chips drop through the floor and are broken up by a Lombard crusher, one being located below each chipper. The entire product falls into a belt conveyor which delivers the material to an inclined conveyor with maple flights, delivering the chips to an inclined Lombard chip screen.

The first section of this screen permits the sawdust to drop into a worm conveyor carrying this refuse to a belt in the basement. Chips suitable for pulp fall through the lower section of the screen and are carried by a series of belt conveyors to the digester building and then upward to the chip bins to which they are distributed by a Robins conveying belt with automatic movable tripper. The refuse that is refused by the screens drops into a tank in the basement and the chips which float are put through a Short rechipper and sent back to the screen. The knots which sink in the tank are delivered to the refuse belt. All refuse from the barkers, splitters, screens, etc., is carried by belt conveyors to the power house where it is used as fuel under two boilers.

The chips stored in the bins of the digester building are dropped through openings in the tops of the digesters, the connection between the bin and digester being made by a galvanized iron spout mounted on a trolley so as to be movable from one digester to another.

Acid Making.—The sulphur is delivered in box cars and wheeled to a gallery in the storage building from which it is dumped to the floor, often being stored to a depth of 30 feet. It is wheeled from the storage pile in a standard iron charging car to the burner room and shoveled by hand into ten burners built by the Portland Company, Portland, Me. The burning gases pass through the wall in cast iron pipes which drop into and connect with 10-inch lead pipes, 70 feet long and covered with water, in a long concrete tank built out of doors. At the far end the cool gas is piped into the bottoms of wooden tubes containing limestone located in the tower building. Arrangements are made so that the pipes between the cooler and the towers may be sprayed with water in unusually hot weather. The tower building contains ten wooden tubes 5½ feet in diameter and 145 feet high, each of which is fed independently from a single burner. All of the tubes are supplied by water from two tanks on the roof.

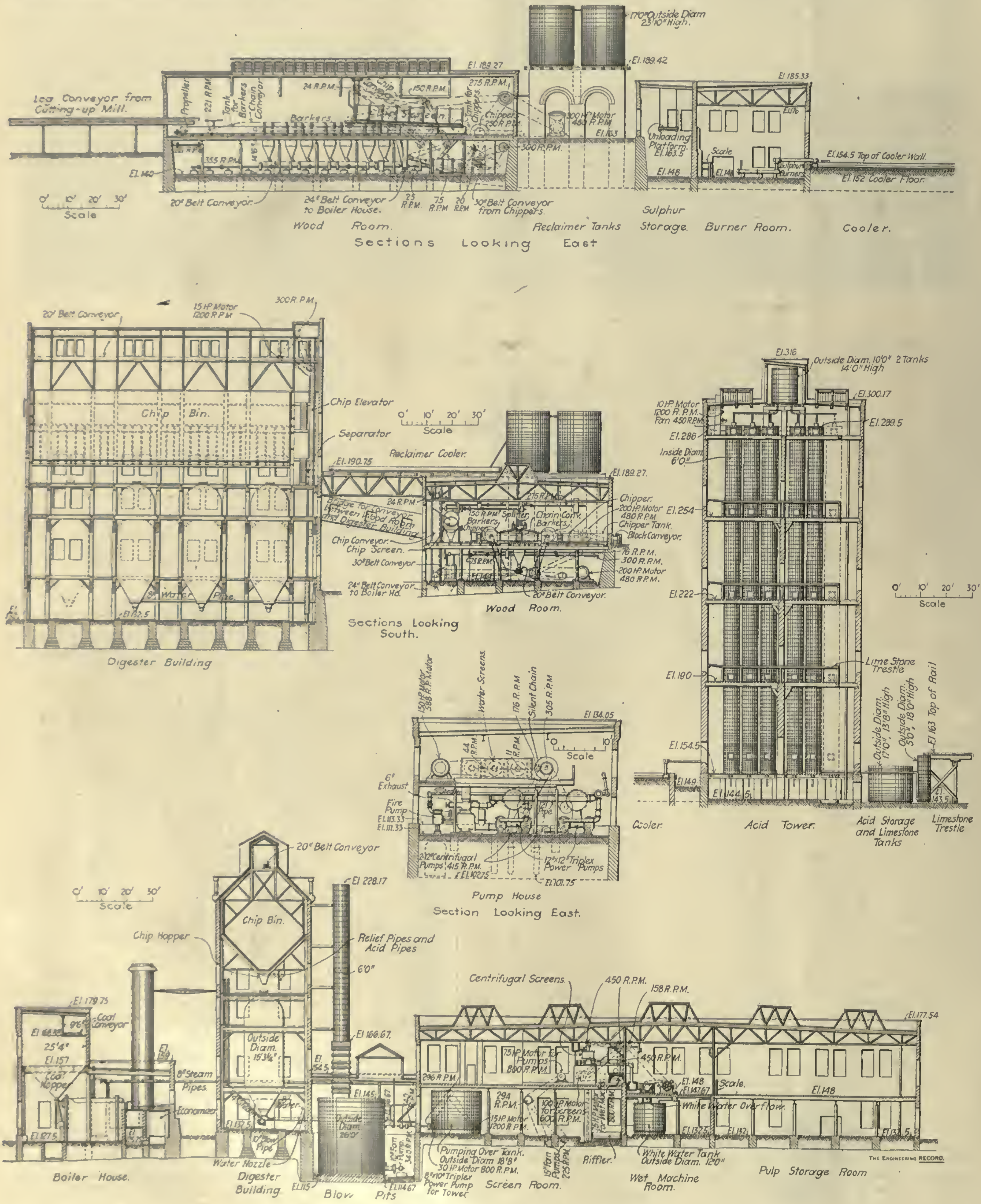
The limestone used is waste marble from Vermont. It is dumped directly from the cars on an elevated wood trestle and is loaded from the storage pile into narrow gauge cars and run into an elevator by which it is lifted to low trestles on each floor of the tower building where it is dumped to the charging floors. The sulphur gas enters the towers at the bottom and passes up through the limestone



GENERAL PLAN OF THE FENIMORE SULPHITE MILL, UNION BAG & PAPER COMPANY.

which is sprayed with water. The limestone is slowly decomposed and the sulphite liquor is collected at the bottom, whence it flows to a storage tank out of doors. From this tank it is pumped to four elevated reclaiming tanks between the wood room and the sulphur room. The upward current through the tubes is assisted and regulated by a bronze exhaust fan electrically driven and located in the attic. Owing to its liability to injury from the acid fumes no steel is used in the construction of this building, which is built of heavy Georgia pine timber with brick walls.

Digester Building.—This building has room for four digesters; three are installed at the



SECTIONAL ELEVATIONS OF BUILDINGS OF THE FENIMORE SULPHITE MILL.

present time. They were made by the Manitowoc Steam Boiler Works. Each is 15 feet in diameter and 50 feet high, built of 1⅛-inch steel plates with triple-riveted butt straps of 1¼-inch material. The digesters were tested when completed to 150 pounds hydraulic pressure and made tight at that pressure. They were then lined with lead with burned joints which were carefully tested and made tight, and inside of this a lining of acid proof bricks was then provided to withstand the mechanical action and also to some extent the action of the acid with which the digesters are filled. The lining was done by the Non-Antem Company, New York, and the lead work was furnished by the Raymond Lead Company of Chicago.

View in Wood Room, Showing Chippers and Chip Screen.

The acid storage tanks are elevated so that their contents flow by gravity through an 8-inch pipe into the digesters, which can thus be quickly and easily filled after they are charged with chips.

Pulp Making.—After the wood is properly cooked, as determined by tests made from time to time, the contents of each digester are blown under pressure into a corresponding wooden blow pit or tank, furnished by the Williams Manufacturing Company of Kalamazoo. Each of these is 26 feet in diameter and 30 feet high. A quantity of water, equal to the liquid contents of each digester, is forced under pressure into these discharge pipes when the contents of the digesters are blown out, thus condensing the gaseous fumes and avoiding the usual strong odor in the vicinity of sulphite plants, while at the same time preventing the escape of pulp which would be carried up through the vapor pipe if this arrangement had not been provided. The bottoms of the blow pits are perforated and the waste liquid from the washing is drained off and passed through an 18-inch sewer pipe into the river, about 2,000 feet down the stream from the mill.

The washed pulp is pumped to a small storage tank, marked "pump-over" tank in the drawings, from which it flows to the riffler in the basement of the adjoining screen building. Most of the centrifugal pumps for such purposes in this mill were furnished by the Morris Manufacturing Company. At the delivery point all the pulp passes through copper washers where the large and uncooked knots are discarded, to be afterwards ground and used in the manufacture of a cheap grade of wrapping paper. The remaining pulp flows through the riffler to the far end, and on the way more or less sand, dirt and foreign substances are deposited, these being removed weekly and thrown away. The product is pumped to the story above where it is delivered into a series of Baker & Shevlin rotary screens. The pulp that passes these screens is made into sheets in a group of six Bagley & Sewall wet machines and is then folded for shipment.

View in Screen Room, Showing Rotary Screens.

The refuse from the rotary screens is subjected to two other screenings which produce an inferior grade of pulp.

The Power Plant.—The boiler house is located a short distance from the digester building, where most of the steam is used. The building is approximately 160 feet in length, 60 feet in width, and on the north side where the coal bunkers are located, is 50 feet in height above the boiler room floor. The south half of the building, however, is but 30 feet in height, no extra head room being required there for the the steam piping, which is suspended a short distance above the boilers from the steel roof. There are four batteries of boilers arranged on each side of a central area where the feed pumps, stack and mechanical draft outfits are located. In the rear of the boilers the smoke flues and economizer chambers extend throughout the length of the batteries. The latter are placed next to the building wall so as to leave a passage about 7 feet in width in the rear of the boilers. In front of the boilers a 16-foot passage provides ample space for cleaning. Along the center of the room is a row of Z-bar columns surmounted by 36-inch plate girders, which support the south wall of the coal storage loft, the roof and half of the weight of the coal bunkers. A second and parallel line of columns, with 20-inch plate girder stringers adjacent to the outer wall, but entirely independent of the brickwork, carries the remaining weight of the bunkers. The bottom of the coal bunkers is formed by a series of six pyramidal steel hoppers, one to each boiler, these hoppers being suspended from transverse 24-inch girders carried by the columns above mentioned. In the upper part of the coal loft is a runway supporting the discharge leg of the coal conveyor, which is of the scraper type and elevates coal to the bins from a hopper, located between the tracks of the coal siding paralleling the west wall of the building. When the bins are filled, the coal siding itself, part of which is built on trestle, is utilized for coal storage, from which the coal may be transferred to the conveyor system by a secondary conveyor extending underneath the storage trestle.

In the extreme northwest corner is an ash tower rising to a height of 65 feet and containing a bucket elevator for raising ashes from the basement to such a height that they may be conveniently discharged into an empty car awaiting upon the coal siding. The elevator is driven by an induction motor, located in the top of the ash tower, the necessary speed reduction being retained through belt and worm gearing.

A 7x7-foot tunnel extends throughout the length of the building underneath the boiler floor, and immediately in front of the boilers. This tunnel communicates with the ash elevator mentioned above and through it ashes are removed from the ash pits underneath the stokers. This work will ultimately be done by a conveyor, but is now accomplished by hand. No ash storage capacity is provided other than that already furnished by the ash pits and ash tunnel. The latter has a concrete floor and roof and ashes may readily be raked out of the ash pits through openings in the wall and stored until such times as it is found convenient to remove them.

The total capacity of the plant is 2,400 horse-power divided between four batteries of two boilers each. Both coal and wood is used for steam fuel; the former is buckwheat anthracite and the latter is in the form of shavings, bark, knots and refuse chips from the wood mill as before mentioned. Three batteries of coal boilers have been installed, each consisting of two 300 horse-power Aultman & Taylor water tube boilers. The wood burning battery consists of two 300 horse-power boilers of identical type. These wood boilers are fired by means of special furnaces of "Dutch oven" construction, and in order not to encroach on the passage in front of the boilers, this battery has been set back about ten feet, the width of the ovens.

Steam is generated at 150 pounds pressure for use in the auxiliary steam plant and is reduced in pressure for the digester plant. The safety valves on each boiler are provided with discharge pipes leading through the roof, so that the boiler room will not be filled with steam at an occasional blowing of the valves. The boiler blow-offs are piped to the passage in the rear of the boilers where all valves are readily accessible.

The feed water is obtained directly from the river, but before entering the boilers is first clarified in a special combination filter-heater. The mineral constituents of the Hudson river water cause little trouble from incrustation, but a large amount of vegetable matter is usually present. The apparatus consists of a vertical boiler shell about 23 feet in length and 6 feet in diameter, assembled in five sections with flanged heads at top and bottom. The top section contains a filter bed of cocoa matting, sponges, etc. The three sections below constitute a tubular heater of the conventional type, and at the bottom is a receiving chamber. The feed water enters at the top where the suspended matter is removed by the filter bed. It then passes through the heater tubes and from the bottom chamber directly into the feed pump suction. The heater sections are supplied with exhaust steam from feed pumps, fan engines and stoker engines, thus conserving the entire amount of waste heat from auxiliaries. The filter bed is renewed from time to time through suitable manholes provided in the shell. The three feed pumps are of the compound Worthington outside packed plunger type, cross-connected through both steam and water piping for relay service.

The three batteries of coal boilers are equipped with Roney mechanical stokers arranged for burning buckwheat anthracite coal. The stokers for the two main batteries are operated from a single driving shaft, extending throughout the length of the batteries and driven through worm gearing by a small Westinghouse standard engine, mounted on an independent brick pier at the end of the battery. The ash pits are concrete lined and slope downward to openings beneath the stoker fronts, through which the ashes may be raked out into barrows or ash cars in the ash tunnel, as before mentioned.

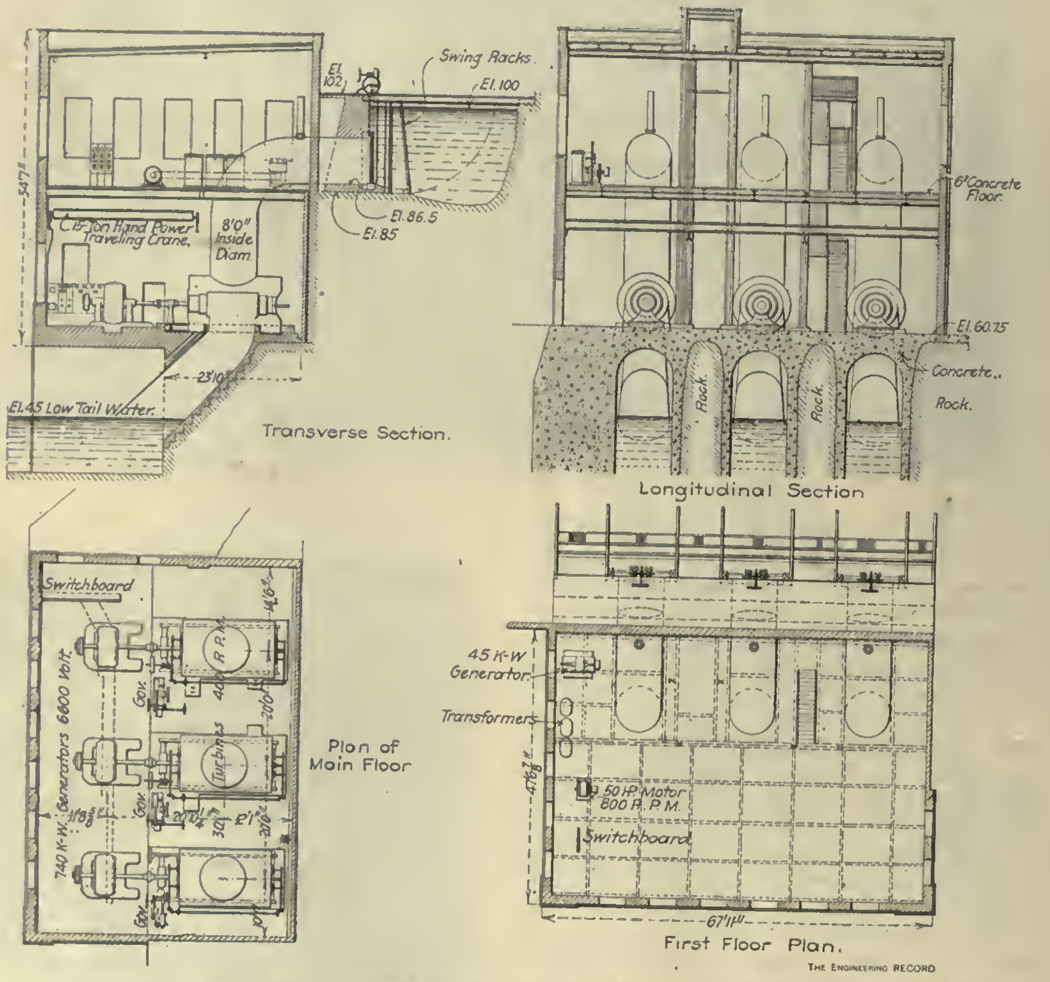
The wood burning battery is fitted with two Dutch ovens, approximately 8 feet in depth and of the same width as the boiler front, 10 feet. The ovens are provided with horizontal grate bars of close design and ordinary boiler fronts with fire and ash pit doors. The shavings are received through a shaving conveyor from the wood mill, and charged into the furnaces from an elevated platform through 20-inch round openings. Each furnace has two firing holes and the two sides are fired alternatively to reduce as much as possible the quenching of the fuel bed by large quantities of wet bark and shavings. No difficulty is experienced in maintaining a uniform steam pressure with this fuel, and it is found that the wood burning boilers supply a considerable portion of the total steam required for the operation of the mill.

The arrangement of flues, economizer settings and mechanical draft outfits is clearly shown in the accompanying engraving, and provides for the operation of either half of the boiler house equipment by either fan and with or without its economizer. There are two Green economizers installed, with provision for a future third. They are of the improved circulating type, manufactured by the Green Fuel Economizer Company, under the patents of Westinghouse, Church, Kerr & Company.

Draft for the boiler plant is mainly furnished by two 180-inch exhaust fans built by the B. F. Sturtevant Company from the special designs of Westinghouse, Church, Kerr & Company. The fans are of the three-quarter-housed type and occupy the space between the boilers in the center of the boiler house. The fans exhaust the burned gases from the collecting chamber immediately in the rear, and discharge them into a steel stack, mounted directly upon the top of the fan hoisting, which is strengthened by structural sections for this purpose. The stack is 8 feet in diameter and 70 feet in height, and is constructed of ¼-inch and 3-16-inch steel, with single riveted joints. It rests on and is bolted to a 4x6-inch angle flange riveted to the top of the fan housing. At its lower end is a short uptake which changes the section from a 6x8-foot discharge opening in the top of this housing to the circular section of the stack. The stack is braced near the top by a horizontal combined strut and tie anchored in the wall of the adjacent building.

The high-pressure steam piping is characterized by the absence of expansion joints, separators, traps and returns. The entire system is pitched back to the boilers at sufficient slope to return condensation automatically without the employment of special apparatus. Long radius sweep bends have been employed to provide the necessary flexibility for expansion and contraction. The piping system is suspended by adjustable iron hangers from the steel roof beams of the boiler house, and is anchored at the center and two intermediate points. Walworth valves were employed and the Walmanco pipe joint was used.

The steam mains from the two halves of the boiler room converge to a central distributing point, where a short cast-iron manifold header is located, from which extend the various supply lines to the digester building, the auxiliary engine plant and the auxiliaries in the boiler room. Screw and yoke valves located upon either side of the manifold header and also in the riser, from each boiler battery provide adequate means for proper manipulations of the boiler equipment and the isolation of a defective section of piping. All high-pressure steam lines are protected from excessive radiation by magnesia pipe covering.



Fenimore Sulphite Mill: Plans and Sectional Elevations of Hydraulic Power House.

A striking though comparatively unimportant feature of this plant is the effect produced by the judicious use of aluminum and other paints. The coal hoppers, chutes and stoker fronts, feed water heater, fans, stack and steel work, are finished with black graphite paint, while the boiler fronts and drums, stoker engines, fan engines and feed pumps are finished in aluminum. The building walls and boiler settings are stained with a subdued color to a height of 5 feet from the floor, and the remainder, including the roof of the south half, is finished in white. The effect of this simple decoration in addition to the white pipe lagging is extremely effective and lends an appearance of cleanliness which might well be given consideration in more pretentious boiler rooms. The aluminum paint has been used throughout the works at Sandy Hill for finishing steam, hydraulic and electrical machinery with the most satisfactory results.

The general water supply for the entire premises is obtained from a two-story pump house, 32 x 40 feet in plan, located on the bank of the river. The first floor of this building is just above high water level. It is connected with the boiler house by a concrete tunnel through which pass all pipes leading to and from the pump house. These pipes are suspended from iron supports attached to vertical wooden posts securely anchored in the concrete wall of the tunnel. The water supply is drawn from a concrete penstock beneath the floor communicating with the river through suitable racks. The water is elevated by two 12-inch centrifugal pumps to a reservoir on the second floor containing three rotary screens which remove the wood chips and vegetable matter that are not of sufficient size to be caught by the racks. The water is drawn from these tanks by power pumps which discharge into the distributing system. The pumping equipment consists of three Gould 10x12-inch triplex pumps belted to an elevated countershaft driven by a 200 horse-power induction motor. The pump house also includes one 1,500-gallon Worthington underwriters fire pump supplied through a 5-inch steam line from the boiler house. All pumps connect into a 12-inch water main with branches supplying all buildings and a 5,000-gallon water tank elevated 50 feet on a steel tower some distance from the buildings.

View in Wet Machine Room, Where Finished Pulp is Produced.

The electric power for the operation of all of the mills is located on the opposite bank of the river about one-half mile distant. The power-house is built close to the river bank in an excavation blasted out of solid rock. Water is taken from the canal heretofore used by the company at its mills located at that point. Fine and coarse racks are used to prevent obstructions from entering the turbines. The water passes through the canal above through wooden gates to steel penstocks 8 feet in diameter each connecting with a pair of 30-inch McCormick turbines built by the S. Morgan Smith Company, of York, Pa. Each pair of wheels discharges through a central draft tube into the river below. Lombard water wheel governors are attached to each pair of wheels.

Each pair of turbines is connected to a 750-kilowatt three-phase 6,600-volt generator with the exciter armature mounted on the end of the generator shaft and overhanging the main bearings. Two generators are installed at the present time, but all other work has been done for the installation of a third. A traveling crane spans the generator room for handling the heavy machinery. The transformers and other devices for furnishing the working current at 600 volts are located in a sub-station in the sulphite mill, although there is a small transformer station in the second story of the power-house where current is transformed for use in the vicinity. As before stated the hydraulic power can be replaced by the steam plant in the sulphite mill at times of low water. This plant consists of a cross-compound Hamilton Corliss engine driving a 1,200-kilowatt generator at 600 volts.

The motors are of the induction type, and that they may be interchangeable to some extent as few sizes as possible are used. The entire electrical equipment was furnished by the General Electric Company, and installed under supervision of Mr. A. R. Bush, of Boston.

The buildings are of brick and steel construction with concrete floors and roof reinforced by expanded metal. They were erected by Grace & Hyde, the steelwork being supplied by the Penn Bridgo Company. The plant covers about twelve acres, exclusive of saw mill, conveyors and wood storage, and was completed in November, 1902. The buildings and the entire equipment were designed by the company's engineering force. Mr. E. G. Barratt, now the vice-president of the company, was at the time of construction in entire charge of the work, and was assisted by Mr. M. O. Kasson, the present general superintendent of the company, and by Mr. R. B. Wolf, superintendent of the mill. Mr. H. A. Moody was in charge of all instrument work in connection with the construction of the buildings.

Engineering Problems in Tanneries.

Tanning is a most interesting industry to the engineer and chemist, because it is largely secret. Each company keeps its methods and its mechanical equipment as closely guarded as possible, and even when specialists are called in for advice, it not infrequently happens that they are refused admittance to some parts of the works they are visiting. For this reason, special interest attaches to a paper read a few months ago before the Michigan Engineering Society by Mr. Byron E. Parks, and recently published in its proceedings. The entire paper is too long to reprint in this place, but the following extracts from it indicate what an advantage such a close industry as tanning will derive from the services of an engineer and chemist who is permitted to make a really thorough search for opportunities to introduce improvements.

Hemlock bark is the principal tanning medium used by all tanners of heavy leather throughout the Northern States, and is the largest single item of cost in the operation of a sole leather tannery. Investigations made a few years ago indicate that bark pitched in the leaches as "spent tan" still contained a considerable strength of tannin; in fact, analyses of numerous samples showed that they still contained from 5 to 7 per cent. of tannic acid. Bark taken from forests in the mountain districts of the Eastern States shows when air dried an average of 8 to 10 per cent. of its weight in tannin, while bark taken from the forests of Michigan and Wisconsin contained from 10 to 12 per cent., and some samples analyzed have shown as high as 15 per cent. of tannin. A comparison of the values shown by the analysis of the "spent tan" and of the bark in its original state as taken from the tree, indicates that about half the strength had been wasted.

Formerly it was the practice to leach bark at low temperatures, or with practically cold water. One reason for this was the want of adequate means of heating the large volume of water required in the time allowance, and the other and principal reason was that those who had tried higher temperatures found that a coloring matter called "the reds" was dissolved and extracted from the bark. This darkened the tanning liquor and gave an undesirable color to the finished leather. When the chemist demonstrated to a certainty that about half the bark consumed was a waste, and when the growing scarcity led to increased cost, the progressive tanners were ready to consider any feasible means of reducing their bark consumption. Here the chemist came to their aid and gave them a system of bleaching leather after the tanning process was complete, by means of which the desired color could be given it, whatever its color may have been when taken from the vats.

With the advent of the bleaching system came the engineer's problem to provide an efficient means of heating the required volume of water or tan liquor to a temperature approximating 212 degrees, and maintain it at that temperature during the process of leaching. The earliest form of heater was a box coil built up of brass tubing surrounded by a wooden box made as nearly water-tight as possible. Steam was circulated through the tubes of the coil, and the liquor was pumped through the box and thence to the leaches. A large number of these heaters were installed during the few years after their first introduction. They were, of course, a great improvement over no heater at all, but in every case that came under Mr. Parks' notice they were put in without proper consideration of the capacity required, and were invariably too small for the service. Temperatures of 140 degrees to 160 degrees were the rule instead of approximating 200 degrees. Samples of bark after being leached under these temperatures still showed by chemical analysis from 3 to 4 per cent. of tannin, indicating that there was an opportunity for a considerable additional saving.

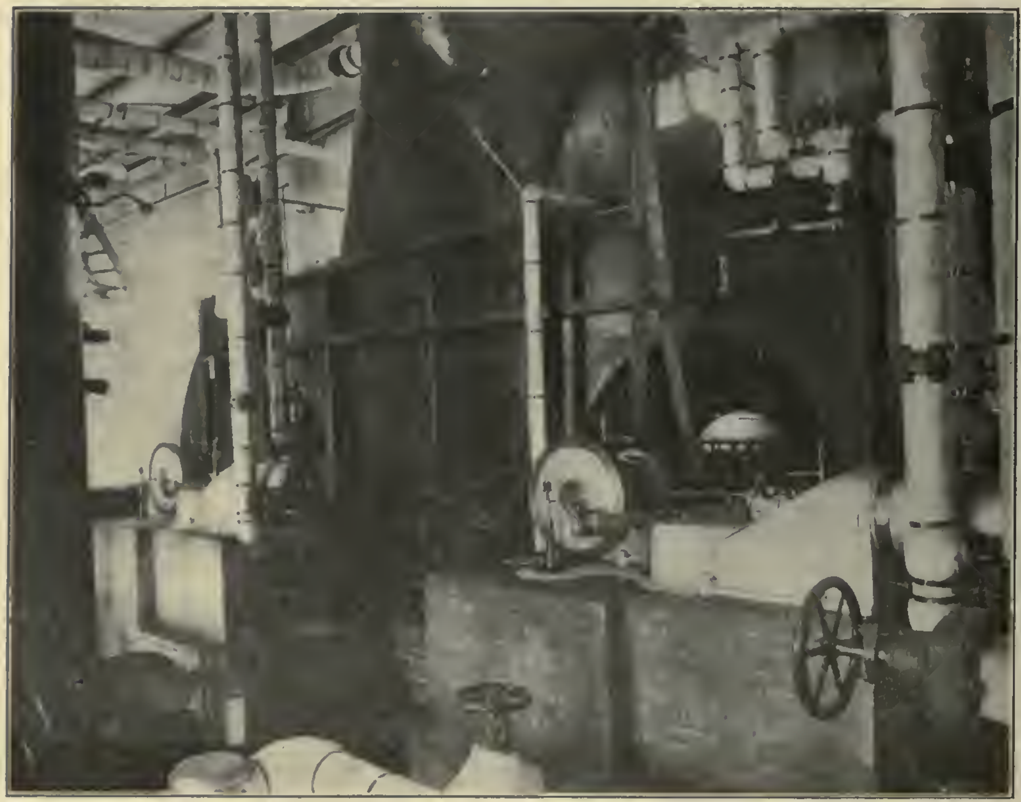
During the years of 1893 to 1895 some tanners tried building heaters for themselves out of standard pipe, using a 6-inch iron pipe with a 3-inch brass pipe inside, and circulating steam and liquors through them in opposite directions. This type of heater was very efficient and low in first cost, but, like the box coil heater, was installed without any consideration as to capacity required and also like that was always too small. In the fall of 1895 Mr. Parks was requested by a tanning company to furnish it a plan of arrangement and proportion for one of these pipe heaters. In this case the liquors were pumped over at the rate of 7,000 gallons per hour, and the initial temperature would be about 62 degrees. The steam available for heating liquors was the exhaust from a single-valve automatic engine developing an average of 60 to 70 indicated horse-power. In using this heater the intention was to pump the liquor through twice in order to raise the temperature to about 200 degrees. In working out the design a heater was decided upon having 400 linear feet of 3-inch outside diameter seamless brass tubing, No. 12 gauge inside of a 6-inch standard lap-welded iron pipe. The effective heating surface of the 3-inch brass pipe measured on the outside was 314.2 square feet. The 6-inch iron pipe through which the steam circulated was covered with a good grade of molded asbestos, in order to reduce to a minimum the heat losses by radiation. When the liquor was pumped through this heater at the rate of about 7,000 gallons per hour, using the exhaust steam only for heating, the pressure being 4 pounds per square inch above atmospheric, it entered at 62 degrees and discharged at 130 degrees the first time through. The steam was entirely condensed and discharged as water at very near the temperature of the entering liquor. The liquor at about 130 degrees discharged on to a leach, and after percolating through was drawn from under the false bottom by a pump, passed through the heater and discharged on the leaches the second time through at very near the boiling point. This heater cost, complete and installed, $676.92, or a fraction over $1.69 per linear foot. It has been in use about five years and has been satisfactory in every way.

The usual practice has been to use open top leaches, but when the liquor temperatures were increased clouds of vapor arising from the surface indicated a considerable loss through this source. The leaches were then covered as tightly as possible by means of matched lumber; an appreciable improvement or reduction of heat losses was at once apparent. In their form and general construction the leaches used have not been materially changed for a number of years. They are round wooden tanks 12 to 16 feet diameter built of staves 2 inches thick from 8 to 14 feet long. Formerly white pine was the material used, but as this grew scarcer they are now taking up and using Washington cedar or cypress; cypress is preferable as being longer lived. Inside of the leach, 12 or 16 inches from the bottom, there is built a false bottom of strips 1¼x2 inches, set edgewise about ¼ inch apart. The purpose of this false bottom is to support the ground bark clear of the main bottom, and to provide a chamber from which the tan liquor can be drawn off after it has percolated through the bark. In the leach house these tanks are arranged in one or more rows according to the number in use, and have pipes running over the top which distribute the water or liquor to each leach as may be desired, and also another pipe running under the bottom which connects to each leach and through which the liquor is drawn off. To obtain thorough leaching of bark it is desirable that the liquor going into the leach after the first run should have a temperature near the boiling point, and further it should be maintained at that temperature, or actually boil, while in the leach.

The different steps in heating the leach liquors finally led up to the coil system by means of which, in conjunction with the pipe heater, very nearly perfect leaching is now possible. What is understood as the "coil system" of heating liquors is the introduction of a flat spiral coil of brass or copper tubing under the false bottom of each leach and connecting one end of the coil with the steam supply piping—either exhaust or live steam—from boilers, and the other end with the return piping which carries the condensation back to the engine room, where it is then pumped into the boilers. The first of these coils which Mr. Parks designed were made of 1½-inch outside diameter, seamless drawn brass tubing No. 16 gauge, the diameter of the outside coil being 14 feet and the pitch of the pipe 11 inches; it contained 188 linear feet. The five outer turns of the coil were made in half circles only, and were connected together with brass ground joint unions brazed on. These coils were in every way satisfactory when put in, but after they had been in use about a year a few leaks developed on account of cracks just back of where the unions were brazed to the pipe. These, however, were repaired, and since then there has been no further trouble, but in putting the ground joint unions together a second time there was some difficulty in getting them tight. Although the defects mentioned were slight, the next specification was changed to copper tubing and brass flanged unions with rubber gaskets. The copper coils have never given any trouble whatever, although in some instances where repairing of leaches require it, they have been taken out and put back again a number of times.

With these steam coils it is possible to boil the liquor in the leach in a very short time, and in the arrangement of the leaches circulating tubes were put in running from under the false bottom to the top of the leach. When the liquor reaches the boiling point it rises in these tubes and discharges over the top of the bark and thus can be circulated over and over in the leach as long as desired.

Many progressive tanners are looking carefully after their leaching since they have learned what an important bearing it has upon the economical operation of the plant, and carefully designed liquor heating systems are now becoming the rule instead of the exception. It is also becoming a general practice among them to have a chemical analysis made of samples of the "spent tan" pitched from their leaches at least once a week, and it is not unusual for this analysis to show only 0.5 or 0.7 of 1 per cent. of tannin instead of as in former years, 5 to 7 per cent.



Mechanical Draft Installation, Fenimore Sulphite Mill.

The foundations under leaches were formerly simply posts set in the ground. These, of course, did not last, and they were seldom sufficient in number to properly carry the loads. The piping used for conveying liquors was wooden pipe and gave considerable trouble on account of leaks due to checks in the pipe, and with the higher temperatures incident to the heating of the leach liquors it became still more troublesome. Tanners finally realized that the loss of liquors from this source extracted from high-priced barks would run up into hundreds and sometimes thousands of dollars per year. During the past few years Mr. Parks furnished plans for a number of installations in which concrete foundations were put in for leaches and a complete system of liquor pipes of seamless drawn brass tubing was installed.

After leaching there is the refuse or "spent tan" which is the source of fuel supply and formerly was more than ample for all requirements, and, in fact, large quantities were hauled away and disposed of by other means. The introduction of the improved methods of leaching by heating the liquors has materially increased the demand for steam; at the same time the extraction of a larger percentage of tannin from the bark has rendered it possible to reduce the quantity ground per given output of leather so that there is no longer a surplus of "spent tan" for fuel; on the contrary, it is often found necessary to supplement it with other fuel, the quantity of which will vary with the efficiency of the steam plant as a whole and with the class of leather manufactured. The "spent tan" from the bark required in a sole leather tannery should furnish fuel sufficient to very nearly, if not quite, supply steam for all purposes about the plant.

The type of furnace used for "spent tan" is what is known as the "Dutch oven," extending out from the front of the boiler. The fuel value of "spent tan" may be analyzed as follows: One cord of air-dried bark before leaching will weigh 2,300 pounds, of which about 18 per cent., equal to 414 pounds, will be water; the tannin and other matter soluble in water will amount to about 11 per cent. of its weight, equal to about 253 pounds, which, under present methods, will practically be extracted by the leaching process; deduct this with the weight of moisture from the original weight of bark, and there is left of fibrous matter, if absolutely dry, 1,633 pounds available as fuel. It is obvious that the condition of absolute dryness is impossible to obtain in actual practice, but where the thermal value of any fuel matter is known the net value carrying any known percentage of moisture is easily computed. "Spent tan" in the condition as usually pitched from the leaches contains from 60 to 65 per cent. of water; the 1,633 pounds of fibrous matter, therefore, represents only 40 per cent. of the gross weight, which, with the 60 per cent. of contained water, will weigh 4,082 pounds. For each pound of tan in this condition it is obvious that there will be only 0.4 pounds of fuel matter, the other 0.6 pound being water. The first step towards the consumption of this fuel after it enters the furnace is the evaporation of the contained water. The heat necessary for this purpose must come from the combustion of the fuel itself, therefore for every pound of wet tan in the furnace instead of there being 0.4 pound of fuel matter available for producing steam in the boilers, there must be deducted the heat required to evaporate the 0.6 pound of water with which it is saturated. The water in the fuel must be raised from the temperature at which it is fed into the furnace to 212 degrees, evaporated from and at that temperature and superheated to that of the escaping chimney gases. The number of heat units required to do this will vary somewhat with the temperature of the tan when dumped into the furnace, and also with the temperature of the gases escaping up the chimney. It will, however, approximate 950.

View in Sulphite Mill Boiler Room, Showing Sawdust Firing Platform in Background.

In 1875 Theron Skeel made a series of carefully conducted experiments in burning "spent tan," using the Dutch oven type of furnace of several different proportions, and demonstrated that when absolutely dry it had a thermal value equal to about 9,000 heat units, or about 65 per cent. of the value of coal. The highest efficiency obtained from the fuel by Mr. Skeel was 76.7 per cent., or the equivalent in evaporation of 7.14 pounds of water from and at 212 degrees per pound of absolutely dry tan consumed. This is a high efficiency, and, undoubtedly, close to the maximum obtainable, but as it was obtained under actual working conditions it is not impossible, and would seem to indicate that the boiler and furnace proportions were very nearly right.

The number of heat units generated by the complete combustion of 0.4 pound of "spent tan" will be 40 per cent. of 9,000, equal to 3,600; from this 3,600 must be deducted the 950 heat units required to expel the water from the tan, leaving 2,600 heat units available for evaporating water in the boilers; this quantity multiplied by the efficiency of the boilers and furnaces will give the net heat units which will be transmitted to the water in the boilers. If the efficiency be assumed at the highest obtained by Mr. Skeel in his experiments, 76.7 per cent., it gives as a result (neglecting the fractions) 2,032 heat units. Provided the boiler feed temperature is 212 degrees, this number of heat units will evaporate 2+pounds of water from that temperature to steam at 80 pounds gauge pressure; or, in other words, it is possible to evaporate 2+pounds of water in the boilers per pound of "spent tan" saturated with 60 per cent. of its weight of water. With a lower feed temperature, of course, the quantity of water evaporated in the boilers would be slightly less, or with drier fuel greater.

Spent tan in its highly saturated state is essentially a slow burning fuel, therefore the grate areas should be large per unit of fuel consumed. The quantity that can be efficiently burned per square foot of grate surface per hour will vary somewhat with the percentage of moisture carried, hence the grate areas should vary slightly within certain limits of the average condition of the tan. It is apparently possible to burn as much as 30 pounds of wet spent tan saturated with 60 per cent. of moisture per square foot of grate surface per hour. To do this, however, fires must be forced by a very strong draft, and this means a large volume of air passing through the furnace and up the chimney in excess of the requirements of complete combustion. Besides the heat carried off by this excess of air which must be raised from the temperature of the boiler room to that of escaping chimney gases, and the high velocity of the gases incident to forced firing, will carry a large percentage of the finer particles of the fuel up the chimney unconsumed. It is possible in this way where forcing of the fires is carried to an extreme to waste a large percentage of the fuel, and in such cases it will generally be found that the grate of the oven is too small in proportion to the heating surface of the boiler.

Two different types of furnace for burning spent tan have been designed by Mr. Parks. One is arranged to be self-feeding by setting the grates at an angle slightly more than the natural slope of the tan, and placed in relation to the feed pockets so as to give a thicknes of fuel over the surface of from 4 to 5 inches; then the tan will slowly feed down the grate by gravity as it is burned away along the bottom. The other type is known as the Hoyt furnace, in which a plain flat grate is used, and the fuel or tan is fed into the furnace through round openings in the top and drops in conical piles on the surface of the grate. With this type of furnace the fire is simply a surface fire burning on the outside of these cones with little or no combustion on the inside. The arrangement of these openings is such that the cones come close enough together to completely cover the grate with tan. In either of these furnaces the interior surface is lined with a good grade of fire brick, and with the fire in its best condition the interior of the furnace is maintained at a very high temperature; or, in other words, the brick work is heated to very near an incandescent heat, surrounding the tan in the furnace with these highly heated surfaces so that they will not be cooled off from the fresh charges of fuel below the temperature necessary to ignite the gases given off by the tan after it is dried. The proportions of furnace which have been found most successful are such that the combustion of wet tan per square foot of grate per hour runs somewhere from 10 to 12 pounds, and about 1½ to 1¾ pounds of wet tan per square foot of heating surface per hour. The ratio of grate to heating surface should be from 1 to 10 to 1 to 12 square feet, and the ratio of grate to cross section of tubes from 20 to 26 to 1.

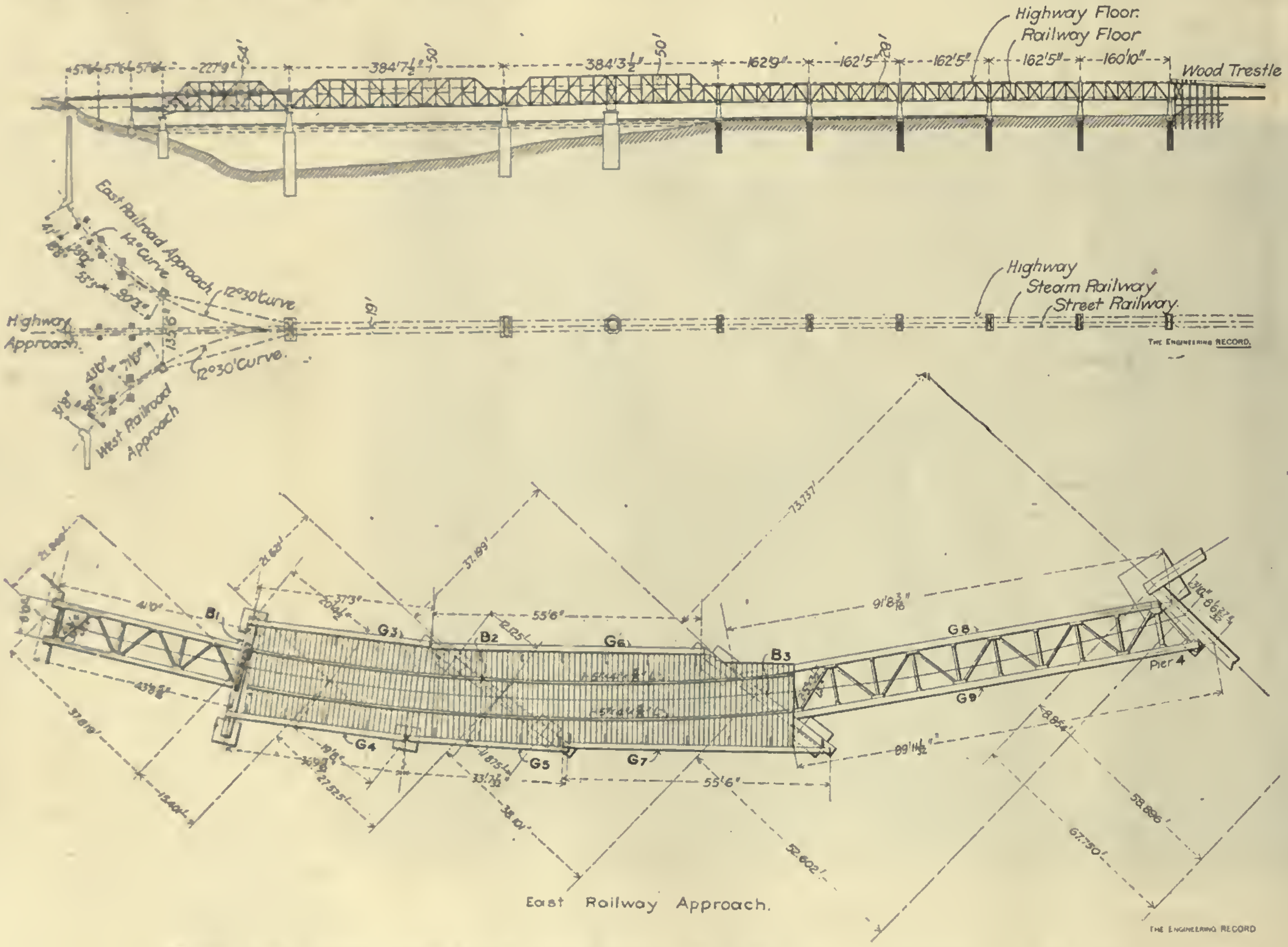
A case is mentioned by Mr. Parks where all of the spent tan available was consumed and a considerable additional fuel, and yet it was impossible to generate steam enough to run the plant. A new boiler was contemplated because it was thought those in use were being taxed to the limit of their capacity. Investigations, however, demonstrated that these boilers were not evaporating anywhere near the quantity of water that they should evaporate under proper conditions, and at least one boiler could have been dropped out of service. It also proved that the quantity of water evaporated per unit of fuel consumed was very small, thus showing a low efficiency. New furnaces as near being properly proportioned to the boilers as the available space would permit were built after which there was no further trouble in making all the steam needed; it was even possible to let one boiler lie idle without taxing the others beyond their economical steam capacity. Following this change the spent tan handled was sufficient to supply all the fuel required.

AIR-COMPRESSING STATIONS have been erected in St. Louis for the St. Louis Transit Company, which has adopted the Westinghouse air storage system of brakes for its cars. One of these stations is housed in a brick building about 25 feet square, containing three compressors and two storage tanks designed for 325 pounds pressure. The tanks are 3 feet in diameter and 18 feet long. Water from the cylinder jackets of the compressors is discharged into a well from which it is raised by an air lift to a small tank above the level of a group of radiating coils on the walls. Through these it is passed for use over again in the cylinder jackets. Tests have shown that the consumption of air is 100 cubic feet of free air per car per hour, each car scheduled for over 10 miles to the hour.

The Fraser River Bridge, British Columbia.

PART I.—GENERAL DESCRIPTION, APPROACHES AND PLATE-GIRDER SPANS.

The bridge across the Fraser River, at New Westminster, has just been built for the Lands and Works Department of the Province of British Columbia, Canada. It has a total length of about 2,000 feet and carries a highway, and steam and electric railways across the river at at a point where the latter is nearly 2,200 feet wide, and has a maximum depth of about 80 feet and a tidal current of 5 miles an hour. The substructure consists of four concrete piers sunk with timber caissons to a maximum depth of 134 feet below low-water level, six other main piers with concrete footings in timber caissons on pile foundations and several smaller piers with concrete footings seated on shore beyond the water line. The superstructure consists of 900 feet of pile-trestle approach at the east end of the bridge and 1,980 feet of plate-girder and trussed spans, measured on the axis of the bridge. There is one 380-foot swing span, and there are five 159-foot, one 380-foot and one 225-foot fixed spans.



Fraser River Bridge: General Plan and Elevation, and Detail Plan of East Railway Approach.

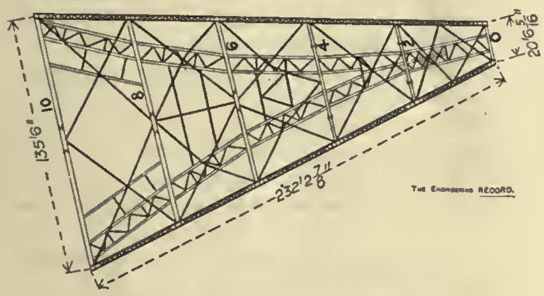
The bridge has two decks. One of them is at the level of the top chords of the 159-foot spans and is far enough below the top chords of the other spans to give suitable clearance in the overhead lateral system. The other deck is carried at the level of the lower chords, which are in the same plane in all spans. The lower deck carries a single track railway, which is also used by an electric car line. At the west end of the bridge these two tracks commence to diverge at the river end of the 225-foot span, where they are laid on 12½-degree curves, which gives a distance of nearly 120 feet between them at the shore end of the span. To provide for this arrangement, the trusses of the span are placed 19 feet apart on centers at one end and 136 feet apart at the opposite end, thus involving unusual features in the construction of the trusses, bracing and floorbeams. From the shore end of this span there are three separate plate-girder approach viaducts. One of them on the axis of the bridge carries the highway; the others are curved structures carrying the railroad tracks to the abutments. This arrangement, in reality, gives a larger number of linear feet of bridge than was indicated by the length stated, which is the direct measurement in the axis of the bridge and does not include either of the curved viaducts. The viaducts are made with both deck and half-through plate-girders with spans of from 35 to 96 feet. The grade of the highway deck is maintained nearly level from the west end of the bridge to the top of the bank, but at the east end it diverges from the parallel approach and electric tracks and descends to the surface of the ground at the end of the wooden trestle on which the two tracks are carried side by side at the same level.

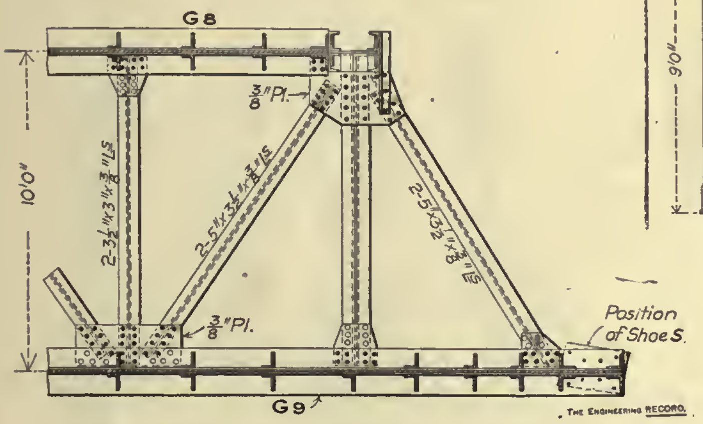
The timber trestle bents are about 14 feet apart and have longitudinal struts and are X-braced in alternate panels above the railroad tracks. The stringers are made in two-panel lengths, breaking joints. The timber is first quality Douglas fir treated with two coats of carbolineum and having all joints, ends of timbers and bored holes saturated with hot creosote oil and painted with hot asphaltum. At the south end of the bridge the trestle approach is built with framed timber bents 14 feet apart, having eight vertical piles in each bent. At the river end these piles are 55 feet long, but they decrease in length to 30 feet at the shore end.

The highway piles are capped with a 10x12-inch timber 22 feet long, one end of which rests on the end of the cap under the railroad track. On this cap are seated two 10x12-inch vertical posts about 26 feet long, which are X-braced transversely and carry a 12x12-inch cap 20 feet long. On the cap are nine lines of 3x12-inch stringers covered with a bottom floor of 2-inch diagonal planks and a top floor of 2½-inch transverse planks for the 16-foot roadway. The sides of the roadway are enclosed by heavy wooden hand rails with their posts kneebraced to the projecting ends of the caps. The pile bents are braced longitudinally by two double lines of 6x10-inch horizontal pieces at the tops of the highway piles and by four single lines of 6x10-inch pieces at the height of the intermediate horizontal braces.

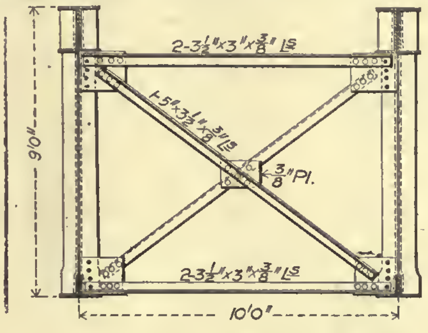
The highway approach has three deck plate-girder spans 57 feet 6¼ inches long over all and 54 inches deep. The girders are spaced 10 feet apart on centers and have 12x12-inch wooden floorbeams 20 feet long dapped over their top flanges and secured to them by hook bolts. These carry nine lines of 3x12-inch stringers covered with a diagonal course of 2-inch planks and an upper transverse course of 2½-inch planks. The roadway is 16 feet wide in the clear and is protected by wooden hand rails kneebraced to the cantilever ends of the floorbeams. The girders have zigzag top lateral braces and are supported by single trestle bents each made with two battered posts. The posts are bent so that their upper ends are vertical and are field-riveted to the end web-stiffener angles of the girders. The feet of the posts are anchor-bolted to masonry piers and some of them are enclosed in sectional circular cast-iron shells which are filled solid with concrete.

From the river end of the approach proper to the 380-foot span, the deck is carried on a continuation of the plate-girder viaduct supported by the special floorbeams of the 225-foot spread span. These floorbeams are about 45 feet apart and are from about 20½ to about 135½ feet long on centers of trusses. On the center of each floorbeam there is seated a single bent with two vertical posts about 24 feet high carrying the pair of roadway girders. On the first three floorbeams at the shore end the bents are made with pairs of vertical posts 10 feet apart on centers and X-braced in two vertical panels

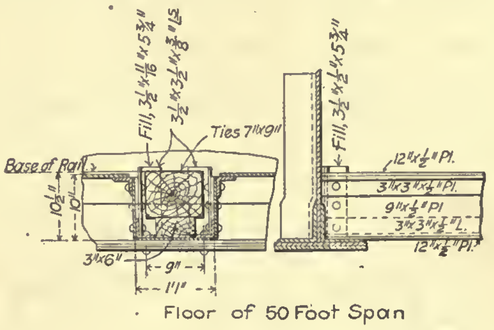




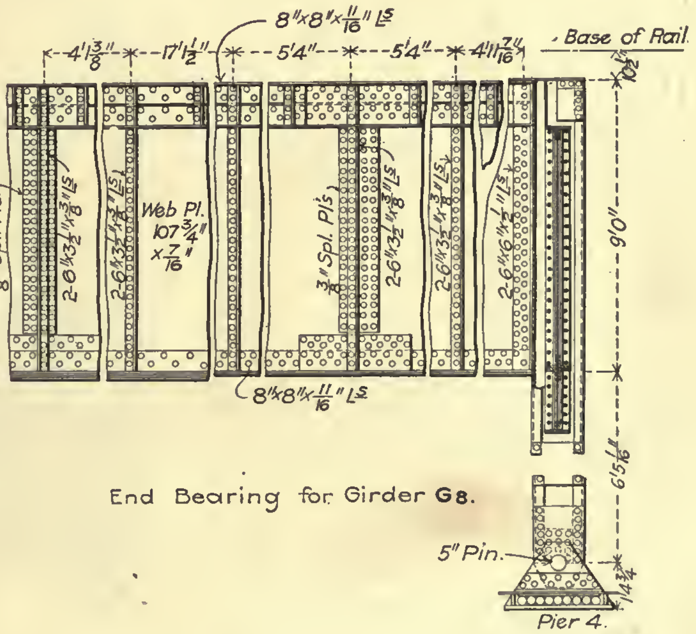
River End of Approach Girders.



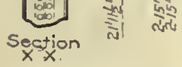
End Sway Bracing, Girders G8-G9.



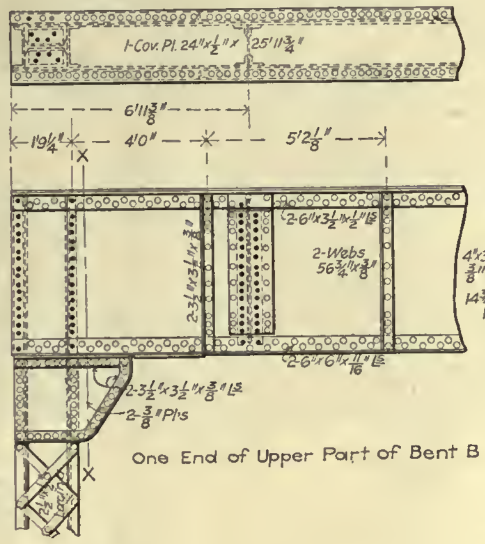
Floor of 50 Foot Span



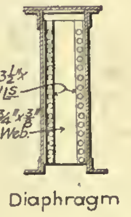
End Bearing for Girder G8.



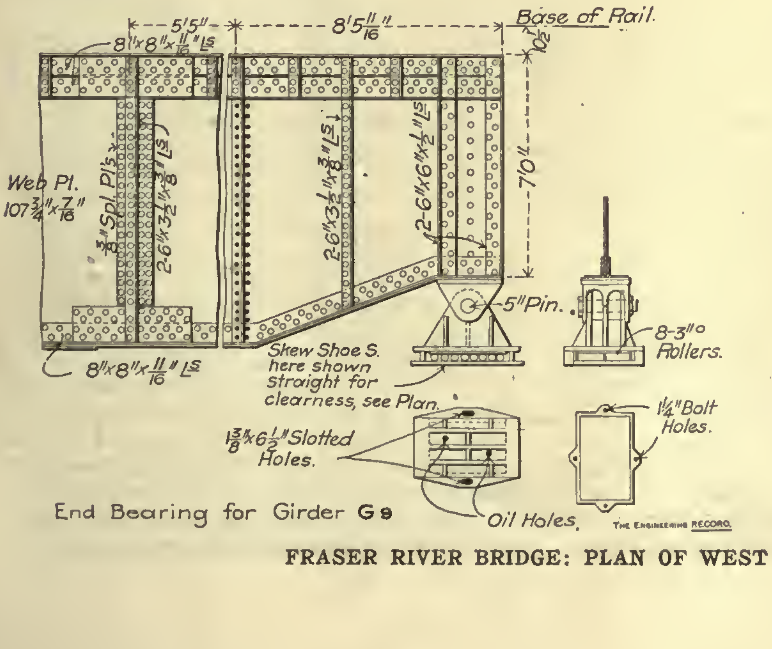
Section X-X.



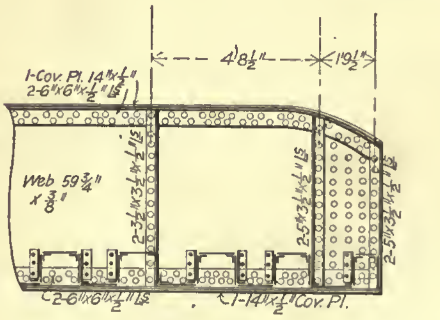
One End of Upper Part of Bent B



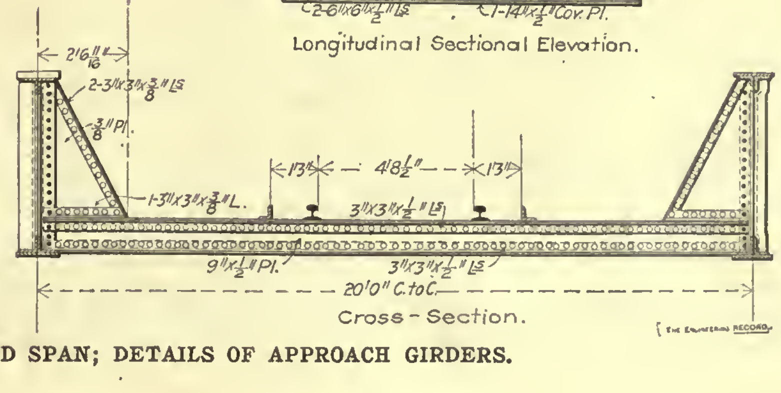
Diaphragm



End Bearing for Girder G9



Longitudinal Sectional Elevation.



Cross-Section.

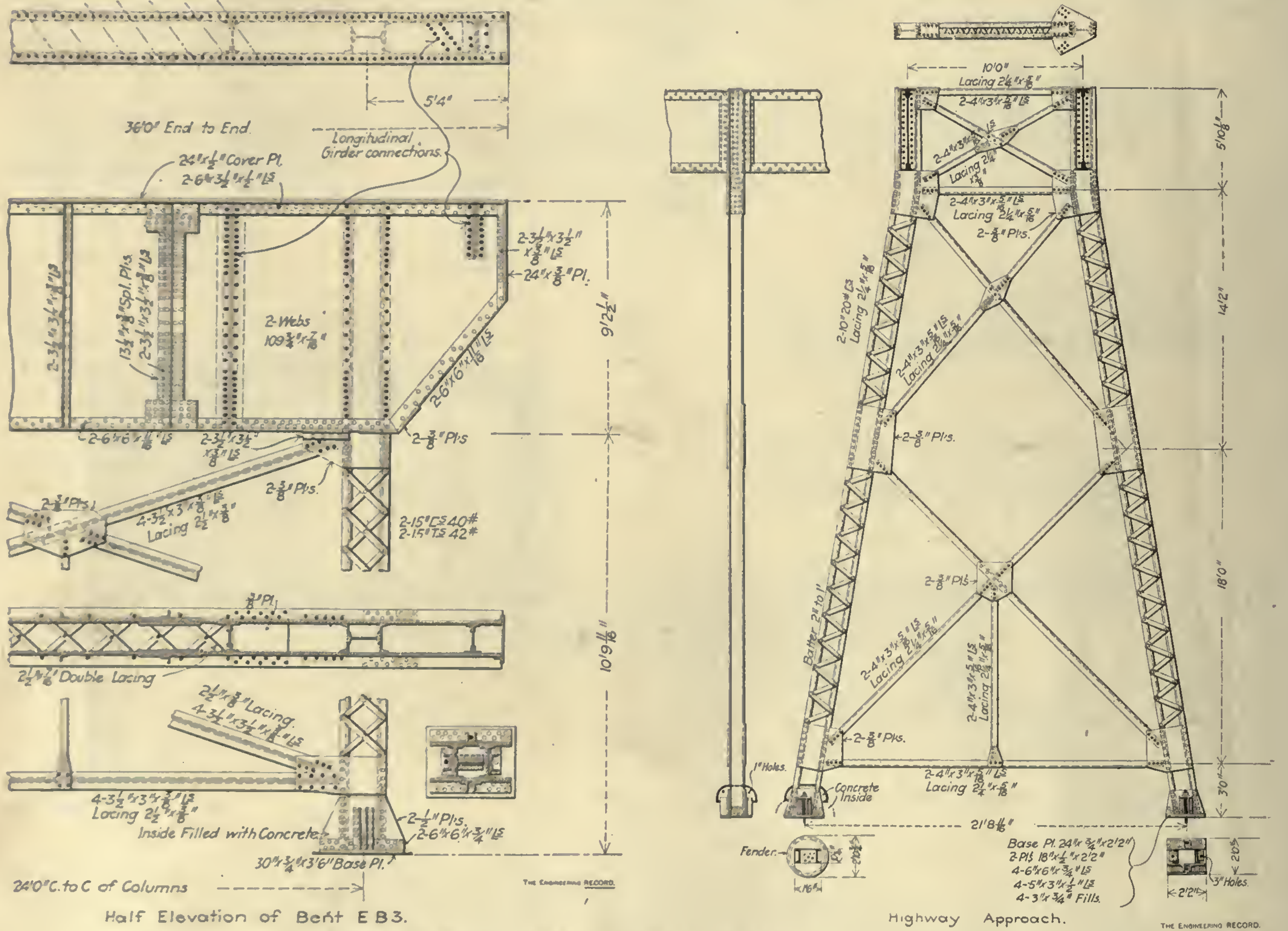
FRASER RIVER BRIDGE: PLAN OF WEST END SPAN; DETAILS OF APPROACH GIRDERS.

with pairs of angles latticed. Each column has an I-shaped cross-section made of two pairs of 4x3-inch angles latticed in the longitudinal plane. The ends of the girders are web-connected to the column flanges and the latter are sway-braced with the usual angle frames between the girders. On the remaining three floorbeams of this span the columns supporting the highway girders are spaced from 19 to 35 feet apart in order to clear the railroad tracks. In these bents they are made of pairs of 9-inch channels latticed and their upper ends are web-connected to 40-inch transverse plate-girders with angle-iron kneebraces at both ends. The longitudinal roadway girders are supported from the transverse girders with web-connections like those usually found between stringers and floorbeams. The two divergent railroad tracks have pairs of skewed longitudinal girders directly connected to the floorbeams, as indicated in the general diagram.

From the shore end of the 225-foot span each curved track is carried on pairs of skewed plate girders supported by special single-bent trestles with their vertical posts connected at the top by heavy transverse girders. At the abutments and at the piers of the 225-foot span the tracks are carried on deck spans, but in the middle of each approach they are carried on through spans with solid trough floors to afford the greatest possible clearance underneath for the low-grade roads, which they cross. The arrangement of the trestles and girders is substantially alike for both tracks, and is indicated by the diagram for the east track. That for the west track corresponds to it in general, except that the girders are supported entirely by three trestle bents and the intermediate single column, seen under the east track, is there omitted. Bent B3 has a very deep double cantilever transverse girder with two web plates, each made in three sections, shop-spliced and field-riveted across the flanges of the vertical posts which act as spacers between them and extend to their top flanges. The ends of the through girders, G6 and G7, are carried on the extremities of the top flange of the transverse girder, and at these points the webs are connected by vertical diaphragm plates to distribute the loads and form seats for the longitudinal girders. The ends of the deck span girders, G8 and G9, are web-connected to the transverse girder at points adjacent to the web splices, where the webs are connected and stiffened by vertical diaphragms shop-riveted to one web and field-riveted to the other. The end and top flange angles of the transverse girder have cover plates, and the latter, as well as the lattice-bars on the lower flange, are field-riveted to allow for separate shipment and field assembling.

Bent B2 is similar to B3, but differs in dimensions and proportions. The columns are 24 feet apart on centers and the transverse girder is 39 feet long over all and 57 inches deep, each of its webs being made with single plates. It has no web-connections to the longitudinal girders, but supports them all on reinforced seats at the extremities of the uper flange. Bent B1 has a box-girder shipped complete. Its webs are field-riveted to the flanges of the columns, which extend through it to the top flange, as in the case of the other bents. The columns, however, have heavy double web brackets shop-riveted across their flanges to form seats for the girder which is field-riveted to them so as to secure lateral rigidity, which is equivalent to kneebraces. The through span girders are supported on the tops of the columns, and the deck span girders are web-connected to the transverse girder at the points stiffened by the diaphragms. There is no material difference, except in dimensions, between the trestle bents for the west track approach and those for the east track approach.

The longest railroad girders are those adjacent to the 225-foot span. Those for the west track are both 71½ feet long over all, and correspond in most respects to girders G8 and G9 for the east track, which are respectively 91 feet 8 3/16 inches and 89 feet 11 1/32 inches long over all. They are made with two angles in the lower flange and with four in the upper flange, and have their details and materials throughout corresponding to those shown in the end sections. The top flange has a uniform section throughout, which is composed of four 8x8x 11/16-inch angles without cover plates. The bottom chord has a maximum cross-section of two 8x8x11/16-inch angles and three 16-inch cover-plates aggregating 1⅜ inches in thickness. The web plates are made in sections from about 7 to 14 feet long and are spliced with double cover plates and four rows of vertical rivets, except at the bottom flange, where longer horizontal splice plates are used, as shown in the detail. The horizontal flanges of the upper and lower top flange angles are braced by verti-



Fraser River Bridge: Details of Railway and Highway Approach Bents.

cal angles about 2 feet apart, which are riveted to the webs and have both ends milled to bearing.

At the shore ends both girders have pairs of bent vertical plates shop-riveted to their webs with three vertical lines of rivets. These make oblique flanges which are field-riveted to the web of the transverse girder in bent B3. The river end of girder G8 is field-riveted through the flanges of its end web stiffener angles to the flange of a vertical post about 15½ feet long which project 6½ feet below the lower flange and there has a pin connection to a roller shoe seated on the pier of the 225-foot span. The river end of girder G9 is several feet beyond the pier of the 225-foot span, and is carried directly by the long end floorbeam of that span. In order to engage it, the girder is made with a drop end and has riveted to the lower flange a cast-steel shoe, pin-connected to a cast-steel pedestal seated on a roller nest in a pocket of the floorbeam. Girders G8 and G9 are connected together by zigzag lateral bracing and by panels of sway-brace angles about 8½ feet apart. At the river end the sway-brace frame is replaced by a solid transverse diaphragm made with a 90x⅜-inch plate and pairs of 3½x3½-inch angles on all sides. This diaphragm has a solid-web kneebrace at one end to extend its connection with the vertical post to which it is field-riveted, as shown in the elevation of the end of the girder.

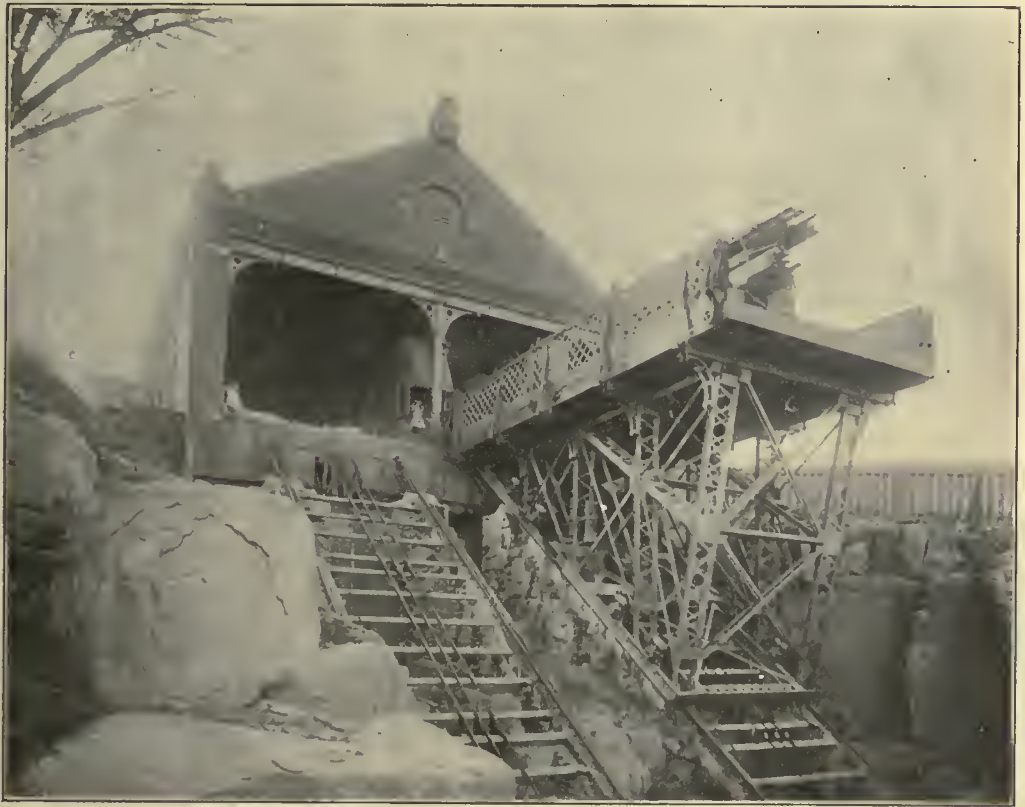
The west track girders adjacent to the 225-foot span are similar to G8 and G9, except in their dimensions, and in the fact that the girder, which is seated in the floorbeam pocket, being only 84 inches deep, does not require to be made with a drop end. The through span girders, G3, 4, 5, 6 and 7, are of ordinary construction, made with rounded upper corners and having the ends of the web plates reinforced, as indicated in the part elevation. These spans have neither floorbeams nor stringers and their girders are connected only by the solid trough floor which is shop-riveted in sections about 4 feet wide and is field-riveted to the girders through short vertical angles shop-riveted to each side plate. The floor is made continuous across both through spans and the sections are beveled to fit where they intersect on account of the different angles of adjacent girders. The girders are kneebraced by wide gusset plates reaching to the top flanges and riveted to the floor troughs and to each vertical web-stiffener angle. Each trough contains a tie supported on a 3x6-inch packing timber laid flat on the bottom plate. The space around the ties is filled with gravel ballast saturated with asphalt.

(To be continued.)

Legislation for Schoolhouse Ventilation has at last been enacted in New York State after some years of effort in which the American Society of Heating and Ventilating Engineers has held a very prominent position. The bill is in part as follows: "No schoolhouse shall hereafter be erected in any city of the third class or in any incorporated village or school district of this State, and no addition to a school building in any such place shall hereafter be erected, the cost of which shall exceed $500, until the plans and specifications for the same shall have been submitted to the Commissioner of Education and his approval indorsed thereon. . . Such Commissioner of Education shall not approve any plans for the erection of any school building or addition thereto unless the same shall provide at least 15 square feet of floor space and 200 cubic feet of air space for each pupil to be accommodated in each study or recitation room therein, and no such plans shall be approved by him unless provision is made therein assuring at least 30 cubic feet of pure air every minute per pupil, and the facilities for exhausting the foul or vitiated air therein shall be positive and independent of atmospheric changes." The remainder of the bill referred to provisions for fire protection, chiefly as to the openings on stairways, the use of platforms on stairs, the opening of main doors outward and so on. The passage of this bill will probably be used to its fullest extent as a wedge in pushing such measures through other State Legislatures.

The Inclined Elevator at Weehawken, New Jersey.

An electrically operated inclined elevator, designed primarily to lift loaded wagons from the shore roads along the Hudson River at the foot of the Palisades to the heights above, near Weehawken, N. J., has been in successful operation for some time. Besides the interest which attaches to it on account of its size, being designed to haul a live load of 40,000 pounds at 200 feet per minute or 30,000 pounds at 300 feet on an incline of over 35 degrees with the horizontal, the chief instructive feature of the installation lies in the combination of electrical and hydraulic machinery that has been furnished. There are two cars, one of which descends as the other rises, and each is fixed to hoisting cables which pass over two large drums, one for each car. The drums are electrically driven and in the ordinary operation this method of hoisting is employed for bringing the car to a point within 2½ feet of the top landing. For the rest of the travel hydraulic power is resorted to through hydraulic rams, which take hold of the car and lift it to the landing level. While it was decided that electric power would be better for general hoisting than hydraulic under the conditions obtaining, it was felt that better control of the termination of travel could be obtained in the manner outlined than if the attempt were made to regulate accurately the absolute travel of the electric motors.


Car at Upper Landing, and Rams at Top of Near Track, Weehawken Inclined Elevator.

The tracks are of 12 feet gauge and 22 feet apart on centers, and the rock excavation that had to be made in the hillside, in one point 40 feet deep, is approximately 50 feet wide. In order to accommodate each car at the bottom of travel the excavation has taken the form of a pit below the level of the roadway of the Hackensack Turnpike, and this, it may be stated in passing, has to be drained. While a low masonry wall has been built across the incline below the track level to divert most of the rain water, the pit had no means of emptying itself by gravity. On this account a small submerged centrifugal pump is employed, connected by means of a vertical shaft to a 3-horse-power motor enclosed in a shelter for the gatekeeper at the Turnpike level. This, of course, is only operated at intervals. The rails, which weigh 58 pounds per yard, are laid on concrete stringers built upon the rock, but are held together every 3 feet by steel ties. These are 6-inch channels, flanges pointing downward, anchored at each end to the concrete by bolts passing through clamps on the rail. Where carrier pulleys between rails for the cables are fixed, the ties are 2 feet apart to decrease the span of the stirrups which support the carrier pulleys in turn carried by the two ties. The carrier pulleys are spaced 20 feet apart. The difference in elevation between the top and bottom landings is 166.3 feet and the angle of inclination is 35 degrees 45 minutes, so that the length of the car travel is 284.6 feet.

The cars are identical in construction. Each has a platform 40 feet long and 20 feet wide carried by two triangular steel truss frames over the two rails, each truss supported on the rail by four 33-inch cast-iron wheels. The bottom member of each truss consists of two 12-inch 27-pound channels; the inclined latticed columns shown in the view of the car have each two 6-inch 10-pound channels; the verticals are pairs of 6-inch 8-pound channels; and the whole is braced in the manner indicated, largely by 3x2x5/16-inch angles. The members parallel with the bottom or rail channels are pairs of 6-inch 8-pound channels. The two trusses are connected together at the bottom by pairs of 9-inch 13-pound channels latticed together except where the cables are hitched to the car. Here there are two ½-inch plates, about 5 feet apart, one 23½ inches wide and the other 12 inches. At the top the trusses are connected together by pairs of 10-inch 15-pound channels, which carry the floor construction. This consists of 3x12-inch yellow pine stringers and two layers of 2-inch yellow-pine planking. Along each side is a timber guard rail, giving a clear floor width of 17 feet 10 inches. Each guard rail is surmounted by a latticed railing, fencing in each side of the car. Each end is closed by a length of 2½-inch wrought-iron piping which is hinged at one end. At the hinge it is attached to a counterweight suspended underneath the car, so that the pipe gate can readily be swung upward. Whenever horses or cattle are carried, folding lattice gates divided in the middle and fixed to the car are closed, but in the ordinary case these are not found necessary. The car has been designed to allow for running street railway tracks on the platform in case it is decided at any time to transport railway cars in that manner.

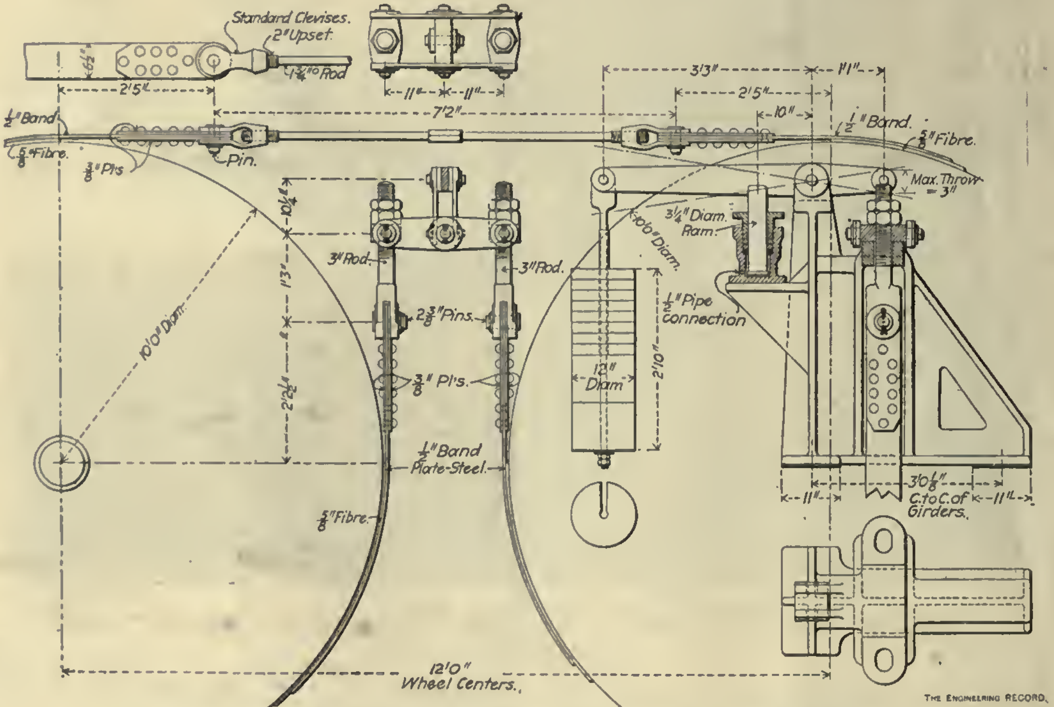
To each car is attached three 2-inch hoisting cables, two going to a winding drum in the basement of the station building at the head of the incline, one drum for each car, and the third passing in series over two separate drums, this cable continuous from one car to the other. It is called the safety cable, in distinction from the two others, which are the hoisting cables, and provides that the two cars, each of which weighs without load about 80,000 pounds, counterbalance each other, leaving the hoisting cables to handle the live loads. The manner in which the safety cable is passed from one track line to the other will be referred to later. All three cables are attached to the framework of the car at the bottom through devices fixed to three long, independent steel screws, each 3 inches in diameter. By means of a worm gear, which moves the screw relatively to the car frame, each cable is taken up by hand, that is, brought into the requisite degree of tension, the worm having a head for a socket wrench. The screw is locked in place by bronze nuts. This scheme for adjustment, which apparently can be manipulated while the car is in motion, gives a satisfactory method of keeping the cable lengths such that when one car is at the top landing, the other lies at the bottom.

The machinery for operating the incline is all housed in the basement of the headhouse, which is 64 feet in the direction of the railway and 45 feet wide. Besides the two hoisting drums and the two main electric motors, which are grouped toward the far end of the room, the hydraulic plant for the landing rams, the sheaves and apparatus forming part of the safety or balancing cable, and the switchboard are located there. The rough rock of the excavation has been concreted to form a cement floor, the walls are of stone masonry and the ceiling is of steel plate. The steel work forms part of a buckle-plate flooring for the landing, being covered with concrete and a pavement of brick with the usual cushion of sand between the concrete and the brickwork. It may be stated in passing that the thickness of this floor construction is 10 inches from the top of the beams spanning the room to the brick pavement surface. The masonry walls are provided with a number of windows.

Each hoisting drum is independently connected through a triple reduction of spur gears to a 135-horse-power Westinghouse electric motor, but the two shafts of the drums are connected together. In regular operation, therefore, both motors are operated, and in order that the cars may travel simultaneously in opposite directions, one pair of hoisting cables passes over to one drum and the second passes under to the other, one winding as the other unwinds. Each drum is 12 feet in diameter and has a face about 4¼ feet wide.

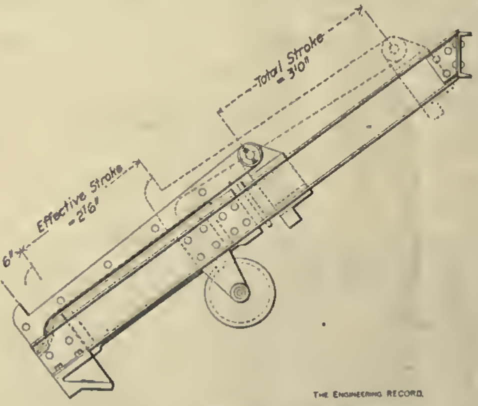
The rim is in one piece and is attached to two large circular web plates, all of cast-iron. The latter have circular holes which allow for getting within the drum. To one side or flange of the drum is bolted the cast gear by which it is driven. Taking the speed of the motor at 600 revolutions per minute the corresponding drum speed would then be 7 1/3 revolutions, corresponding to a linear velocity of the cables of 275 feet per minute. As a matter of fact the car is hoisted in less than two minutes including the acceleration of the motor, the slowing down of and stopping of the motors and the application of the hydraulic rams. The motors are of the compounding type, wound for 550 volts, and supplied by an independent circuit from a neighboring street railway plant. They are designed for 50 per cent. overload, so that 200 horse-power is obtainable from each of them, or 400 together.

Each motor is provided with a magnetically operated brake, of the regular Otis design for elevator work. The brake wheel is mounted on the motor shaft and is 30 inches in diameter and the brake band encloses about 290 degrees of its periphery. It is operated in conjunction with a solenoid type of magnet which is wound with two coils, one shunted across the armature terminals and the other in series with the armature. A spiral spring fixed underneath the magnet keeps the brake on except when current is passing through the armature when the magnet overcomes the power of the spring. As the motor slows down the shunt winding serves to keep off the brake until the motor has fully stopped. On the other hand if the brake has not yet been released, this winding is of itself incapable of releasing the brake, so that in the event of the armature's being out of order an accident that might result if the heavily loaded car should be above the bottom landing is avoided. For starting, a system of magnet control, similar to that employed for the regular Otis electric elevator is in use, and an automatic limit stop, mounted on one end of the drum shaft, has been provided, so that the important requirement that the car shall not be allowed to overrun and hit the upper landing at speed is not entrusted solely to the vigilance of the operator. It is also necessary, however, that the cars be allowed to approach near enough to the top, within 2½ feet, so that the hydraulic rams can catch the projections under each car for that purpose.



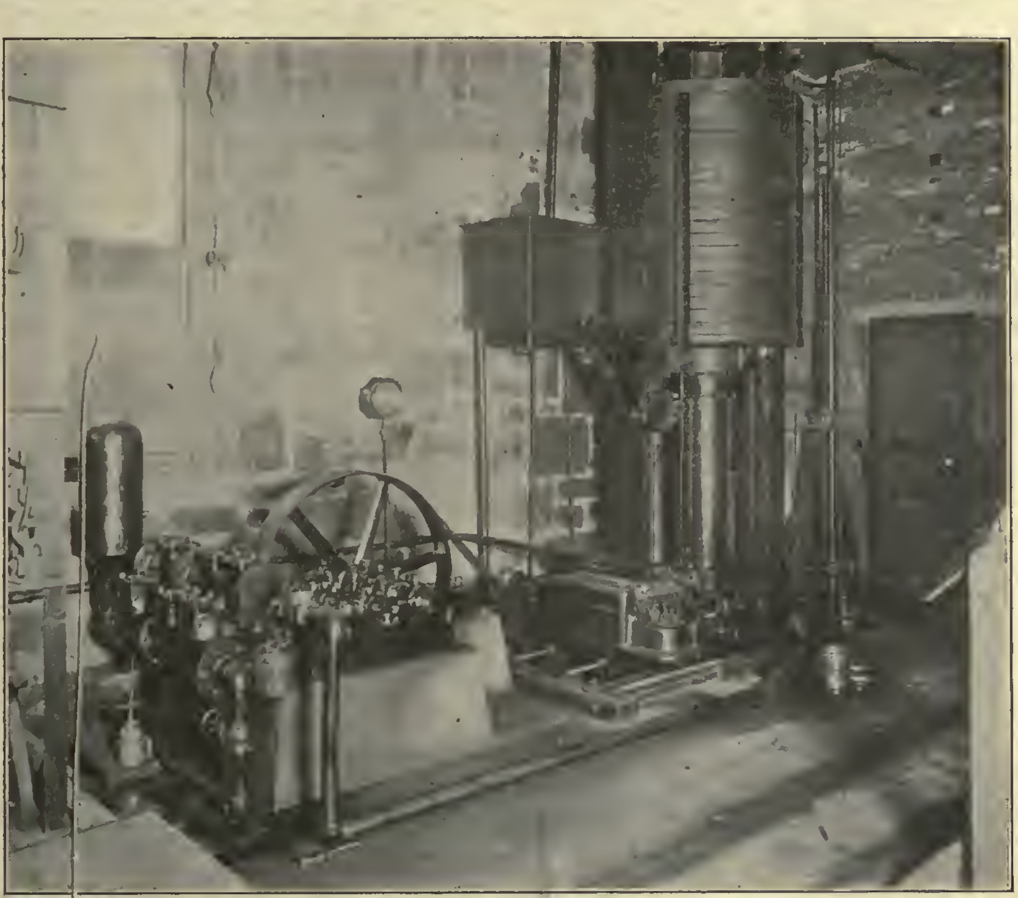
Brake Apparatus for the Safety Cable, Weehawken Inclined Elevator.

There are two rams for each car, each lying in continuation of the line of direction of the rail. Each has a cylinder of 6½ inches bore and a stroke of 3 feet. The plunger, which is of steel, carries a hook, formed of two ⅞-inch steel bars as shown in an accompanying drawing. During the first 6 inches of the stroke the hook is raised into position for reaching the projection, so that the effective stroke is 30 inches, or the 2½ feet within which the car must be stopped. The rams are operated with oil at a pressure of 750 pounds per square inch so that the lifting load of each is 10 to 12 tons, while the maximum load on the car is 20 tons. Each pair of rams is under the control of the operator, who is stationed in a pilot house at the top landing between tracks. By means of a hand lever the ram is started and by further movement of the lever, when the ram begins effective work, the motor magnet brake is released, so that both of the main drums may be turned to allow for the movement of the cables and the completion of the travel of the cars. The cylinder of the ram is fixed between two steel channels, as indicated, and the bottom of the hook travels on a finished surface on the top of the cylinder.



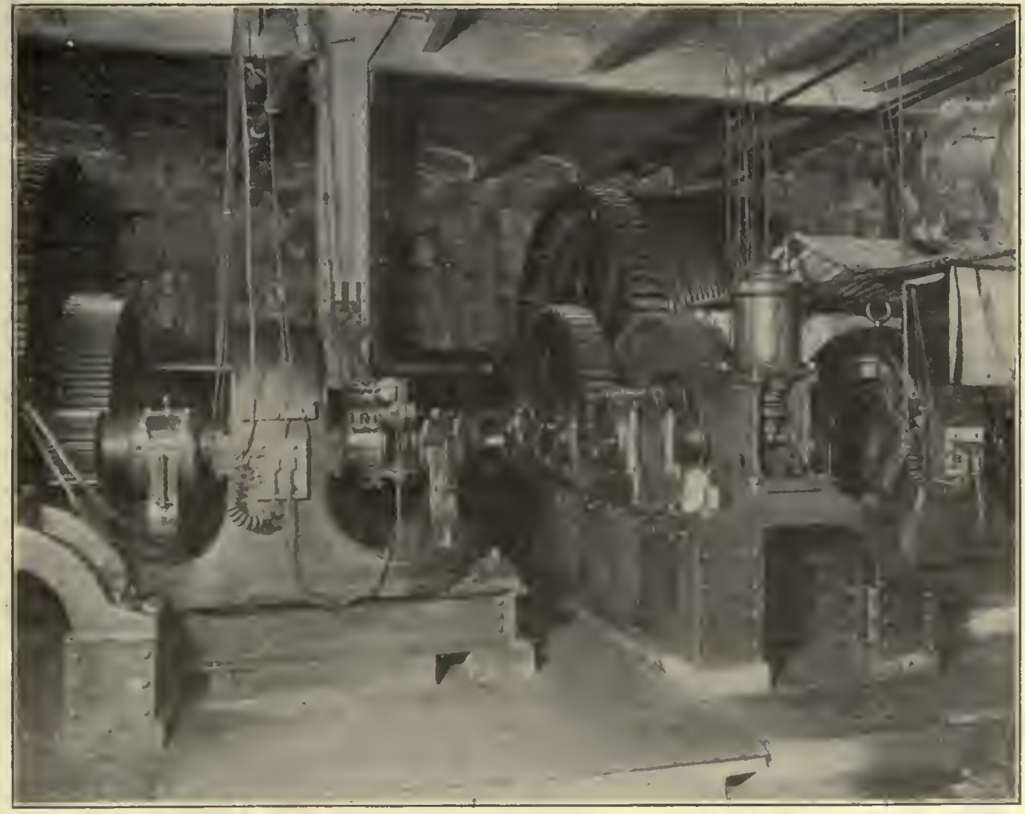
One of the Hydraulic Rams.

The hydraulic plant in the basement includes a motor driven Worthington triplex pump of the horizontal pattern and a weighted accumulator. The pump has plungers 2 inches in diameter and 4 inches in stroke and is driven by belt from a 7½-horse-power Otis motor. It has a capacity to work against a pressure of 1,500 pounds per square inch. The accumulator has a stroke of 5 feet and is 7½ inches in diameter. When the operator shuts off the valve to the ram, a counterweight provided for each of them draws the ram back to its original position, forcing the oil to an open discharge tank supported above the floor line of the basement, near the accumulator. When the rams are put into operation the weighted accumulator plunger falls. The descent of the plunger throws in two contacts, the first of which starts the motor-driven triplex pump, while the second, a moment later, brings it to a speed of about 100 revolutions per minute. When the pump has succeeded finally in lifting the accumulator plunger to its normal position, which it does in a short time after the car has been brought to rest, the contacts are broken and the motor and pump are cut out. They are thus only in action a few minutes every time the rams are used.



Accumulator and Electrically Driven Hydraulic Plant.

The remaining feature of the plant relates to the balancing cable and safety brake, a drawing of the apparatus being included among the accompanying illustrations. At the top of each track there are three 10-foot idlers and the two outer cables pass over these to the hoisting drum. The center cable, however, passes downward from the idler and then across the basement, wrapping around each of a pair of 10-foot drums about two and one-half times and then upward and over the central 10-foot idler at the head of the other track and thence to the other car. To each of the two 10-foot drums is attached a brake wheel and these are shown in the engraving mentioned. The dimension and arrangement of the brake bands is shown. The fiber blocks are 6½x⅝x4 inches in size. The bands are brought into contact against the wheels by means of the weights on the lever and the lever arms being 3 to 1 and two bands depending from the lever, for the load of 2,000 pounds on the end of the lever a pull of 3,000 pounds can be exerted on each band. The weights are normally held in the mid-position, however, by means of a hydraulic ram connected to the accumulator system described. The pressure is released from the cylinder of this ram at the will of the operator whenever the necessity arises of locking the cars in position at any point of the tracks. Light springs serve to hold the band from the wheels so that it does not touch at any point when not required. The ram is 3¾ inches in diameter and has a stroke of 3 inches, and its use prevents a too sudden application of the brake.



Main Motors Triple-Geared to Drums at Rear, Weehawken Inclined Elevator.

The railway is open on week days from 6 A. M. to 7 P. M. The charges are as follows, the first figure giving the charge for the up trip, the second the charge for the down trip, and the third for an excursion or round trip: Double truck or wagon, 25, 15 and 30 cents; single truck or wagon, 15, 10 and 20 cents; two-horse coach, 15, 10 and 20 cents; each passenger, 2 cents extra; push cart, 10 and 5 cents; timber, etc., over 30 feet long, 40 cents; boilers, machinery, safes, over 6 and under 10 tons, 50 cents; for weights over 10 tons, special rates; horses or cattle, 5 cents; wheelman, 5 cents; passengers, 5 cents. The head house is of brick open at each end with gates at the street entrance. The pilot house stands at the edge of the landing and in the center of the head house between the two through roadways, and the operator commands an unobstructed view of the incline. Through this cabin the stairway leading to the basement is reached, and in it, as stated, are the controller for the motors and the hydraulic valves. The bottom landing has telephone communication with the pilot house, but signals for starting are made by electrical bells. Besides the operator, a man is stationed at both top and bottom landings, and the one at the upper platform collects the tickets. These are sold in bulk, ten trips, for example, at 10 per cent. discount.

The incline was originally built for the New Jersey Elevating and Transportation Company, which was organized through the efforts of Mr. A. S. Niven, but is now the property of the Public Service Corporation of New Jersey. The general design was the work of Mr. Thomas H. McCann, M. Am. Soc. C. E., engineer for the original owners. The machinery was designed by the Otis Elevator Company while Mr. Thomas E. Brown, now consulting engineer of the company, was its chief engineer. Mr. Charles L. Duenkel was resident engineer and Mr. J. D. Ihlder, as chief electrical engineer of the company, designed the electrical equipment. The Sandford & Stillman Company, of Jersey City, was the general contractor. The cost of the incline complete, including real estate, was about $170,000, and of this the machinery and cars cost $32,000. Mr. H. McMahon is the operating engineer in charge of the railway.

The Construction of the Times Building, New York City.

Part I.—General Description, Excavation and Foundations.

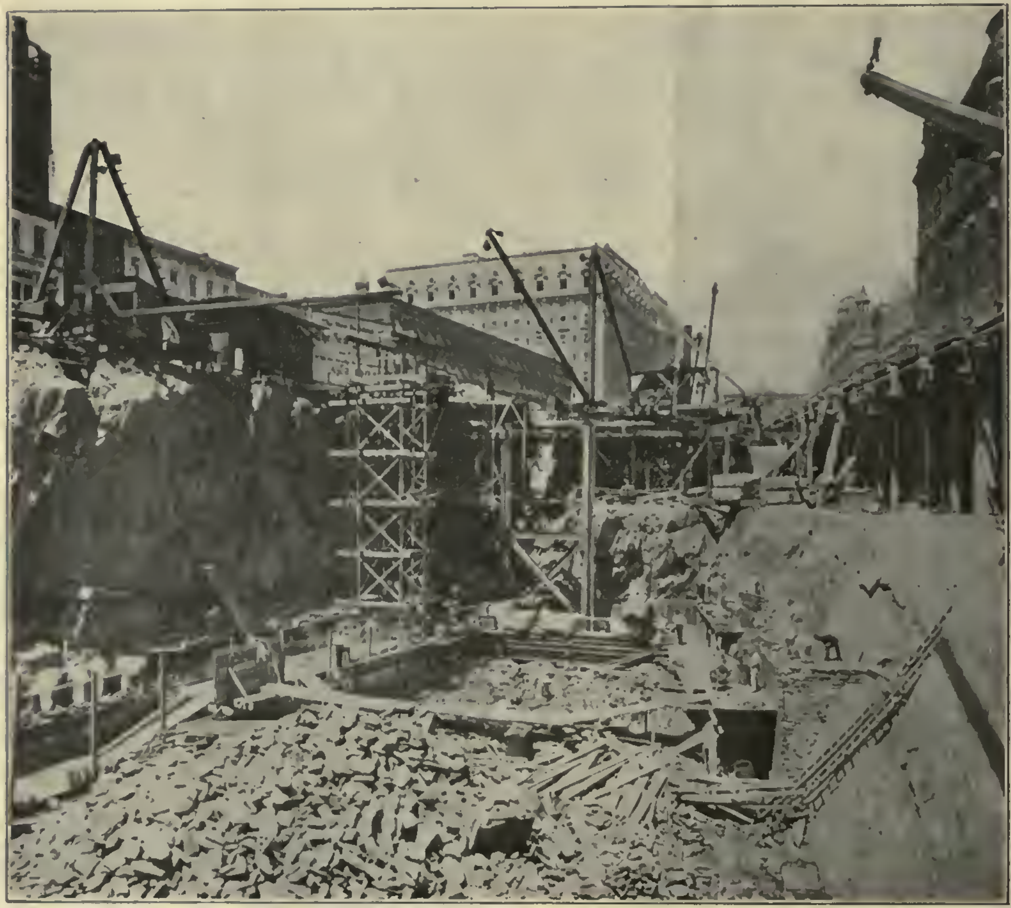
The Times Building, between Broadway and Seventh Avenue and between Forty-second and Forty-third Streets, New York, occupies, above the street level, a trapezoidal area about 137 feet 8 inches, and 143 feet long on the building lines on the long sides, and about 58 feet 4 inches, and 20 feet long on the short sides. It has sixteen full stories and five tower stories above the street, and three stories below the street, giving it total heights of about 430 feet from the bases of the columns to the highest point of the structure, 380 feet from the curb to the highest point, 331 feet from the curb to the cornice of the tower, and 225 feet from the curb to the top of the main roof. It is of heavy steelcage fireproof construction, with thick brick walls, faced with granite up to the fourth story, and with floors and partitions of hollow tile construction. There are twenty-five main columns with rectangular closed cross-sections built up of plates and channels.

The building is intended to be occupied, in the tower and basements, by the publishing and editorial rooms, composing rooms and printing presses of the New York Daily "Times," and to have rented offices in the other stories. Work was commenced on it in January, 1903, and it was expected that it would be ready for occupation in May, 1904, but it will be completed somewhat later. The construction of the building is especially interesting on account of its proportions; the great weight of some of its members; the accuracy with which the steelwork was fabricated and erected; the difficulties attending the work in a very restricted site in a congested district with double lines of street cars running on three faces of the building and no adjacent storage space; and also because of the great depth of the excavation and the fact that a portion of the tracks of the Rapid Transit subway pass through the lower part of the building.

This building resembles in some respects two recent tall steel buildings in New York City, although it differs from them in essential features, which afford opportunity for special comparison. The plan of the building is trapezoidal with one side so short that it is not unlike that of the famous Flat Iron Building, which was erected about two years ago by the same contractors at a point about a mile farther south on Broadway, and was described in The Engineering Record of March 29, 1902. Like the latter building, it has its foundations on the solid rock, and corresponds to it in some general features of the bracing. Unlike it, however, a very deep excavation was made and the columns were carried far below the level of the street. It is also comparable with the Hotel Belmont, which is about one-half mile distant on Forty-second Street, and was described in The Engineering Record of February 7, 1903. The latter building, which is still incompleted, is also a steel-cage structure with tall riveted columns, which extend to the bottom of a very deep excavation in the solid rock, and in both buildings provision is made for the intersection of the lower part of the framework by curved tracks of the Rapid Transit subway, where it deflects from Forty-second Street to the north and south lines.

While the extreme horizontal dimensions of the superstructure are only about 143 feet by 58 feet 4 inches, the location and the intersection of four streets gives building vault privileges on the three longest faces, where the excavation has been carried down under the sidewalk to the curb line, making a pit with the sides parallel to the main walls of the building and having lengths of about 178 feet on the east, 108 feet on the south, 168 feet on the west and 60 feet on the north. The site was previously occupied by several small buildings at the north end and by the Pabst Building at the south end, the latter being a comparatively new steel-cage structure, the demolition of which afforded some interesting facts concerning the condition of the steel framework, and was described in The Engineering Record of January 31 and April 18, 1903.

As the site of these buildings was a small irregular block with long crossings on the north side and heavy traffic on the south side, the sidewalks were not much frequented, and it was deemed admissible to close them entirely so that the entire area between curb lines was devoted to the construction operations without obstruction from sidewalk bridges, which are often provided for work of this character. All of the ground being either private property or within the curb lines was practically free from pipes, conduits or similar obstructions, so that there was practically no hindrance to the excavation within the curb lines. After the removal of the old buildings, a small amount of surface earth was encountered and the remainder of the excavation was in solid rock of the gneiss formation, familiar in this part of the city, and corresponding very closely with that encountered in the excavation for the Hotel Belmont.

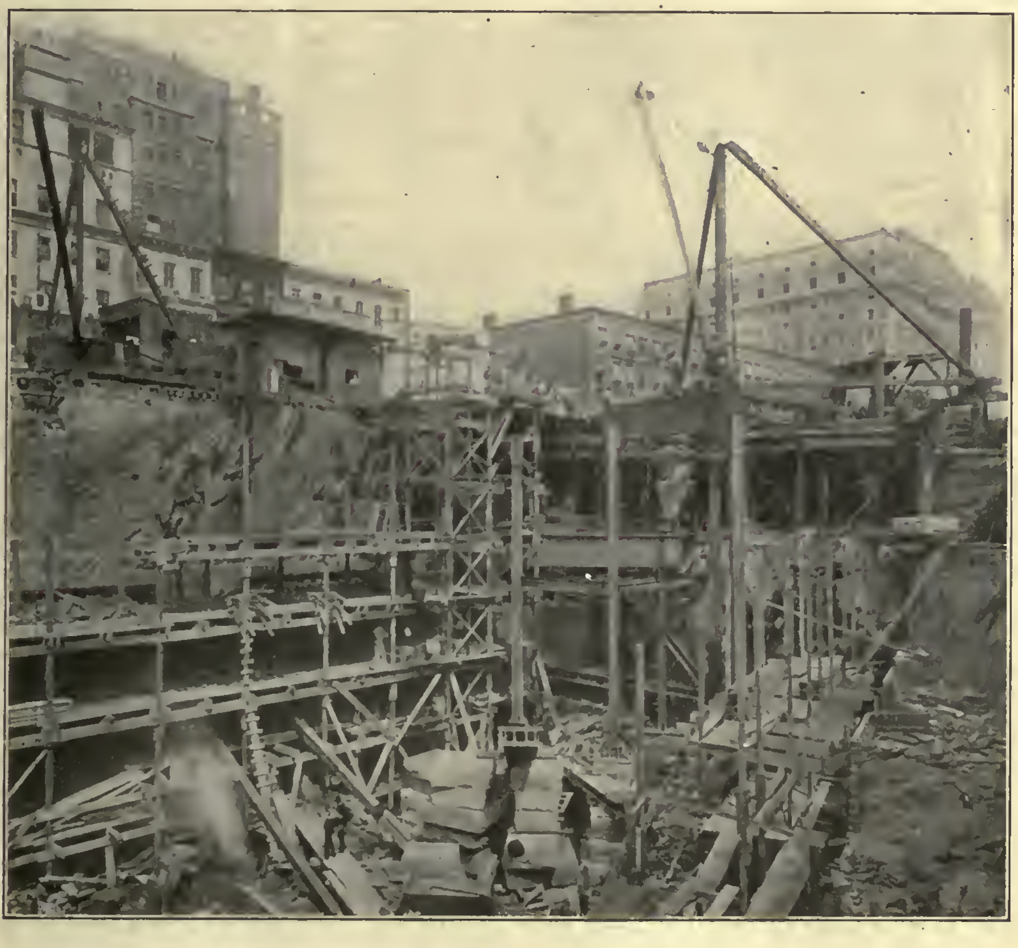


Excavation; Shoring under Street Railway; Filling behind East Retaining Wall.

Before work was commenced for the Times' Building, an open trench had been excavated north from Forty-second Street for the four-track standard subway structure of the Rapid Transit Railway. The portion of this excavation, which was included within the limits of the Times' Building, was about 33 feet wide and 60 feet long on the curved west side, where it intersects the Times' Building, the east side being under Seventh Avenue, entirely beyond the east wall of the building. The contract for making the excavations for the Times' Building was awarded to the contractors for this section of the subway, and they continued operations from the bench already formed by the subway trench. The sides of the excavation were enclosed by a protecting fence and a fixed cableway with a span of about 300 feet was installed to handle the spoil. It had timber towers about 30 feet high, one of them being located near the south curb line at Broadway and Forty-second Street and the other at Forty-third Street, where there was a Lambert engine to operate the trolley and hoist. There were also provided three stiff-leg derricks with 40-foot booms at different points on the long sides of the excavation. One of them had timber sills framed together, was mounted on double-flange wheels rolling on track rails and was moved from place to place as the work demanded. The others were stationary, and all of them remained at street level, and, with the cableway, handled all of the excavated material and part of the supplies which were later used in the building work. Each derrick was operated by a double-drum Lidgerwood hoisting engine with swinging gear.

The surface of the rock was irregular, but nearly horizontal and reached almost to the street level. The rock itself was in some places soft and rotten and in others hard, and had many cracks and fissures filled with wet greasy material. The strata were inclined downwards from the east to the west at a slope of about three vertical to one horizontal, which caused nearly all of the east side of the excavation to slide into the pit as fast as the rock was removed, thus carrying that wall back to the natural slope and widening the excavation beyond the desired limits. The rock was excavated west and south from the subway trench over the whole area of the building and then the remainder was taken out in two more deep benches working from the broad south and northwards towards the point of the triangle.

The north, south and west walls were easily maintained approximately vertical, and the lower part of the east wall was vertical to a height of 5 to 10 feet above the bottom of the excavation. Some attempt was made to shore up the loose rock on the east side, but generally it slipped down into the pit as soon as the supporting rock was blasted out. At the southeast corner where the south wall of the pit helped to retrain it, a portion of the east wall was held up by shoring, but nearly all of the remainder of the east side slipped into the excavation, and in one place did some damage by undermining and breaking a 20-inch water main which flooded the pit to a depth of about 26 feet. This was shut off and capped on both sides of the excavation, so that it was dead while the remainder of the work was in progress. The rock was excavated to a level bottom about 55 feet below the surface of the street. It was drilled by twelve or fourteen Rand and Ingersoll-Sergeant machines, which were operated both by steam and by compressed air. Blasting was done with small charges of dynamite, and such care was taken to protect life and property by covering it with timbers and rope mats before the charges were fired that no accidents resulted.



Times Building: Subway-Construction at Right, Retaining Walls and Waterproofing in Progress.

About 25,000 cubic yards of rock were excavated. The rock fragments were removed in one-yard and one and one-half-yard steel buckets and one-yard steel and wooden scale boxes, which were handled by the derricks and cableway, and were dumped on four timber platforms elevated above street level, so that wagons could drive under them. These platforms had a nominal capacity of 2 or 3 cubic yards of material, but were not used for storage. They served more as chutes or hoppers without controlling gates. The wagons, about twenty of which were employed, were driven under them and received the rock directly as it was dumped from the buckets and scale boxes. If the contents of the buckets were not sufficient to fully load the wagon, enough material could be added from the platform to complete the load. Some of the rock was taken to the contractors plant on Forty-second Street and crushed for concrete to use in the subway. Some of it was used for building masonry piers on top of the subway roof to support the street-car tracks and for back-filling around them. Some was used by the contractors for a railroad embankment on the Hudson River and much of the sound hard rock was left in the pit for use in the concrete and back-filling there.

During the excavation considerable water was encountered and was all drained to the sewer by a Worthington pump with a 3-inch discharge. The derricks, pump, cableway engine and drills were generally operated by compressed air from the contractors plant at the foot of east Forty-second Street, which furnished air at 100 pounds pressure and delivered it to the subway machinery along this section. The working pressure at the Times' Building was usually about 70 pounds. A 150-horse-power steam boiler was also installed and was kept in service so as to be certain to afford an auxiliary power if the connections were broken or any other interruption occurred to the air pressure. Most of the work, however, was done by the compressed air. The excavation was made with an average force of about eighty men working two ten-hour shifts daily.

After the excavation was completed, the sloping face of the east side of the pit was cleared and roughly stepped, and the construction of the vault walls and cellar floor was commenced. The vault walls were of self-supporting massive brickwork 2 feet 8 inches thick at the base and about 55 feet high up to the sidewalk level. They are seated on concrete footings and carry the ends of three tiers of I-beams for the vault floors. These beams are seated in the brickwork and have pairs of very wide flange vertical angles riveted to their webs at the outer ends, so that the projecting flanges virtually form transverse diaphragms, which afford a wide vertical bearing in the brickwork. This enables these beams to act as struts and transmit possible external pressures to the main steel framework, to which their inner ends are connected.

On the east side of the building the lower part of the wall is reinforced by vertical 24-inch I-beams 3½ feet apart on centers and 30 feet long. These are built into the brickwork with their inner flanges flush with the inner face of the wall. Their lower ends are seated on the rock bottom, which was here excavated 5 feet below the cellar floor for the full width of the sidewalk vault. Concrete was filled around the bases of these beams and the foot of the wall and carried up to the cellar level, making a horizontal mass 5 feet deep and about 20 feet wide, which provides reaction for the feet of the vertical beams and securely holds the lower part of the wall. The brick work between the beams, although laid straight, is calculated to act like vertical arches and oppose a very firm resistance to the heaviest pressure which it may sustain as a retaining wall. The thrust at the upper ends of the beams is provided for by a thick floor of solid concrete with heavy horizontal beams connected with the interior columns at that level. The bottom of the excavation was leveled up with about 1 to 2 feet of 1:2:5 concrete. In it were laid 6-inch perforated tile drain pipes with open joints covered with broken stone and intended to collect the ground water and deliver it to sumps.

On the center line of the retaining walls ribs about 12 inches wide and 6 inches high were made in the top of the floor concrete or footing, so as to key the latter to the wall and prevent any danger of the wall from slipping transversely on the waterproofing, which it was feared might act as a lubricant. The upper surface of the floor concrete is covered with five thicknesses of felt and an upper layer of burlap, all lapped and laid in hot asphalt. This extends over the footings of the vault walls and is flashed up on their outer faces, where it continues to the top of the wall. The horizontal surface of the waterproofing is covered with 6 inches of concrete finished with 1-inch of cement mortar to make a smooth cellar floor. Before the vault walls were built, perforated 6-inch tile drain pipes were laid around their feet on the outside of the building and covered with loose stone to receive all water which might collect there and carry it away, so as to prevent any possibility of external hydrostatic pressure which might exert a tremendous force at this depth and would require very massive and costly construction to properly brace against it if it were permitted to develop. The drain pipes are connected at two points with cast-iron pipes, which pass through the walls and deliver into the sumps that receive the sub-floor drainage and are automatically emptied by electric pumps. These pumps now discharge about 4,000 gallons daily and the water is apparently of such good quality that an analysis will be made of it, and it may be found possible to make use of it instead of discharging it to the sewer as is at present done.

Above the drain pipes the space between the outer face of the vault walls and the irregular or stepped sloping face of the excavation was back-filled with a solid mass of rubble masonry laid up in cement mortar. The inner vertical sides of this masonry were faced with 4 inches of brickwork, which afforded a smooth surface on which the waterproofing was carried up as the work advanced. The back-filling was built simultaneously with the inside brick walls, and the top of it was kept a few inches higher than that of the brickwork to facilitate the application of the waterproofing.

The bricklayers worked on ordinary timber scaffolds carried up along the interior faces of the walls, as shown in the accompanying illustration. Bricks and mortar were delivered to them from the street level by means of ordinary hod elevators in wooden towers, which also served to deliver the broken rock from the bottom of the pit for use in back-filling. About 500 cubic yards of concrete was required in the substructure of the building. A portion was mixed by gravity mixers, but most of it was mixed by hand at street level and was delivered to the bottom of the pit through a wooden chute at the north end. All concrete was made with Atlas or Vulcanite cement, which was also used for the 1:3 mortar for the rubble masonry. The sand and cement for the mortar was mixed dry and supplied in bags by the cement company, which delivered it several times a day. This did not materially reduce the work at the site, as it had to be tempered when used, but was a provision required by the architect.

All the main columns have extended-web cast-steel bases seated on two 12-inch courses of granite. These courses are made with single stones from 6 to about 8 feet square, and with the horizontal surfaces carefully dressed. The lower stone is bedded with cement mortar on the leveled surface of the hard solid rock from 6 to 7 feet below the level of the finished cellar floor. The tops of the upper courses were very carefully dressed and leveled and on them the heavy base castings were seated on pairs of wooden wedges which elevated them not more than 1 inch above the surface of the stone. The castings had accurately planed upper and lower surfaces and were adjusted to alignment and height by repeated observations with transit and level. References were made to an established bench mark, and the height of each corner of casting was very accurately measured and adjusted if necessary by the wedges to absolute uniformity, so that the top of the base should be perfectly horizontal and insure verticality in the columns, which were so tall that any deviation from a plumb line would be a very serious matter. Wooden wedges were used because if any were accidentally left under the columns no injury could result while if steel wedges were left there the loads might be concentrated on them and crack the stones or the castings.

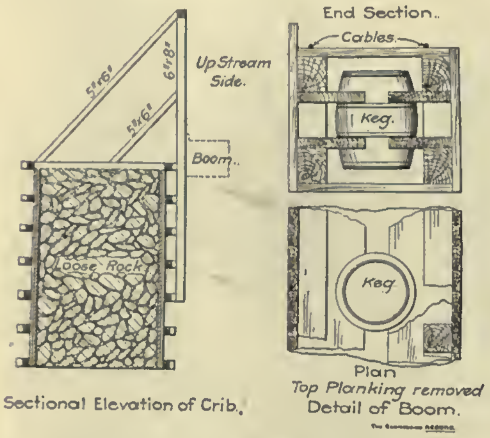
After the bases were thus set, clay dams were built around their lower flanges and the space between them and the granite footings was filled with neat cement grout. After this had set, the wedges were removed and the cavities left by them were filled with 1:1 cement mortar. The column footing stones in many instances were carried below the general level of the excavation, and the small pits in which they were set were filled with concrete which was carried up to the level of the upper course of pier stones. Here, before the column base was set, waterproofing was carried over the tops of the pier stones so that it could be connected with the waterproofing under the cellar floor and be made continuous over the whole area of the building. It was feared that if the felt and asphalt waterproofing which was used elsewhere was inserted between the columns and their footings, that the great weight of the former would practically cut it in two and invite breakages around the edges of the casting. Therefore sheets of 20-ounce copper were substituted for the felt at these points and were made of such size as to entirely cover the tops of the stone footings. They were laid directly on the dressed granite, and their edges overlapped on all sides about 8 inches on the first three courses of the feet, which was laid between the columns. The column bases were set on top of the copper and grouted as above described. Later the waterproofing was laid over the remainder of the excavation and the concrete floor was laid on it, enclosing the column bases and the base plates of the riveted columns.

Mr. Cyrus L. W. Eidlitz is the architect and the George A. Fuller Company is the general contractor for the building. The steel was furnished by the Carnegie Steel Company, and the excavation was made by the Degnon Contracting Company, Mr. H. C. Sanford, chief engineer, Mr. E. A. Herrick, superintendent, and Mr. W. C. Briggs, resident engineer in charge. Mr. L. R. Barras and Mr. George Moyer were the superintendents successively in charge of all the construction and erection.

(To be continued.)

Floating Boom at the Eagle & Phenix Mills, Columbus, Ga.

Across the intakes to the water wheels of the Eagle & Phenix Mills, at Columbus, Ga., there is an interesting type of floating boom. The water-power development for this industrial establishment has been successively enlarged to provide power for additional mills erected from time to time. There are as a result a number of independent plants, but the intakes to them are now arranged for the greater part side by side at the end of a long dam extending across the Chattahoochee River. This river is one subject to frequent and considerable changes in level and also carries a considerable amount of debris. A boom to divert logs and floating trees and the like from the intakes was quite necessary and the form shown in the accompanying engravings has been in use.



Floating Boom and Supporting Crib.

The boom is of timber construction, as shown, made buoyant by the use of kegs placed within it at intervals. The main timbers are 7x9 inches in section, the horizontal planking holding the kegs is 2½x16 inches in size, and the whole is surrounded by 2-inch planking. The boom is submerged very nearly to the top, so as to prevent logs, for example, from diving underneath it, and the downstream sheathing of the timber extends some 6 inches above the general top to act as a shield or barrier for catching drift and trash which may be thrown or hauled upon the top of the boom. The top of the planking of the boom serves also as a walk by which the man in charge may get from one end of the boom to the other and lift up the collected debris upon it. From time to time this is cleaned up and carried to the end of the boom at the dam, where it can be carried off by the current of the river.

The boom has a total length of 300 feet and is supported in its position by three cribs filled with loose rock and spaced 72 feet apart on centers, against which it slides up and down with the changes of river level. It is further fixed by two ⅝-inch steel cables which are fastened at intervals to the top flooring of the boom, as shown in the cross-section drawing. At the shore end these cables are anchored to the top of the wall and drop to the boom, in the manner indicated in the photograph, and at the outer or dam end they rise vertically to a pier at that point, where they are counterbalanced or held in tension by means of weights. This arrangement provides for keeping the cables taut with the periodic rise and fall of the boom. The general construction of the rock-filled cribs is also shown, together with the vertical posts against which the boom presses. They are about 11x14 feet in plan. The boom extends outward from the shore wall at an angle which is greater than that which would bring it in a straight line to the near end of the dam. At a point about 210 feet from the wall it has a flexible bend, in a horizontal plane, the flexibility being furnished through the two steel cables fastened to the top, and the remaining 90 feet lie in a straight line to the pier at he end of the dam. The use of the flexible bend gives the boom a capacity to adjust itself in position with respect to the shore and dam and crib supports, where a more rigid arrangement would be unsatisfactory in a river that becomes as torrential as does the Chattahoochee.

The Louisville Filters.

As considerable interest has recently been shown in the probable date of the completion of the water purification system at Louisville, Ky., it is of interest to note that President Charles R. Long of the Louisville Water Company has recently reported on the subject to the Board of Aldermen. He fixes the date for the completion of the works at June, 1905, and explains the reason for the remoteness of the time when the city will receive filtered water as follows:

On May 25, 1903, this company placed an order with the Holly Manufacturing Company for two 24,000,000-gallon triple-expansion pumps, six boilers and a crane, to be ready for operation in March and June, 1905. This work "requires a longer period of time for completion than any other work yet to be done to complete the entire filter system, and hence the data to base the commencement of supplying the city and citizens with filtered water rest with the progress to be made by the Holly Manufacturing Company, and it is reasonably expected that said company will perform the conditions of the contract, and filtered water will be supplied the city in the summer or fall of 1905, and the work finally accepted by the company in the summer or fall of 1906. The work of constructing the pumping engines, batteries of boilers, etc., by the Holly Manufacturing Company is progressing satisfactorily at their plant in Buffalo, N. Y."

The foundations for the pumping station were delayed by cold weather, but it is expected that they will be completed early this spring. The coagulant building and the filters, except in some minor details and connections, and the clear-water basins and filter-house buildings, have been finished. The pumping station building and the standpipe have not yet been placed under contract.

On February 13 Mr. Charles Hermany, chief engineer and superintendent of the company, took frequent samples of the effluent from the company's experimental filter, which was working with the muddiest raw water ever experienced in the company's history. His report on the results is as follows:

"The experimental filter has been constructed and is being operated to conform to these two cardinal requirements; that is to say, it has a sand area of 3.3 square feet, through which the water is filtered uniformly at the rate of 7.5 gallons per minute, which is equivalent to a rate of 142,320,000 gallons per twenty-four hours per acre of sand surface. This rate of flow is continued until the available head on the filter (12 feet) has been exhausted, when more head is required, filtering is suspended, and the sand layer is washed. The filtering might be continued for longer periods between sand washings with satisfactory quality of effluent and considerable reduction in volume of wash water and weight of alum, but the volume of effluent would fall in rate per acre per twenty-four hours, therefore not meeting the second cardinal requirement; in brief, the filter has been operated longer than within the limits that meet the two cardinal requirements jointly.

"The filter, when being operated as above stated, nearly invariably gives a brilliant effluent; and when the effluent is not brilliant it is in no way objectionable in appearance or taste. As to the extent or degree of bacteria removal, I am not able to make any statement, except to say that I think it will be found that when the Ohio river water has been coagulated with the use of alum, filtered and clarified, it will be found bacterially to be satisfactory.

"The filters in process of construction for the Crescent Hill station are three in number, the sand area of each being one-tenth of an acre, and the rate of filtration by them, based upon the yield from the experimental filter, would be, for each, 14,232,000 gallons per twenty-four hours. Assuming that the filters would have to be out of service four hours (one-sixth of the time) in each twenty-four hours for washing, the yield would be five-sixths of this 14,232,000 gallons for each filter; that is, 11,860,000 gallons, which multiplied by three will give a yield of 35,580,000 gallons per twenty-four hours at such times as the water in the river is of the worst quality, such as we are having now and have had for a week past.

"I claim, therefore, that it is physically a logical conclusion, and in business a safe proposition to say that the filters in progress, which are being constructed upon the same principle that the experimental filter has been constructed, will give the same results in their practical operation as regards quality of the filtered water and the estimated greater volume."

The Pavements of the City of London consist principally of compressed asphalt, creosoted deal blocks and Australian jarrah wood blocks. In January, 1903, a standing committee of the borough councils, known as the Metropolitan Paving Committee, was appointed to collect and distribute information relating to paving materials and methods, life, wear, cost, maintenance and suitability, not only for the city proper, but also for the various metropolitan boroughs.

Notes on the Water Supply of London, England.

In 1902 an act of Parliament provided for the apointment of a Metropolitan Water Board to take over and operate the works supplying Greater London with water. Hitherto London has been supplied by private water companies, eight in all, most of which have been in existence for over a century and one of them for over three centuries. Since the comparatively recent appointment of the Board, negotiations have been in progress for the acquirement of the ownership of the various works by the Board. Final awards in the cases of seven companies have been made by the Court of Arbitration, and this has been made the occasion for an interesting contribution by Mr. Richard Price-Williams, M. Inst. C. E., in a recent issue of "Engineering." Some impressive facts as to the size, rapid growth and the consumption of water of the English metropolis may be drawn from this article.

At the beginning of the nineteenth century the population supplied by the eight London water companies numbered a little less than 1,000,000, a number of which the metropolis has added to itself in each of the last three decades, the addition during the last decade exceeding a million. The Metropolitan area now supplied by the companies' works comprises 535,734 acres, or about 837 square miles, the population on which, according to the last census, in 1901, amounted to 6,750,000, in round numbers, a population largely in excess of that of either Scotland or Ireland, all located within 16 miles from Charing Cross. At a constant rate of increase of 18.18 per cent. per decade, an exceptionally low rate, which applied to the decade of 1891, the population of the Metropolitan area in 1941 would reach the stupendous total of 13,000,000. The Royal Commission on the water supply of the Metropolis, of which Lord Balfour was chairman, estimated that the population would be 12,000,000 in 1941.

On this increase of population, Mr. Price-Williams makes the following comment: As regards the estimated future population of 12,000,000 in 1941, based on the late Registrar-General's prognosticated constant rate of increase, its constancy has already been discredited by the Census returns for 1901, which show a continued but much-reduced decrement in the rate of increase; it, however, strikingly makes manifest what few people fully realize—that during the last Census decade, with its still-continuing decrease in the rate of increase of population, London has in that short space of time added to itself the largest number of inhabitants on record, over a million having been added within the area supplied by the London water companies. There is everything to indicate that even with a slight continued decrement in the rate of increase, the Water Commission's estimate of a future population of 12,000,000, with its water supply requirements of 420,000,000 imperial gallons a day (the limit of the present available sources of supply), will be reached long before the year 1941.

The main sources of water supply are the Thames and Lea, a limited quantity being obtained from springs and deep wells in the chalk. The present average supply from all sources exceeds 200,000,000 gallons a day, or about 76,413,000,000 gallons annually; the supply has nearly doubled during the last 31 years, the average annual rate of increase during that period being just 2¼ per cent.—a rate which, if maintained, would again double the quantity in 31.29 years. By the end of this 31-year period, the present available sources of supply would be drawn upon for the full quantity which they are safely capable of furnishing, namely 420,000,000 gallons per day, divided as follows: From the River Lea, 52,500,000 gallons; from wells in the Lea Valley, 40,000,000; from wells in Kent, 27,500,000, and from the Thames, 300,000,000 gallons per day. For a future additional supply London looks to the mountain regions in North Wales, with their exceptionally high rainfall of over 100 inches annually.

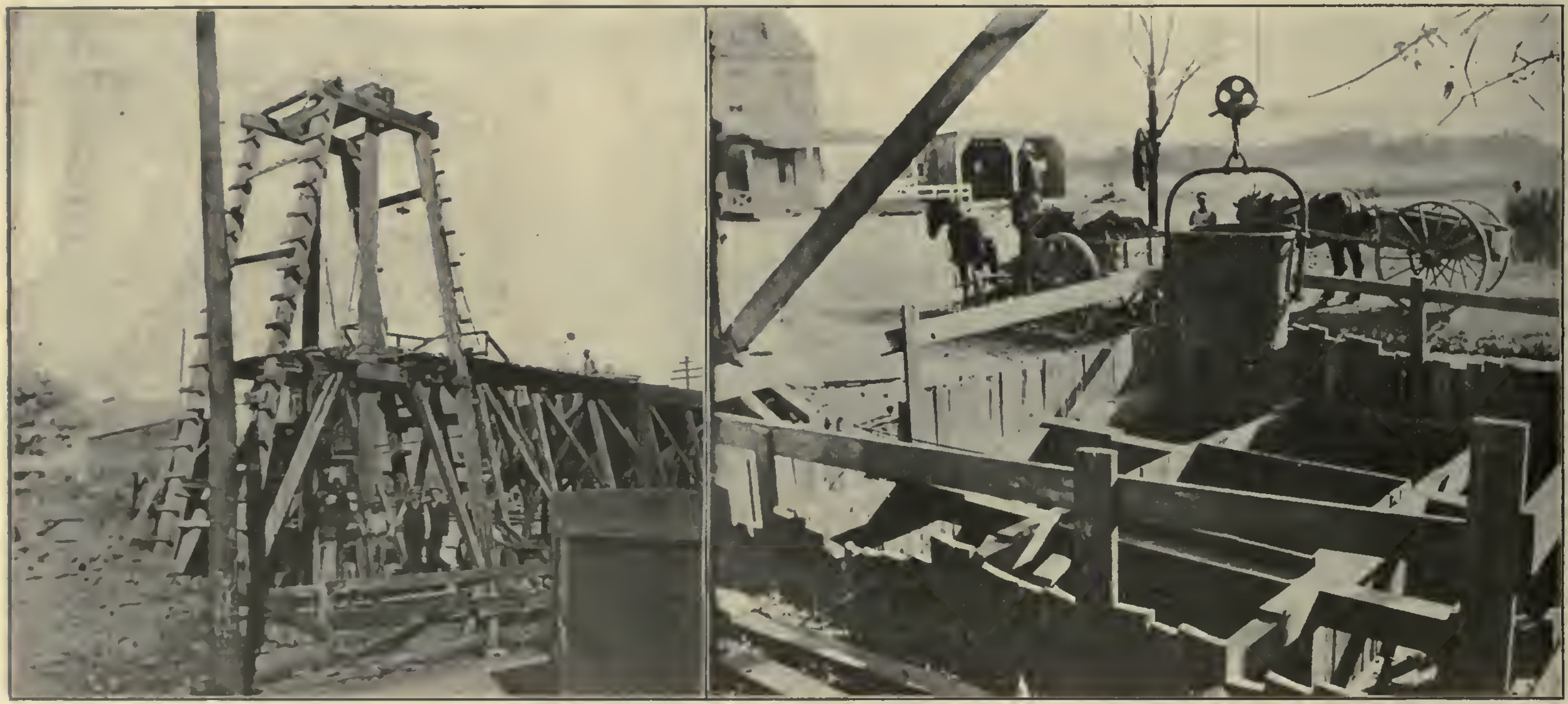
Discussing the capital and repair expenditures of the companies, Mr. Price-Williams states that the capital cost of the London waterworks and plant in the aggregate has, during the last thirty-two years, averaged 260.77l. per million imperial gallons of annual supply, and the average annual expenditure on repairs and renewals has, during that time, averaged 4.35*l*. per million imperial gallons. It follows that with such annual expenditure, the capital cost of the whole of the works in terms of per million gallons would be recouped and renewed in about sixty years. The capital in terms of per million gallons has slightly increased of late years with the rapid growth of the water traffic; but the annual cost of repairs and renewals has kept pace with it, and the average serviceable life period of the operative works has remained almost the same. But with the increased cost of repairs and renewals, the operative works have not only been maintained in a state of efficiency, but have been replaced, when their serviceable life periods have been reached, by others of a more durable and powerful type.

That water purveying in London has been a profitable business is made evident by the figures relating to income and expenditures. The average water supply charges throughout the entire Metropolis for domestic and other purposes are by no means excessive, and amounted in 1902 to only 8.076d. per 1,000 gallons, while the average cost to the companies amounted to 3.770d., leaving a balance of 4.306d., equivalent to just 60 per cent. net profit to the water companies, which largely contributed to make up the 10 per cent. dividends which many of the companies have been paying on their ordinary stock for many years. The secret, in fact, of their great financial success has been the exceptionally low but fully adequate cost of the water companies' working expenses, which, taken in the aggregate, have never yet during the last thirty-two years exceeded 48 per cent. of their receipts. The expenditure in the case of the Chelsea and Kent Companies have, during that period, only averaged about 35 per cent. The smallness of this full and sufficient working expenditure strikingly contrasts with the present 61 per cent. average railway working expenditure in England, whereas in former years 50 per cent. used to be regarded as a maximum.

Floating Boom at Columbus, Ga., Showing Cribs and Cables.

Extensions of Brooklyn Sewerage System; Ninety-Second Street Trunk Sewer.—I.

The Ninety-second Street sewer is one of the important new trunk sewers now under construction in the Borough of Brooklyn, New York City, which were mentioned in the article on the extensions of the Brooklyn sewerage system printed April 16. It will drain a territory of about 1,904 acres area in the extreme southwesterly part of the borough, including the Bay Ridge and Fort Hamilton districts, and will discharge storm water and house sewage into the part of New York Bay known as the Narrows, between Long and Staten Islands. This sewer is almost wholly in tunnel, with 16-inch brick lining, 10, 10½ and 11-feet in internal diameter, and has a total length of 6,342 feet, extending under Ninety-second Street from Eleventh Avenue to the bulkhead line at the water front, piercing a low ridge with a summit elevation, on the line of Ninety-second Street, of about 83 feet above datum, which is mean high water in the bay.



Brooklyn Sewers: Head House at Shaft Number Two; Method of Sinking and Timbering Shaft Number Three.

At the bay front the shore rises abruptly as a bluff to a height of nearly 50 feet above mean high water, and beyond the face of this bluff for a distance of about 240 feet out into the water, to a point where the depth of water is about 15 feet below mean high tide, the sewer is to be supported on piles driven into the hard gravelly bottom. This portion of the sewer is to be of special construction, of brick and reinforced concrete. The strong prevailing currents passing the outlet will carry the sewage rapidly into the lower bay, and the dilution will be so great that treatment will be unnecessary.

At the inland end of the portion of this trunk sewer now under construction, a brick bulkhead is to be built, which can be removed whenever it becomes desirable for the purpose of extending the sewer. Two more sections of this sewer extending farther inland have been contracted for, but active construction has not yet begun on either section. The total cost of all three contracts will be somewhat over $1,021,800. At the inland end of the portion under construction the street surface is about 39 feet above mean high water and the invert of the sewer is just at datum. The elevation of the invert at the outfall is —4, thus giving a total drop of 4 feet in 6,108 feet, which makes the grade which is uniform, .00065488.

The maximum depth of the finished tunnel invert is about 85 feet, and the minimum depth, at the upper end, is about 38 feet below the present surface of the ground. This necessitated very deep manholes, and consequently they are spaced farther apart than is the usual practice in Brooklyn, as explained in the preceding article. The maximum distance between two consecutive manholes is 900 feet, this stretch spanning the crest of the ridge; the maximum depth is about 83 feet. There are eleven manholes altogether into the tunnel, four of which are shafts for construction purposes. Besides these there are to be three manholes in the outlet.

In plan the sewer is not straight, since it follows the street, which has one bend and two offsets in the part under consideration. The tunnel passes the bend, which is a deflection of about 30 degrees, at a point 630 feet from the outlet and of the sewer, by a curve of 100 feet radius. At Third Avenue, about 2,600 feet from the outlet, the parts of Ninety-second Street on opposite sides of the avenue are offset about 100 feet and have a difference of direction of about 17 degrees. This change of direction is overcome by a reverse curve having radii of 100 feet. At Seventh Avenue, about 5,900 feet from the outlet, there is a similiar deflection, but much less in degree, the offset being only 50 feet and the change of direction about 3½ degrees. Here the tunnel has a second reverse curve with radii of 100 feet. The two simple curves of the first reversed curve are separated by a tangent 65 feet long, and at the second place there is a tangent 60 feet long between the two curves. At each end of the reverse curves there is a manhole. These curves have been successfully constructed and present a neat appearance inside.

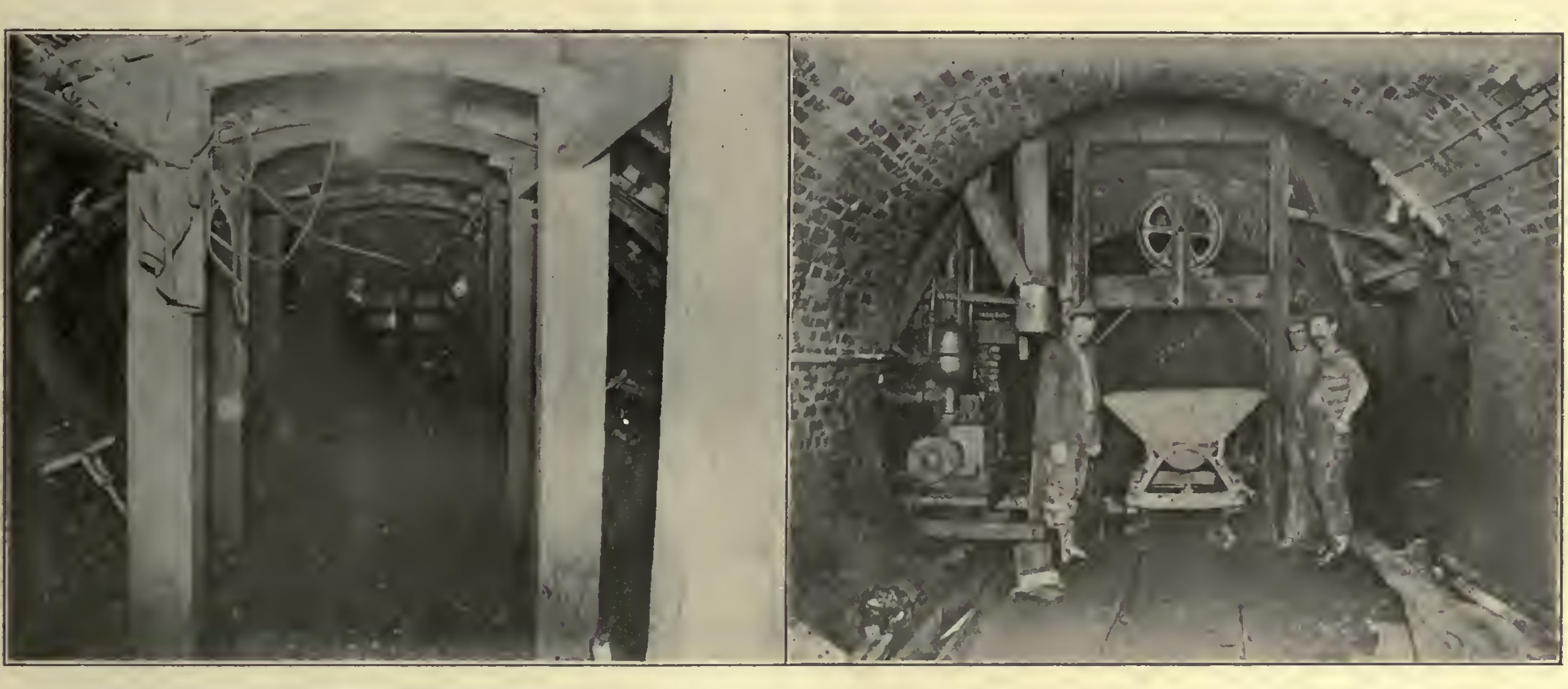
The contract for this first section of the sewer was awarded to James Malloy & Company, of Brooklyn, late in 1902, but active construction was not begun until March 16, 1903; at the present date about three-fourths of the portion of the sewer under this contract have been completed. The contractors' method of tunneling, which was devised by Mr. J. F. Cogan, one of the members of the firm, has several novel points and a number of advantages, among which may be mentioned the recovery of most of the timber used in driving the tunnel so that it may be used over and over again; the conforming of the inside of the excavation very closely to the shape and the size of the outside of the brickwork of the sewer; freer space for the brick masons to work in; the reduction of all timbers, excepting the wall plates, to sizes which can be handled by one or two men, and greater safety and rapidity of construction than can be realized with the ordinary methods of soft-ground tunneling. These advantages result in considerable economy. Some of the features of the method are indicated by the accompanying photographs and are described in some detail below.

The ground through which the tunnel is being driven is a modified drift, the material varying from a fine running sand to coarse gravel and clay. Boulders have been found in a number of places, usually about ½ to ¾ cubic yard in volume or less with a few larger ones, the maximum being about 3 cubic yards. These boulders are of hard trap rock and have caused considerable annoyance in some places. In many places there has been sufficient clay in the drift to make it a stiff material almost like hardpan, requiring picking. Most of the material, however, has been easily shoveled and has usually required close boarding at the breasts of the headings.

The principal difficulty has been caused by water, as much as 500,000 gallons per day on an average having been pumped at times from the open portion of the tunnel between shaft No. 2 and the bluff. In other places, however, one or two Edson diaphragm pumps have been found sufficient. For handling the larger quantities of water Cameron steam pumps and sinking pumps have been used exclusively. In some places it has been necessary to use two 8-inch pumps. One interesting pump installation was found in the tunnel about 800 feet from Shaft No. 2, being supplied with steam from a boiler at the head of the shaft. The steam, at 80 pounds pressure at the boiler, is conducted through a 1½-inch bare wrought-iron pipe to within a few feet of the pump, where the pipe is reduced to ¾ inch for connection to the pump, the steam end of which is very small. The duty of this pump is very light, the purpose being to draw the water from the sump in the heading and discharge it at a convenient point into the drain in the finished portion of the sewer leading to the sump at the foot of the shaft. The suction of this pump is 5 inches in diameter, and when seen by a representative of this paper was about 100 feet long. The lift was only about 4 feet and the discharge pipe into the drain was not more than 4 or 5 feet long. The exhaust steam was turned into the discharge pipe and so thoroughly condensed by the very cold water that no vapor was noticeable anywhere about the pump. The exhaust steam of all the other pumps used underground is turned into the suction pipe close to the pump. Mr. Cogan has used this method for four or five years with excellent succes, and it has the decided advantage of keeping the air of the tunnel free of vapor.

In the system of tunneling used all the timber, excepting the poling boards or lagging above the springing line and the cradle below the springing line, the wall plates and the short props or posts supporting the wall plates, is removed as the brickwork is built and is available for further use. The heading which includes very nearly the upper half of the sewer is taken out first and then the bench is excavated and the bottom prepared for the brickwork in lengths of 16 to 25 feet, according to the nature of the ground. The miners first drive an adit in the center of the top of the heading and set pairs of 6x8-inch posts 7½ feet long 4 feet apart in the clear on 6x12-inch sills placed transversely to the tunnel axis, the pairs of posts being spaced about 4½ feet on centers longitudinally. The tops of these posts are beveled, as indicated in one of the pictures, and on top of each pair is placed a ring of angle irons to serve as a cap.

These caps are made up of two 3½x3-inch angles placed back to back to form a T-shaped section. Each cap is made in three pieces, the middle or crown piece being 8 feet long and the two side pieces each 6 feet. The pieces are connected by fish plates of angle irons, with four bolts at each joint. The caps are curved so that the radius of their top flanges is slightly greater than that of the outside of the sewer brickwork, the radius in the 11-foot portion of the tunnel being 14 feet, while that of the outside of the sewer is nominally 13 feet 8 inches. The vertical leg of the cap fits into a slot cut into the top of each post, and four lugs riveted to the vertical leg bear against the inside faces of the posts, thus holding them apart at the top. Poling boards are inserted over the top of the cap and driven forward as the work advances. Side boards are placed against the backs of the posts, if necessary, and usually one or two such boards are used as a matter of precaution, even in stiff earth.



Brooklyn Sewers: Top Drift Showing Temporary Posts and Steel Caps; Bottom of Shaft Showing Timbering, Pumps and Cage.

Following the adit in the center of the heading, the material at each side is removed and the lagging carried down to the proper level for placing the wall plates, the lower boards being carried out from the circle of the sewer so that the wall plates may be placed inside of them. The wall plates are placed with their tops 1 foot below the springing line, and are set very accurately to grade and so that their inner faces will be just outside the brickwork. The wall plates are 8x10-inch timbers 16 to 25 feet long, depending upon the nature of the ground, and, in order to place them, a trench is dug at each side of the bench. In firm ground the plates have sometimes been placed directly upon a ledge cut in the earth, using only such wedging and blocking as may be necessary to bring the plate exactly to grade and give it a firm bearing throughout its length. Usually, however, short posts or props of round timber have been placed under the plate by digging small pockets, these props being set under the frames of permanent timbers. These props, however, are not placed until after the frames of timbers resting on the plate have been set.

As soon as possible after the wall plates are set, the frames of segment timbers, as they are called, are set upon them close to the temporary bents of posts and angle-iron caps just mentioned. The frames of segment timbers each consist of three pieces of 10x10-inch spruce, a horizontal or cap piece and two inclined pieces, the abutting ends being beveled to make the miter joint. The lower ends of the inclined pieces are cut to a uniform bevel and are set on wedge blocks on the wall plates. All the segment timbers are cut to exact size in the contractors' shop and any inequalities due to slight inaccuracies in placing the plates or doing other parts of the work are made up by driving small wedges between the wedge block and the wall plates. These frames are placed 4½ feet apart on centers and are designed to come inside the finished brickwork, excepting the lower ends of the inclined pieces resting on the wall plates. The brickwork is built around these ends, and, when the arch has been completed, the timbers are removed and the holes thus caused in the brickwork are filled. These holes, it will be perceived, come very near the springing line and consequently do not materially weaken the structure. By toothing the work at these places the holes are so neatly and solidly filled as not to be readily noticeable.

As soon as a frame of segment timbers is placed,, small timbers cut to fit approximately the inside of the lagging are placed in position directly over the segment timbers, carefully plumbed and thoroughly braced from the segment timbers by radial braces, which are wedged so as to take all the pressure of the surrounding earth, thus permitting the temporary posts and the steel caps to be removed. These secondary braces and timbers, as they may be called, set on the segment timbers, are removed piece by piece as the brickwork is carried up. Some apprehension was felt at first that these secondary braces might slip longitudinally under the roof load, but no such movement has been detected. At the middle of the horizontal segment timber the upright braces on top of it are far enough apart to leave abundant room for the brick masons to work in when keying the arch.

The weight of the roof having been taken on to the segment timbers and being transferred through them to the wall plates, the bench can be removed without interfering with any of the permanent timbers. Just before excavating the portion of the bench remaining between the side trenches, at any given point, the props mentioned above are placed under the wall plate, one beneath each end of each frame of segment timbers. Of course, both the temporary and the permanent timber bents are braced longitudinally by stretcher timbers. A small amount of settlement is unavoidable, but even in the softest ground this has not exceeded 6 inches and very frequently has not been over 2 inches altogether. Proper allowance for this settlement is made when placing the vertical posts and steel caps.

The bench excavation is completed, the bottom formed to fit the outside of the sewer and the 2-inch spruce cradling placed in lengths of 16 to 25 feet, according to the nature of the materials. The first step in preparing such a section of bottom is the digging of a sump hole to which the water may be drained so as to keep the material as sound as possible. The brick masons build the invert as soon as the cradle has been placed. The arch is built subsequently and is usually kept within 20 feet or so of the end of the invert. Since the weight of the roof is carried by the segment timbers to the wall plate, the centers for the brick arch can be conveniently set as there are fewer timbers to interfere than in the ordinary systems of tunneling. The centers are made of two pieces of 2x10-inch spruce, spiked together and cut to the proper radius. These centers are supported on light frames of 2-inch stuff set on the lower part of the sewer and braced in position, the centers being held by nailing them to the segment timbers. The weight of the new brickwork is transmitted to the segment timbers by blocking placed between the timbers and the lagging, so that little or none of this load goes to the frames under the ends of the centers. The centers are thus about 4½ feet apart, and in order to secure a true surface for the brickwork, 2x4-inch lagging is used. The brickwork is all laid in Portland cement mortar, for which Stettin-Girstow Portland cement has been used mostly. Alpha, Atlas and Giant cements, however, have also been used to some extent.

The plans and specifications provided for using concrete to fill the spaces outside of the required four rings of brickwork, but with the method of tunneling used, the excavation has been kept so close to the required size that the contractor has found it more convenient and economical to build the brickwork directly against the lagging or poling boards. That the method of construction is proving successful seems evident from the fact that no cracks have been detected in the brickwork thus far constructed. Furthermore there have been no accidents chargeable to the method; two men have been killed at the shaft, one by being struck by a plank thrown down from above and the other by being hit by the descending cage.

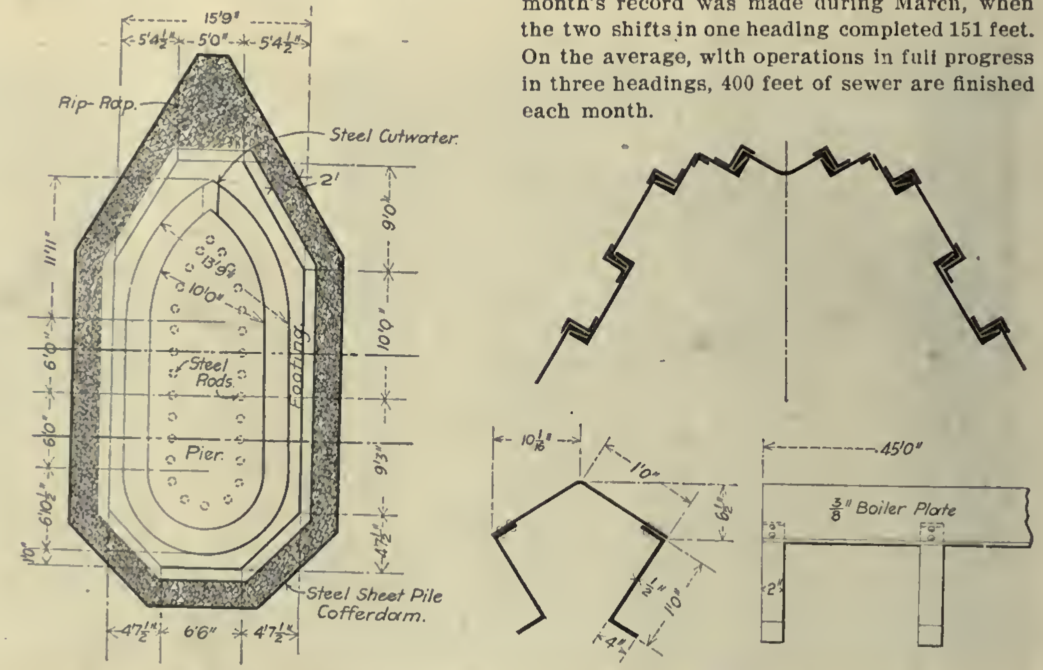
An incidental advantage of this type of tunnel construction is that is simplifies the work of giving line and grade. The center line is marked by the engineers by driving nails in the poling boards. These are tested from time to time. Grade is marked on each of the vertical posts of the temporary timber sets. The steel angle caps being bent accurately to form and having the point in the center line plainly marked on them, can thus be set exactly to position, and they determine the form and location of the sewer. To set the wall plates accurately, two carefully prepared measuring sticks and a plumb-bob line are used, the three forming the sides of a right-angle triangle, the apex of which is at the center line of the crown of the sewer and the other acute angle at the upper inner corner of the wall plate. The measuring sticks having once been carefully prepared and checked by the engineers, no measurements are left to be made by the foreman or miners, in order to determine the location of any important part of the work. Of course, as the work progresses up to the laying of the brick, the line and grade are carefully checked from time to time by the engineer's party. So far the line has been carried through very successfully, the meeting between the headings from shafts Nos. 2 and 3 being exact, and the line carried from shaft No. 1 to the face of the bluff also checked out with no appreciable error.

The shafts have been made of liberal dimensions and have been closely sheeted and strongly timbered, the only unusual feature being that the main timbering for the shafts is supported on segment timbers, and carried to the wall plates just as the roof load is supported in the tunnel. The wall plates being securely held by the invert masonry of the tunnel, this method furnishes a very stable support. The cages are operated by Lidgerwood hoisting engines. At the bottoms of the shafts and at the bottoms of the other manholes the masonry is carried to a greater depth and the invert is made with granite paving blocks. Adequate support is thus provided for the tall shaft of the manhole with its heavy load of masonry, and the paving blocks will afford better resistance to the abrasion which will be caused by the falling sewage discharged by connections to be made into the upper part of the manhole. At the manholes other than those used as shafts, the special construction at the bottom is put in as the tunnel progresses. This has required one or two special features in the method of timbering at these points. At the bottom of each manhole two or three frames of larger segment timbers are used and the roof is carried out flat, so as to provide for building up the walls of the manhole, by using two long crown bars of round timber placed parallel to the tunnel axis and firmly supported at each end on the top of the sewer arch on either side of the manhole. Over these bars horizontal poling boards are driven at right angles to the axis of the tunnel. At a convenient time a small shaft can be sunk from the surface of the street and the walls of the manhole built up from the foundation masonry previously placed.

The large amount of sand and gravel removed from the tunnel is being used for filling low places and swamp holes in lots along and near Ninety-second Street, principally. At the heading the material is shoveled into steel dump cars of either the Arthur Koppel or the Stuebner Iron Works make and hauled to the foot of the shaft by a horse or mule. The cars have been hoisted on cages at most of the shafts to an elevated trestle and then pushed by hand out to an elevated dumping board which discharges into the carts. Coarse screens of steel bars were placed in the bottom of one or two of the dumping boards so that when material containing good sand was found it could be passed over the screen, thus separating the sand from the larger stones. In this way most of the sand required for the mortar has been obtained from the excavated materials. It has been screened a second time by hand. At one shaft material is being hoisted in one-cubic-yard steel buckets and dumped into cars at the surface on a narrow-gauge track running alongside. This method, however, is used only for the work at and near the shaft; cars will be used below as the headings recede from the shaft. In the headings as soon as the brick invert is completed, excavated material is placed upon it to a depth of between 2 and 3 feet and graded to receive a track.

The tunnel is well lighted by incandescent lamps, the current for which in all of the headings is furnished from one Edison dynamo driven by a Donegan & Swift horizontal engine at the central power plant, now located at shaft No. 2. The electric light wires are carried to the other shafts on short uprights and cross-arms fastened to the tops of the poles of the street telegraph line.

About fifteen men are employed in each shift in each heading on the excavating and timbering. The total force on the work numbers about 150, including the men at the wharf, the men at the odd jobs and the brick masons. The brick masons work in two eight-hour shifts and the other laborers in the headings and at the shafts in two ten-hour shifts. In addition to their regular wages the men are paid a bonus for each foot of completed sewer built each month in each heading in excess of 90 feet. The best month's record was made during March, when the two shifts in one heading completed 151 feet. On the average, with operations in full progress in three headings, 400 feet of sewer are finished each month.



Plan of a Pier of the Cuivre River Bridge Showing Steel Sheet Piling and Cutwater.

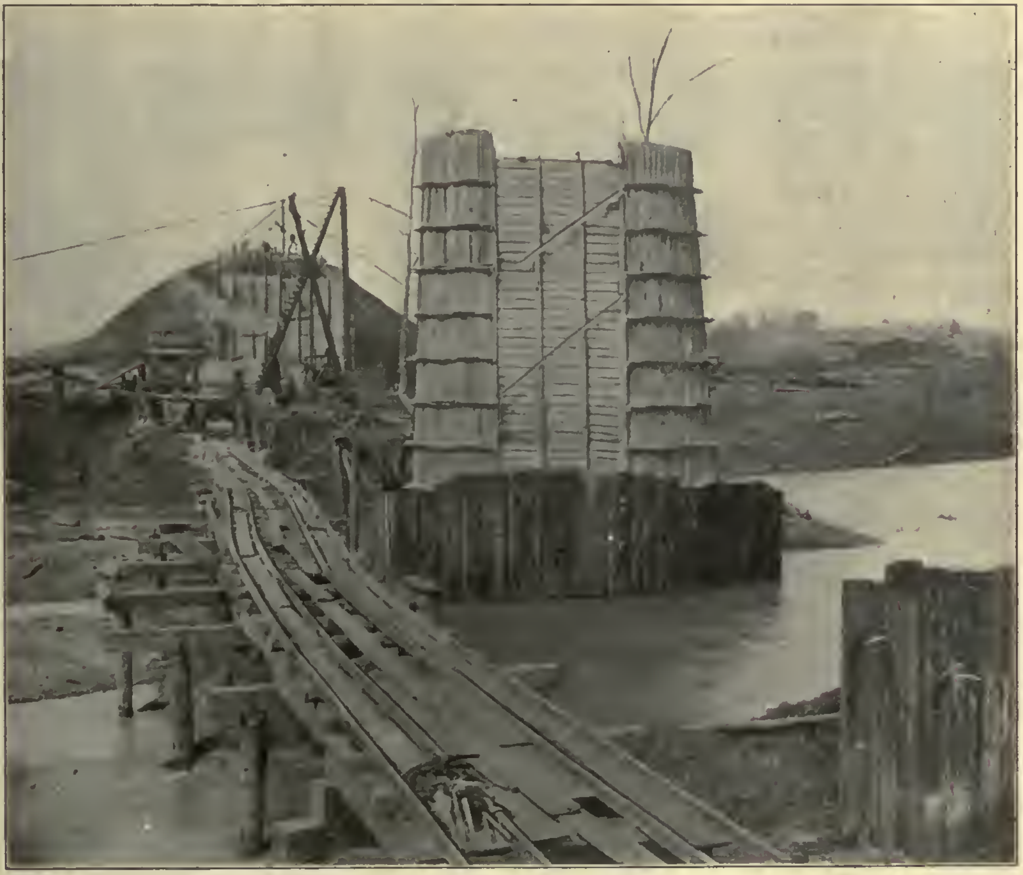
One of the accompanying illustrations shows the cage, car, pump and the method of timbering at the foot of shaft No. 2, where the diameter of the sewer changes from 11 feet to 10 feet 6 inches. Another photograph, as already mentioned, shows the first operations in excavating and timbering in the top of a drift from shaft No. 2. A portion of the head-house and the elevated track and boards for dumping materials at shaft No. 2 is shown by a third illustration, and a fourth picture shows the method of removing the materials from shaft No. 3 before the installation of the head-house. This sewer, in common with all the extensions of the Brooklyn sewerage system now in progress of construction, was designed and is being built under the direction of Mr. Henry R. Asserson, M. Am. Soc. C. E., chief engineer of sewers, borough of Brooklyn. The work was begun under Mr. William T. Bruorton as division engineer, but after his death late in December, 1903, Mr. George W. Cadmus, his principal assistant, became division engineer. Messrs. James Malloy & Company, of Brooklyn, are the contractors and Mr. J. F. Cogan, of the firm, is in immediate charge of the work.

(To be continued.)

Interlocking Steel Sheet Piles for Bridge Pier Cofferdams.

Bridge No. 6,052 carries a single track of the old Monroe-Mexico branch of the Chicago, Burlington & Quincy Railway over the Cuivre River, at Moscow Mills, about 60 miles from St. Louis. The superstructure consists of three deck 105-foot plate-girder main spans and two 70-foot 4-inch deck plate girder end spans. The substructure consists of six concrete piers reinforced with vertical corrugated steel bars. The end piers are 41 and 43 feet in height and have pile footings driven to solid rock. They rise 30 feet above the original surface of the ground and are protected by riprap slopes about 10 feet high. Two of the intermediate piers are in the river bed and two are on the banks; all of them are carried down to the foundations on the solid rock from 70 to 75 feet below the base of rail.

The two river piers are about 10 feet wide and 25 feet long on top with the upstream end pointed like a Gothic arch and the downstream end rounded to a semicircle, as shown in the cofferdam plan. There is no coping or moulding at the top, and the shaft 45 feet high batters equally on all sides to a width and length of about 14½ and 30 feet where it is seated on the top of the seven-sided footing. This footing is made in two offset courses each about 8 feet high with the sides parallel to those of the cofferdam and about 2 feet distant from them at the foot. The reinforcement bars are arranged, as indicated in plan, about 2 feet apart on centers and are parallel to the battered sides of the pier. Each rod is made in two 12-foot and two 18-foot lengths with the ends lapped to splice in the concrete and joints staggered by reversing the positions of the different lengths in alternate lines. The lower piece in each line is set vertical to correspond with the plumb sides of the footing. The cutwater is protected by a facing of bent ⅝-inch boiler plate 2 feet wide anchored to the pier by Z-shaped straps riveted to it and embedded in the concrete.



Substructure for Cuivre River Bridge: Steel Sheet Pile Cofferdams and Forms for Concrete Piers.

The shore piers are similar to the river piers except that on one side of the center longitudinal line there is a 5x12-foot concrete pedestal built up 5 feet above the top of the pier to support the ends of the shore span girders, which are not so deep as those of the river span. The land piers, between the steel superstructure and the trestle approaches, have rectangular cross-sections 7 feet wide on top, 12½ feet wide at the bottom of the footing and 33 feet long. Their ends are plumb and their sides are battered, and they are seated on the pile tops about 12 feet below the surface of the ground.

The depth of the river at the pier sites varies from about 3 to 25 feet, and is subject to sudden floods. The soil is principally coarse sand, gravel and boulders, in which it would be impossible to drive ordinary sheet piling. It was determined to build the main piers in open cofferdams constructed with interlocking steel channel piles, which were easily driven and were considered very satisfactory by the contractors. As the site was remote from any town, a commissary was established, the contractors' plant was located near it on one bank of the river and a narrow-gauge tramway was laid across the river bed, parallel to the axis of the bridge, for the distribution of materials.

Work on the two center piers was commenced by simultaneously driving the cofferdam piles. These were made of a uniform length of 30 feet, consisted of 12-inch steel channels and were of the standard Friestedt pattern. Alternate piles had 3x3x4-inch Z-bars riveted to the inner sides of the webs, forming grooves to receive the flanges of the intermediate channels which engaged them and made a continuous line with the flanges reversed in successive piles. In order to conform to the outlines of the piers, special devices were employed for connecting the lines of piles at the oblique angles. This was ingeniously effected by using the regular right-angle corner pile which gave a deflection of 90 degrees. This angle was then increased to the required amount by bending the web of one of the piles, as indicated in the detail sketch. The web could, of course, be bent with the back convex or concave and enable the angle to be easily and accurately secured.

The piles were rapidly driven without difficulty by a Vulcan steam hammer weighing 9,500 pounds. Whenever one of them encountered a stone or small boulder, the latter was deflected and the pile readily penetrated to the rock. The sheeting for one pier was driven complete in a single week. The piles were held in a sliding cross-head or guide which fitted the leads of the pile-driver and maintained the pile in the proper position. The hammer drove against a wooden cushion block with a horizontal steel bearing plate between it and the end of the pile. The first pile driven was near the middle of one of the long sides of the cofferdam, and special care was taken to drive it in accurate position and perfect vertical and horizontal alignment. Some difficulty was experienced by slight deflections caused by encountering obstructions below the surface, and in each case the pile was drawn and started in a new position until finally it was driven accurately. A guide was thus provided from which the succeeding piles were easily driven with satisfactory verticality and alignment. Care was taken in turning the angles at the corners of the cofferdam, and no trouble was found in closing the dam by the last pile, which engaged the first one.

After the sheeting was driven, the bulk of the excavation was made under water by an orange-peel bucket operated by a boom derrick. When the excavation was nearly completed, a centrifugal pump with a 10-inch discharge pipe was installed and easily drained the cofferdam. As the water subsided in it, the walls were braced in the usual way with rangers and cross struts. The remainder of the excavation was taken out dry with pick and shovel and derrick buckets. It is interesting to note that the total weight of the steel sheeting amounted to about 40 pounds per square foot of the surface of the cofferdam walls and was thus equivalent to that of solid steel plate 1 inch thick. The river carries a large quantity of sediment and the muddy water soon filled the joints of the pipes so that no calking was required between them, and the calking angles sometimes provided were omitted.

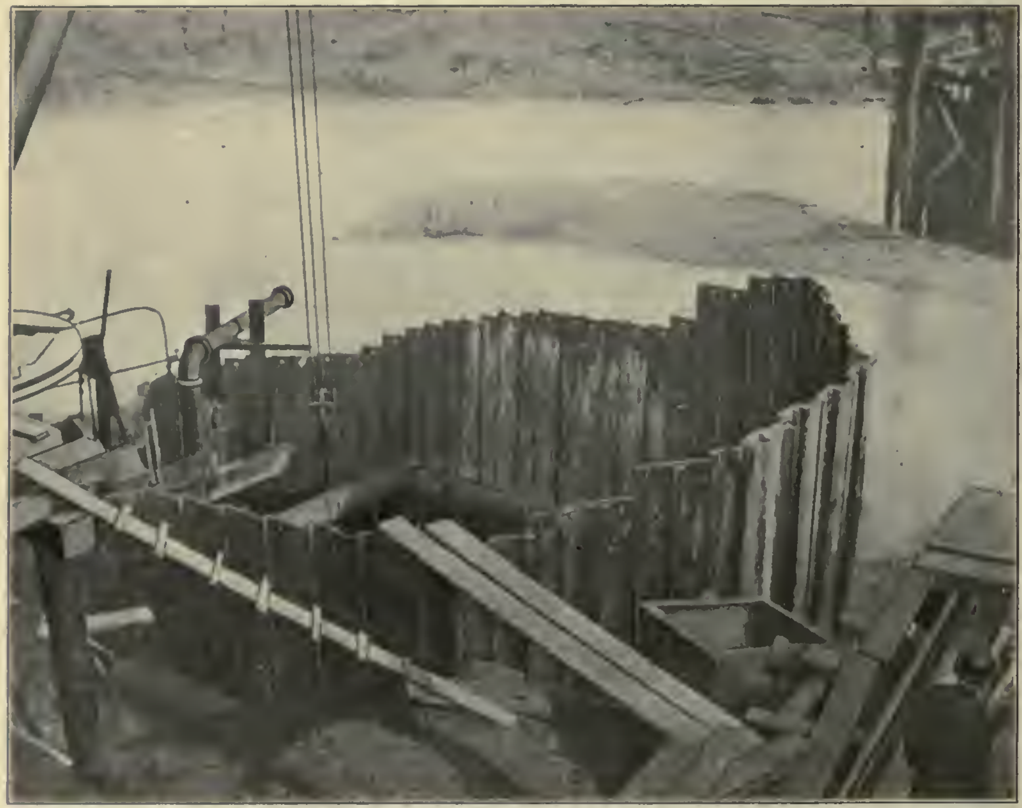
Timber forms were built in the cofferdam and were filled with Portland cement concrete mixed in an Olsen drum machine. For the bases of the piers 1,337 cubic yards of 1: 4: 8 concrete was required and for the upper portions 2,496 cubic yards of 1: 3: 6 concrete reinforced by ¾-inch vertical bars weighing 12,814 pounds. The 3,450 cubic yards of stone was crushed at the site and the 1,725 cubic yards of sand was screened from the deposit in the bed of the river. The railroad company provided 3,699 barrels of Portland cement.

After the completion of the center piers, the moulds were removed and the spaces between the concrete and the cofferdam were filled with riprap. The depth of the shore piers below the original surface exceeded the lengths of the piles and open pits were excavated to such a depth that when the piles were driven in them their upper ends projected above the bottoms of the pits. A force of about 100 men has been employed on the work for about four months, and it is expected will be able to complete it a few weeks hence. The work has been prosecuted at a disadvantage on account of the severe winter and the large quantity of ice encountered. Ordinarily the water has been moderately low, and during a part of the time the presence of the ice was advantageous as it afforded a convenient working platform. On one occasion the water raised 14 feet in 12 hours and carried off all of the ice. Another time a sudden rise of 20 feet washed out the tramway and overthrew some of the derricks, but did not occasion other serious damage.

The piers were designed and constructed under the direction of the engineering department of the Chicago, Burlington & Quincy Railway, Mr. W. L. Breckenridge, chief engineer, and Mr. C. H. Cartlidge, bridge engineer. The piers were built by the Foundation & Contracting Co., New York, under the direction of their western manager, Mr. George Adgate.

A 100-Ton Alternating-Current Crane, with two trolleys, is in use in the Los Angeles repair shops of the Southern Pacific Company. The crane, which was built by the Niles-Bement-Pond Company, is of the double-girder class, each girder having a box section and the two connected together at the ends with carriages of structural steel. Each girder weighs 17,400 pounds, the crane span is 37 feet 5 inches and the lift of the main hook is 16½ feet. Each trolley has a hoisting capacity of 50 tons and one of them is equipped with an auxiliary 5-ton hoist. Each main hoist is driven by a 50-horse-power motor, lifting the full load at the rate of 10 feet per minute or the light load 20 feet per minute; the trolleys are moved along the bridge by 10-horse-power motors, with a full-load speed of 80 feet and a light-load speed of 100 feet; and the bridge is driven by a 50-horse-power motor at a full-load speed of 175 feet and a light-load speed of 225 feet per minute. The motors are three-phase 44-volt, 50-cycle Westinghouse variable speed induction type.

The Measurement of Feed Water, according to an interesting method, is described in the Stevens Institute "Indicator," by Mr. Edwin Burhorn, who devised the apparatus for use in the Milburn Pumping Station at Baldwin, Long Island, where there were few facilities for obtaining the usual apparatus for weighing water. Only one pair of scales was available for weighing both the coal and the water. The apparatus for measuring the water comprised an iron tank 4x5x5 feet in size, provided with a 3-inch suction outlet at the bottom, which was connected to the boiler-feed pump. On top of the tank were two bearings, which carried trunnions of 3-inch pipe fastened to an ordinary oil barrel at about its center of gravity. One trunnion was closed to the barrel and the other was connected to a wrought-iron pipe, running upward inside the barrel to a point about 2 inches below the top, forming an overflow outlet leading outside of the barrel and outside of the tank. The water was led to the barrel through a pipe in its center, this pipe, when the barrel was in its normal position, standing immediately underneath the end of the water-supply pipe, and its lower end extending to a point about 2 inches above the bottom of the barrel, so that the vibration of the water level would be eliminated while the barrel was filling. A lever was attached to one of the trunnions for the purpose of tilting the barrel when it was desired to empty it into the suction tank. This lever was connected to an ordinary revolution counter, which recorded, automatically, the number of times the barrel was tipped. The weight of water that the barrel would hold up to the point of overflow at a given temperature of the water was, of course, ascertained. The barrel could be tipped, emptied and brought back into position in about 10 seconds. Under ordinary conditions the barrel could be filled and emptied once every minute, giving a total capacity of 60 barrels of 360.5 pounds of water per hour, which would make the maximum capacity of the apparatus about 700 horse-power.



Steel Sheet Pile Cofferdam for a Pier of the Cuivre River Bridge.

Timber Treatment and Timber Treating Plants.

Extracts from a paper read by Mr. Walter W. Curtis before the New York Railroad Club.

One of the important elements affecting the solution of the problem of supplying the demands of the railroads for wood in its various forms is its chemical treatment to prevent decay—and the construction of works to give such treatment as quickly and economically as possible. The old saying that a penny saved is a penny earned is certainly true when applied to the timber question. It takes about sixty years to grow a 16-inch diameter pile, of the quickest growing pine; eighty or ninety years may produce an 8x16 inch stringer of the same quality. If we can secure a twenty to thirty-year life for these sticks by treatment at reasonable cost, instead of from two to twelve years if used under like conditions untreated, we can congratulate ourselves as being of some use in the world and as being wealth products in the truest sense.

Creosoting in this country dates from 1865 and has been principally used for the treatment of piles and timber for marine work, to prevent destruction by worms. While a considerable number of ties have been so treated, the expense has been and still is too great to permit general use for this purpose. Creosoting is by all means the best method of preserving timber known, and wherever the financial conditions are such as to permit the first cost, and where the timber will not be destroyed mechanically regardless of its freedom from decay, there can be no question as to the best treatment to adopt.

Various methods of seasoning wood have been patented. Seely in 1867 was granted a patent on a method of impregnating, consisting of immersing the timber in an iron tank filled with oil, heating it to drive out moisture, replacing the hot oil suddenly with cold oil, whereby it is forced into the wood by condensation. A patent to Hayford in 1872 added to the use of steam for seasoning, the pressure of hot air, to prevent the checking of the timber by the more rapid seasoning of the exterior portions of the wood. S. B. Boulton, in 1881, patented a method of seasoning by boiling the wood in the dead oil of coal tar, keeping the pressure in the cylinder below atmosphere, to permit the water to be removed at a lower temperature than 212 degrees Fahrenheit. A patent to Messrs. Curtis and Isaacs, of the Southern Pacific Railroad, was granted in 1895, covering a process identical with Boulton's, except that they do not use the vacuum during boiling.

The philosophy of both is that as water is vaporized at 212 degrees, while the oil does not vaporize under 300 degrees, a temperature maintained between these will drive off all the water, which can then be replaced with oil by pressure. Both of these methods have been used in this country with success.

Preservatives for timber are needed to prevent decay and to prevent destruction by marine worms. As under ordinary conditions, untreated timber will resist decay for a considerably longer period than it will a hungry teredo family, and as the amount of timber used on land and in water differs very materially, the use of treated material for marine work made more rapid and general progress. It was soon recognized that no treatment would avail against the teredo and limnoria, except a large injection of dead oil of coal tar. Treating works naturally sprang up to supply the demand, located along the sea coast and Gulf line.

These plants doing commercial work principally, orders were placed only at the time the material was needed, which necessitated the use of green timber and, I believe, few if any of these plants have yard room sufficient to store any considerable supply of material. The use of such green stock results in a much longer treatment being required.

From eighteen to twenty hours are required to secure the same penetration as is possible with ten or twelve hours if air-seasoned material is used, the difference being principally in the length of time spent in steaming the timber. If the English and Continental practice of long-time seasoning is followed, requiring storage for from eight to twelve months, the steaming is eliminated entirely and the time of treatment is cut down to about three hours.

The use of creosoted material is now becoming more general for an important purpose, which promises a large market; this is for decked trestle bridges, where the ballasted track is carried directly over the structure. Two types of such structures are in use; one where the deck is of solid timber, constituting the stringers and floor of the structure; the other, where separate stringers are used, covered with a 3-inch plank floor.

Mr. E. B. Cushing, engineer of Maintenance of Way of the Atlantic system of the Southern Pacific Railroad, states that road began using solid deck creosoted bridges in 1885. "The first one built was examined recently and found to be in perfect condition. It has never had a dollar's worth of bridge work on it since it was driven, the surfacing, aligning, etc., being done by section men in ordinary process of track work."

The other type of bridge, using stringers and a plank floor has been in use on the Louisville & Nashville Railroad for many years. Mr. R. Montfort, chief engineer, recently wrote:

"I cannot state the length of life of creosoted timber where properly treated. I can, however, say that during the year 1876 the New Orleans, Mobile & Texas Railroad used a large quantity of creosoted timber as piling for piers of iron bridges over Chef Menteur, Rigolets, Pearl, West Pascagoula and East Pascagoula rivers. We are now renewing the superstructures of these bridges; replacing bridges erected by the Phœnix Bridge Company in 1876 with plate girders. At the Great Rigolets we have placed the new superstructure on the piles driven in 1876. Some of these piles are as much as 95 feet long. At Chef Menteur we used seven piers, each consisting of sixteen piles, or a total of 112 piles, not one of which was found defective, although driven twenty-eight years ago. In this climate an untreated pile could not be counted on to last but about seven years, or at the most eight years. The piles at Chef Menteur vary from 75 feet to 90 feet in length.

"We have on the Louisville & Nashville Railroad miles and miles of trestles with creosoted stringers that were placed in 1876 and 1878, and are apparently as sound now as they were then. These trestles have, of course, been strengthened by the addition of other stringers so as to carry modern loads."

As between such structures and metal ones, with open floors, the preference would seem to be with the perishable material, wood, provided proper precautions are taken against fire from beneath the structure. To be perfectly safe, however, the combination of steel girders and creosoted wood floor carrying a ballasted track furnishes the best possible structure where masonry is not justified. For elevated tracks over streets, the use of the wood floor is in my judgment decidedly superior to any other construction. This has been used successfully for such locations, the floor being made water-tight by caulking and pitching before the ballast is put on.

The greatest demand, of course, of the railroads on our forests is for ties. A perfect preservative must be a germicide, which is insoluble in water, non-volatile under usual temperatures, preferably an excluder of air and water, and cheap. In the dead oil of coal tar we have the first three elements, and the fourth to a considerable degree. By the usual methods of injection, it cannot be called cheap, except in consideration of its ultimate economy through long life. The life secured from the ties thus treated varies pretty closely with the amount of preservative used.

Creosote in America is worth about one cent per pound, delivered at the works. The cost of the ties treated depends upon the amount injected. In Great Britain they use from eight to ten pounds of oil per cubic foot of timber for Baltic red wood; in France and Germany, for beech and pine, from 10 to 20 pounds. On the basis of 10 pounds per cubic foot, a tie containing 3 cubic feet would cost here for oil alone 30 cents. The usual charge made by treating works for labor, fuel, profit, etc., is from $5 to $7 per 1,000 feet, board measure. This adds to the cost of oil 20 to 25 cents. The cost of a 12-pound treatment would be about 15 cents per cubic foot. The cost of burnettizing is about 3¾ cents; of zinc tannin, about 5 cents, and of zinc creosote, about 7.5 cents per cubic foot.

The high cost of creosote accounts for the many efforts to secure the same results with other materials, or with combinations with other materials which will reduce the amount of tar oil required.

One way of doing this is to put in less oil alone, but the trouble is that the injection is then superficial and any checking of the timber or wearing under the rail destroys the protection, permiting access of air to the unprotected center and early decay. The Southern Pacific Railway made a test in 1895, in West Texas, where 1,694 sap pine ties were impregnated with 6 pounds of tar oil per cubic foot, and laid in track with the same number of untreated ties of the same character. After five and one-third years service, not one of the creosoted ties had been removed, while 16 per cent. of the untreated ones had been taken out on account of decay. Unfortunately no later reports have been made on this experiment.

The principal objection to the processes using zinc chloride, sulphate of copper and other mineral salts is that such salts are all more or less soluble in water; some of them indeed hygroscopic. They are effective germicides, and as long as they remain in the wood in sufficient quantity will prevent decay. It will probably be admitted that the injection of any antiseptic, which at the same time has no directly injurious effect on timber, is beneficial and in proportion to its antiseptic power and its difficulty of removal. The solutions containing metallic salts are more readily injected than oils, and it has consequently been attempted to use them in conjunction and various methods have been patented for this purpose. Mr. J. B. Card, who introduced the Wellhouse treatment, proposed a method of first injecting a small amount of tar oil, then immediately thereafter injecting a solution of zinc chloride. He stated that by this means he secured a much better distribution of the oil throughout the wood than was possible with the ordinary injection of the same amount of oil, and at the same time thoroughly protected the interior of the stick with the zinc chloride.

In Germany a method has been used for a number of years in which the solution of zinc chloride is mixed with tar oil and the two injected at one time into the timber. This method requires for its success a very light grade of oil difficult to obtain and of high cost, and there is some discrepancy in the reports of observers as to the uniformity of injection in ties occupying varying positions in the cylinder, the tendency being, of course, in any such mixture for the oil and water to separate on account of their varying specific gravities. This method, however, has given satisfactory results in practice and is undoubtedly an improvement over straight burnettizing.

Mr. Boulton has patented a method of first injecting the zinc chloride, then running out this solution and filling the cylinder with tar oil, boiling the timber in this until the desired amount of water of the first solution has been removed, and then injecting under pressure the desired amount of tar oil.

In April, 1894, the Southern Pacific laid in Western Texas 1,824 sap pine ties, which were given an injection of 12 pounds of 2 per cent. solution of zinc chloride; then removed, allowed to dry in the air for ten days and replaced in the cylinder and given a second injection of 3 pounds of creosote, both quantities being in pounds per cubic foot. At the same time, 1,694 untreated heart pine ties were placed in the same piece of track. In December, 1903, after nine and two-third years of service, 8 per cent. of the treated ties had been removed and 95 per cent of the untreated heart pine ties had been removed.

Another method of doing the same thing has been that of injecting the solution of zinc chloride and immediately following this with a second injection of tar oil, the first injection being stopped at the proper point to permit the injection of about 3 pounds of tar oil per cubic foot. A number of these ties have been in service for six or eight years with very satisfactory results.

There is one other treatment which has been before the public for some years, and which has some very desirable theoretical features about it; namely, the Hasselmann process. This consists in boiling the timber in a solution of several substances, the principal one being sulphate of iron. There have been a number of treatments proposed whose value was based upon the securing of a chemical reaction in the wood itself, but there has been a good deal of skepticism about the securing of such reactions.

Still another modification of the method of treatment is a zinc chloride process known as the Wellhouse treatment. This consists of the injection of zinc chloride, followed by injections of solutions of glue and tannin, the object of the latter being to plug up the ducts of the timber.

The Atchison, Topeka & Santa Fe Railway, with an experience extending over seventeen years, shows an average life for inferior pines and spruces treated with zinc chloride of eleven years. The Atlantic system of the Southern Pacific Railroad, with the same number of years' experience, shows a life of sap pine ties treated with the same material of nine and one-half years, while the Pacific system of the same road, where treated ties have been used for ten years, report 57 per cent. of the ties laid in track in 1895 as being in service after eight years. The Pennsylvania Railroad, in a test instituted in Indiana in 1892, where burnettized hemlock and untreated white oak were laid in rock ballast, shows an average life to date of 10.58 years for the first and 10.17 years for the second, with 41½ per cent. of the hemlock and 33 per cent. of the oak still in service. With burnettized tamarack, an average life of 8.84 years, and of untreated white oak, 9.47 years, both laid in gravel ballast and with now all of the ties removed, has been secured.

In a paper read last year before one of our societies, I summarized the situation as follows: "It is safe to say that whenever an inferior tie can be purchased and treated by burnettizing, and then cost no more than a white oak or other first-class tie, the adoption of treatment by that or a better process is justified. It may not be possible to determine which particular treatment is the most profitable, but this should not be considered as justifying the failure to begin treatment. A plant should be designed to treat by either, and if the future necessitates a change, this can be readily made; and in the meanwhile, whichever has been adopted, it is reasonably certain results will be worth the cost."

Progress of Construction of the New Orleans Drainage System.

It is now nearly three score and ten years since the Louisiana Legislature incorporated a company organized for the purpose of constructing works for draining marshes and swamps in and near the city. This and succeeding bodies accomplished little or nothing until the days of the drainage commission created in 1895 to carry out the recommendations of the Board of Advisory Engineers. Under the executive management of the Sewerage and Water Board, which has succeeded the drainage commission, construction has been progressing, for the most part, as rapidly as the financial resources of the city have permitted. From the last semi-annual report of the Board, for the six months July to December, 1903, the following information relating to the progress of the work has been abstracted. A map of the city showing the principal drainage canals and the location of the pumping stations was printed in this journal November 11, 1899, with a general description of the works, and will aid in understanding the report here reviewed.

The construction of complete drainage, sewerage and water works, in a permanent manner, will cost several millions of dollars, but the city's resources make it possible to expend only comparatively small sums from year to year. To secure the maximum benefit from the available funds the Board sought the assistance of the Board of Advisory Engineers, Messrs. B. M. Harrod, Henry B. Richardson and Rudolph Hering, in determining what parts of the works should first be executed. Experience has demonstrated that, while the drainage system in so far as completed has greatly bettered conditions in the commercial and thickly settled area of the city, other areas in the rear portion of the city have not received their quota of relief; and owing to the quick transmission of water from more favored areas, are at times worse flooded than formerly.

The engineers, after a careful study of the condition of the works as found last December, submitted a report to the Board containing the following recommendations:

"The most judicious expenditure at the present time would be the early construction of the works mentioned below, which are parts of the final plan and will very materially reduce the present troubles, which could be entirely removed only by the expenditure of several additional millions of dollars.

"We have included in our recommendations several canals to be lined and covered, because in these cases we believe the necessary expenditure to be proper.

"We also recommend that certain permanent flushing gates and pipes be now built at the New and Old Basins for the purpose of securing, by frequent flushing, a better maintenance of certain canals, and in part postponing the necessity of an early masonry lining and covering.

"We further recommend that at stations Nos. 6 and 7, additional pumps of small capacity be installed for constant service to keep the canal pumped down to the lowest practicable stage. We consider this additional installation essential to reduce the caving of canal banks, which is mainly due to the large daily oscillation of the water level which cannot be economically prevented by the operation of the present pumps of large capacity intended for storm water pumping.

"If means can be found, without prejudice to the more important works recommended in this report, we consider it desirable that additional power plant be installed at the Central Power Station, to operate the existing storm water pumps, after the enlargement of the canals leading thereto, as proposed below.

"We consider additional transmission lines necessary from the Central Station to Station No. 2.

"We recommend that the following drains and canals be improved by receiving a timber lining of the bottom and sides at the proper grades, so that the sectional area of the lined part will be sufficient to carry the water required by a single one of the storm water pumps, say a flow of 250 cubic feet per second. Our purpose in thus limiting the size of this channel, is that in view of the necessary limit of expenditure we believe that a further caving and filling of the bottom can thereby most expeditiously be prevented. The timber channel will allow of a good velocity by which it can be kept clean, and the slopes will be flattened to such an extent that washing of the surface is reduced, and by keeping the water level practically constant, instead of allowing it daily to oscillate many feet as it now does, particularly near the pumping stations, the chief cause of caving will be prevented.

"We recommend that the Broad Street canal from the Old Basin to St. Bernard Avenue, be improved by receiving a box drain of timber to prevent caving, and sufficient in size to take the flushing water introduced from the Old Basin.

"In order to make these timber lined subchannels as permanent as possible, we recommend that the material exposed above the constant water level be creosoted. We recommend the improvements of still other drains and canals, simply by cleaning them in connection with the flushing apparatus already mentioned.

"Until the Broad Street canal is built, conditions may occur at pumping stations Nos. 1 and 2, and have in part already occurred, when after heavy rainfalls the water level on both sides of these pumping stations becomes approximately the same, chiefly because of the lack of canal capacity and power to discharge as fast as it accumulates, the water which ultimately goes to Lake Borgne, but now must go to Lake Pontchartrain. In such cases, the pumps are of little or no use, as the water would as well flow past the station with its natural slope. The power thus saved would then become available at other points, chiefly at stations Nos. 6, 7 and 3, to throw larger quantities of water to Lake Pontchartrain. To accomplish this end, it is recommended that by-passes be constructed of suitable dimensions at the following points: At station No. 1, to allow the arriving waters to pass by to station No. 6 and eventually to station No. 2; at station No. 2, to allow the arriving waters to pass by station No. 7, or eventually to station No. 3; and at station No. 3, to allow the arriving waters to pass by eventually to station No. 4.

"In order to increase the amount of water which can at present be handled at stations Nos. 6 and 7 it is recommended that the suction pipes be extended by suitable curves to the intake basins.

"For the purpose of more accurately proportioning the large canals yet to be built in permanent form, we recommend the establishment, as soon as practicable, of automatic recording gauges at all of the present stations, in order to ascertain the amount of water running off from rainstorms of great intensity. For this purpose we also recommend the continuation of the present automatic rainfall observations.

"Unless sufficient funds are provided, not only for the efficient operation of the Drainage System, but also for maintaining it in perfect order, its full benefits cannot be realized. This demands annual appropriations for furnishing the power necessary to run the pumps, for keeping the canals and drains free from deposits and obstructions by vegetable growth, and for thorough flushing at proper intervals."

As indicated by certain phrases in the above recommendations, considerable trouble has been experienced with the slipping and caving of the slopes of unlined canals previously constructed. In portions of some of the canals the growths of the water hyacinth and other vegetation has become so dense, for lack of funds to keep the channel cleared, as to materially reduce the carrying capacity. Deposition of sediment has also caused obstructions in some places. The form of masonry construction for lined and covered canals was shown November 11, 1899.

Work was in progress, also, during the term of the report, on the construction of sewers, which, it will be recalled, are of the separate system, especially in streets soon to be paved. Existing contracts covered 66 miles of sewers, and nearly 300 miles remained to be built, of which 61 miles were placed under contract in February. Commenting on the sewer construction accomplished, Mr. George G. Earle, general superintendent says:

"The experience thus far on this main sewer work has fully borne out the expectation of this department; it is not by any means without difficulty, yet the amount of water and of material really bad for excavating, which has been encountered, is far less than most people had supposed would be found, and there appears to be every reason to believe that all of the main sewer contracts will be completed fairly close to the time limits as originally set in the specifications; that they will be substantially and satisfactorily constructed, and that the various contractors engaged in their construction will make a sufficient profit to compensate them for their labor, and to warrant them in seeking further contracts at the hands of the Board at what this department can recommend as reasonable prices."

The power for the several pumping plants of the drainage system is generated at one central power station and distributed electrically. In connection with the operation of this power station, Mr. Earle states in his report that the question of the adoption of oil for fuel is now being seriously considered by the drainage committee, and the indications are that the service can be greatly improved by its use. Experience at the Algiers drainage station, where oil has been in use for some time, indicates that such fuel will greatly increase the steaming capacity of the boilers, will permit of a far more rapid raising of steam and will largely obviate both the necessity for the continued banking of fires against emergency and the need for the employment of emergency labor to handle coal during excessive storms. In other words, at any reasonable price for oil, it will give the city a more prompt service and increased capacity at a less cost than coal. For these reasons the expenditure necessary to equip the stations with oil storage tanks and oil burning apparatus appears to be fully warranted.

THE CONDENSER PLANT of the recently built power station of the Glasgow, Scotland, municipal electric tramways is provided with triplex air pumps, each driven by an electric motor which is directly attached to the crank shaft. The pump for each of the larger condenser outfits, which are all of the surface type, designed to handle 60,000 pounds of exhaust steam per hour, has 16x12-inch plungers, operated at 150 revolutions per minute. The cooling surface of each condenser of this size comprises 2,690 tubes 1 inch in outside diameter, presenting 7,000 square feet. These figures indicate that 8.57 pounds of steam are condensed per square foot of surface per hour.

Coal and Water Consumption in a New York Hospital.

Some figures relating to the coal and water consumption in a large hospital in New York City have been received, which allow of making some interesting deductions as to the requirements of such institutions. The building is one of eight stories and is served from its own plant, which furnishes light, heat, ventilation, power for elevators, refrigeration and water supply. The plant in point of design is very complete and in point of operation is exemplary, having shown a continuity of service, a capacity to meet demands and a comparative freedom from extensive repairs. It is not arranged, however, any more than the general run of mechanical parts, with special means of conducting investigations of a more or less detailed character; and it is not practicable, with the necessity to keep things running, to determine the performance of a particular division of the plant. Moreover, such a condition would mean a more or less complicated and expensive arrangement of instruments and measuring apparatus. The total amount of coal burned and the total quantity of water received into the building are, of course, known.

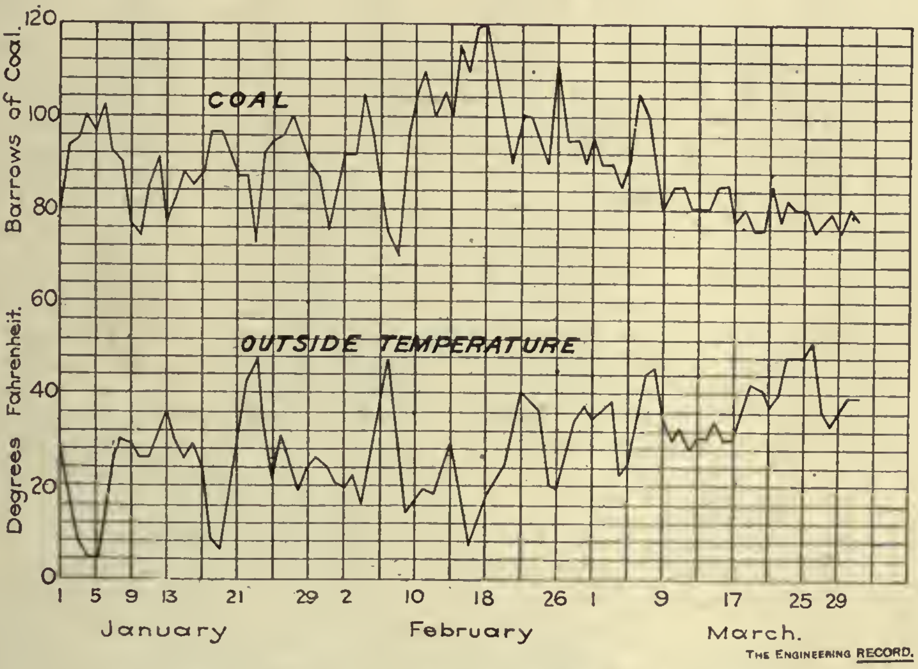


Chart Showing Effect of Temperature Changes on Coal Consumption.

In presenting the figures it should be understood that the building is not yet fully occupied, having been provided with sufficient ward space, for example, to take care of an increase in the number of patients, such as is likely to occur in the course of time.

The building has a total contents of over 1,860,000 cubic feet, enclosed by the outer walls and not including partitions. Of this a little over 1,560,000 cubic feet are heated. The building is warmed by some 22,500 square feet of direct radiation, the extensive ventilating system installed being counted on simply for maintaining the purity of the air and not for contributing to the warming of the building. In the boiler plant there are 6,508 square feet of heating surface, which, at 10 square feet per horse-power, indicates a capacity of 650 horse-power. The total grate area is 146 square feet. The coal burned is measured in barrows and a record made of the amount burned during both day and night. The electric generating plant has a rated capacity of 450 kilowatts, but this is supplemented by a storage battery, which has a five-hour capacity of 2,000 ampere hours, or a 10-hour capacity of 2,500 ampere-hours. Ordinarily the engine generating plant is operated about twelve hours a day with a storage battery floating on a line through the use of a booster, so that a constant load may be kept on the engine plant and all fluctuations arising from the electric elevators may be sustained by the storage battery. The battery and booster connections are arranged in such a way, as usual in plants employing a storage battery in this manneer, that the battery is sufficiently charged at the end of the day's run to operate the entire plant during the night.

The total coal consumption for the twelve months ending April 1, averaged 301.5 tons per month or 9.9 tons daily. This indicates that the average amount of coal necessary for all purposes was 10.6 pounds per day per 1,000 cubic feet of the entire contents of the building, or 12.7 per 1,000 cubic feet of the portion of the building that is heated. The ratio of direct radiation to the volume of the building heated is 1 to 69.4 The exhaust steam from the plant is, of course, utilized for heating, and it is only in the severest weather that live steam has to be added. By taking the coal consumption during the winter months as a basis to determine the requirements of the heating apparatus, which assumption is equivalent to regarding the various classes of machinery in the plant as intermediate between the steam boilers and the heat radiating surface,—that is, regarding the engines, pumps and the like, as is sometimes done, as useful pressure-reducing valves,—it was found that 24,240 pounds of coal were burned per day or about 1 pound per square foot of the direct radiation. This has been calculated by taking the weight of the coal burned from October 1 to April 1. The period has been an unusually severe one and some amount of live steam was necessary at times, so that the figure is probably an outside one.

A calculation of the relative weight of the ashes and of the coal shows that for the period of one year the ashes amount to 24.1 per cent. of the weight of the coal. Their volume, on the basis of the same period, is about 45 per cent. The minimum amount of coal burned in a day was 40 barrows, or 6.3 tons, on May 10, 1903, and the maximum amount was 18.9 tons on both February 17 and February 18, 1904. A number of calculations indicate that the coal consumption during the night is about 78 per cent. of the consumption when the generating plant is in operation. It may therefore be assumed that for the 9.9 tons average daily coal consumption, 935 pounds are burned during the daytime and 725 during the night per hour.

The accompanying chart has been drawn to learn how much of an effect the variation in the outside temperature had on the daily coal consumption of the plant. The abscissas are the successive days of January, February and March of this year and the ordinates give to the same scale the degrees Fahrenheit of the outside temperature, for the lower curve, and the number of barrows of coal, each weighing 315 pounds, for the curve of coal consumption. It will be seen, generally speaking, that, for every drop or rise in the temperature there is a corresponding change in direction of the curve for the coal consumption. If anything, however, the latter curve apears to lag somewhat behind the temperature curve, a matter of a few hours only, which is to be expected when the building is regarded as more or less of a heat storehouse. The curves show that the outside temperature has a marked effect on the consumption of coal.

Water is received through two meters and the sum total of water passed through them for the first nineteen days of April was 25,482 cubic feet. Only a part of it was delivered into the boilers, and as there is no water meter to measure the feed to the boiler plant, the absolute performance of this apparatus is not readily obtainable. For all purposes, however, the water consumption may be rated in terms of the cubic feet of contents, in other words, it amounts to 5.4 gallons per 1,000 cubic feet per day. There was an average of about 75 patients and 150 attendants in the hospital, and on this basis the water consumption may be stated as 134 gallons per patient per day or 45 gallons per capita of total population.

The electrical output of the mechanical plant is measured by wattmeters and for the first nineteen days of April the electric power furnished for lighting amounted to 5,486 kilowatt-hours and that for power purposes to 2,832 kilowatt-hours. Regarding this power as furnished during the twelve hours of operation of the steam-generating plant, as this machinery must both meet the day-time demands and charge the storage battery, the total average output indicates a 12-hour load of 36.5 kilowatts. This is 8 per cent. of the total rated output of the steam-electric plant. During March the output was 14,810 kilowatt-hours, 73.8 per cent. for lighting and the remainder for power. The light consumption is on the average 0.19 kilowatt-hours per day per 1,000 cubic feet of the building contents and the electric power demands 0.067 kilowatt-hour for the same unit.

Reheating and Superheating for steam engines was referred to by Mr. J. A. Seymour, of McIntosh, Seymour & Company, in an article which was the subject of an extended comment in these columns on April 16. As will be recalled he discussed the relative performance of the reciprocating steam engine and the steam turbine, to show that the steam engine is superior to the steam turbine in cases where comparisons with the average and not the latest type of steam engine have indicated otherwise. In conclusion he had the following to say on the water-rate curves of engines: "For engines tested without receiver coils in use, and without superheat, an economy constant within two per cent. is indicated for from about 0.6 to 1.3 load. The corresponding limits for the same engines with receiver coils in use are from 0.5 load to 1.2 load, and with superheated steam from 75 to 100 degrees from 0.4 load to full load; the point of best economy becomes earlier as the rate of steam consumption decreases."

Rope Transmission in Textile Mills.

It is not surprising after so many years of argument for and against electric power transmission in textile mills, that the advocates of rope drives should request a hearing before the societies representing the textile industry. In the long struggle between belts and wires, very little has been heard from the ropes, except as each of the leading antagonists dealt them a casual blow by way of notice of their presence. The New England Cotton Manufacturers' Association, which is a liberal organization that does not require papers on trade subjects to be presented under misleading technical titles, has listened to innumerable arguments between the electric and the leather men, so it is not surprising that this week it listened to a statement of the advantages of rope transmission prepared by Mr. Frederick S. Greene, M. Am. Soc. M. E., of the American Manufacturing Company. So much has been published concerning the advantages of other systems of power transmission in such mills, that it is only fair to give here an abstract of this paper on a rival system.

In the first place the author stated that rope drives are now in successful operation where power is carried economically over distances of 200 to 500 feet, a fact which is advanced for comparison with belt transmission. Where shafts are neither in the same line nor plane, by properly placing guide sheaves, power may be transmitted by ropes around corners, from one building to another, and in short, between any two shafts, no matter how situated. Again, the width of rim surface required for rope sheaves is from one-half to two-thirds that of the width necessary for belting, according to the size of rope used. The supporting bearings may, therefore, be placed much closer for a rope than for a belt drive, an advantage that the practical mill man will recognize as of prime importance in some cases.

No electrical disturbance is produced by ropes. It seems hardly necessary to explain to cotten spinners what a favorable point this is for rope driving, as the electricity generated by belts has always been one of the most serious troubles in textile manufacture. Another important advantage is that no power is lost from slipping. Where the diameter of the rope sheaves is sufficiently large, and the angle of the groove properly turned, so that an air space is left under the rope, it is wedged so firmly in the groove, that loss of power by slipping becomes a factor too insignificant to be considered. As power in all modern cotton mills is transmitted to three or more floors, the advantages of rope driving for such plants is undeniable. The full number of ropes start from the driving sheave, while the number required for each different shaft are easily taken off at the several floors.

To arrive at an approximate cost of the maintenance of rope drives is a difficult matter, as it depends almost entirely upon the manner in which the rope is spliced upon the sheaves, and, where a good transmission rope is used, upon the ability of the man in charge to let the ropes take care of themselves, and to refrain from coating them with all sorts of injurious preparations. The average life of rope on the main drive of a cotton mill, where the multiple or English system is used, is from eight to ten years, during which time, the entire cost of maintenance should be confined to the labor required to take up the slack in the ropes once, or at the most twice.

To make a comparison of the first cost of the three forms of transmission, Mr. Greene instanced a three story mill developing 1,000 horse-power. The engine wheel is 21 feet in diameter, making 70 revolutions per minute. The three driven sheaves are each 64 inches in diameter; 400 horse-power is taken off at the third or spinning floor; 400 horse-power at the second or carding floor; and 200 horse-power at the first or weaving room. Nine 1¾-inch ropes are carried to the two upper shafts, and five ropes to the lower, as against two 40-inch and one 20-inch double belts.

If this arrangement may be criticised on the score that the belts are wider than strict necessity requires, it must also be admited that the amount of work allotted to the ropes is equally conservative, for each rope is doing a little less than 44 horse-power, whereas, the printed tables of some of the most prominent manufacturers of rope driving machinery give 65 horse-power as the amount of work to allow for a 1¾-inch rope running at 5,000 feet per minute. In making this comparison the writer has endeavored to follow as nearly as possible the methods used by successful mills of recent design.

The cost of the rope plant is $4,400 for sheaves and $541 for the rope, a total of $4,941. With a belt installation the cost is $4,050 for pulleys and $1,949 for belts, a total of $5,999. For the rope drives, the plan is to use a 21-foot driver and three 64-inch sheaves. With belts, the driver is also 21 feet in diameter and the pulleys 64 inches. The width of rim for ropes is 58 inches; for belts, 102 inches.

The effort to determine the cost of an electrical transmission for the above mill has not been entirely satisfactory to the writer, for each concern applied to for figures, has recommended different arangements for the motors,—some advocating that the power be divided into units at many points, necessitating the use of a large number of small motors. But the cheapest arrangement that will meet requirements satisfactorily, seems to be to place two 20-horse-power motors on the second and third floors, with two 100-horse-power motors on the weaving floor. These six motors, together with a 750-kilowatt generator, switch board and other necessary appliances, amount to a total of $25,400.

On the banks of the Savannah River in Georgia, stands a cotton mill which is driven by electricity, the power being rented from a company which develops it at a dam located about one mile further up the stream. In this plant the entire power is brought to a central motor, from which it is transmitted by ropes to the different floors. This mode of handling the power has proved economical and entirely successful. Now if it has been found advantageous to drive with ropes from one motor, avoiding small units, even where your electricity is generated by a water power, how can we be made to see the economy of generating electricity by steam and carrying it to a number of costly motors when both generator and motors are under the same roof?

The paper did not discuss which of the two systems of rope driving is the better, the multiple or continuous. In the opinion of Mr. Greene both systems have their place, and the place where the multiple system shows to best advantage is from the main drive of a cotton mill; though should it be necessary to design a vertical, quarter turn or other complicated drive, of course the continuous system should be employed.

A Good Roads Convention is to be held in St. Louis during the week of May 16 to 21 under the joint auspices of the office of Public Road Inquiries of the U. S. Department of Agriculture, the National Good Roads Association, the Louisiana Purchase Exposition Company, the State and County officials of Missouri, and the officials of the city of St. Louis.

The Harway Avenue Bascule Bridge, New York City.

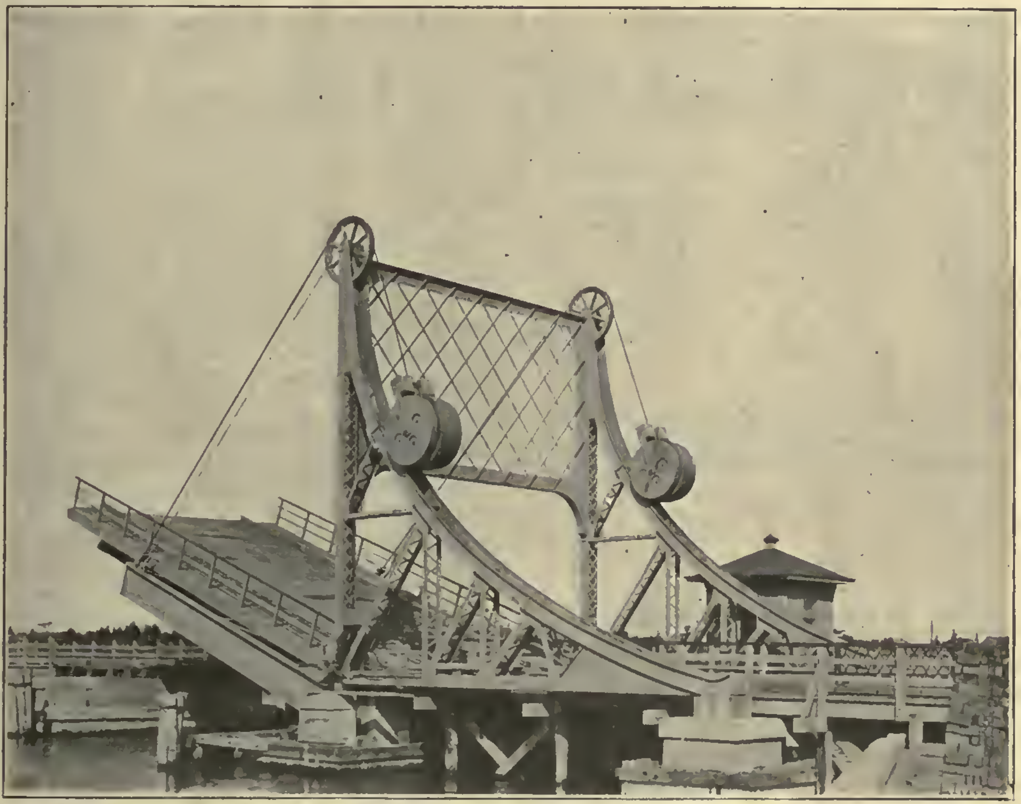
Harway Avenue is carried across Coney Island Creek, in the borough of Queens, Greater New York, by a bascule bridge having a clear span of about 50 feet and a width of 31 feet 4 inches between hand rails. It is built throughout of medium steel and is proportioned for live and dead loads of 1,400 and 550 pounds respectively per linear foot. There are three main longitudinal plate-girders 10 feet apart on centers. Each of them is 42 inches deep with flanges having two 6x4-inch full-length angles and one 13x7/16-inch cover plate 32½ feet long. They are connected by four transverse panels of sway-bracing which consist of top and bottom horizontal angles and zigzag diagonals. There are also pairs of lateral diagonal angles in each of the three main panels. The floor-beams are 12x4-inch timbers about 33 feet long bolted to angle lugs 2 feet apart on the top flanges of the outside girders. They are covered with a longitudinal and transverse thickness of 2-inch yellow pine plank and carry the 20-foot roadway between the main girders and the 5-foot 4-inch sidewalks on their cantilever ends.

At one end the bridge is hinged to the lower ends of a pair of vertical tower columns about 35 feet high. The tower columns are made with pairs of 12-inch channels and are seated in masonry pockets 5 feet 4 inches below grade. They are connected by a lattice-girder about 20 feet deep, which has a clearance of 19½ feet above the roadway and is made with T-shaped top, bottom and end flanges, which are composed of an 18-inch web plate with pairs of 6x3-inch horizontal bulb angles and 3½x½-inch vertical flange angles. The diagonal members are single 3½x3½-inch angles. The concave track girders for the counterweights are made with pairs of 15-inch channels bent to a curve plotted to correspond with the varying moments of the bascule platform in different positions. The horizontal members connecting the feet of the track and the columns are pairs of 12-inch channels, and the principal connecting members are each made with four 4x3-inch angles.

The main girders are intersected by two transverse girders of the same depth and about 35 feet long, which are web-connected to them and diagonally braced so as to form the framework of a solid platform. One of them is riveted across the hinge end and the other about two-thirds of the way to the opposite end. The second girder is cut to clear the webs of the longitudinal girders, and is thus made in four sections. Both girders project about 7½ feet beyond each outside longitudinal girder and have their extremities connected by fascia plate girders 42 inches deep with single 4x3x⅜-inch flange angles. At the tower ends these girders project about 3½ feet beyond the transverse girder and have ¾-inch web reinforcement plates riveted to them which project above and beyond their bevelled ends to form offset hinge plates on which the bridge is pivoted to horizontal 5-inch pins. The ends of these girders enter the open faces of the columns and the hinge pins engage the column webs.

Gusset plates ¾ inch thick are riveted to the revolving ends of the fascia girders and each projects above the top flange to receive a 1½-inch and a 4-inch pin. The former engages the end of the ¾-inch steel hoisting rope and the latter engages the 1¾-inch counterweight rope, both of which pass over sheaves at the top of the tower. The counterweight rope is secured to a yoke pivoted to the axle of a cast-iron roller weighing about 45,000 pounds. The hoisting rope is led down the rear face of the column to a drum driven by a 5-horse-power General Electric motor. The counteer rollers were found a little too light and additional weight has been added to their yokes. They balance the bridge to within about six tons in all positions so that the bascule leaf always has a positive tendency to close.

The bridge can be raised by the motors in about forty seconds. It also has hand gear with which it can be lifted by three men in about five minutes. When closed, both ends of the main longitudinal girders rest on flat bearing plates on the masonry abutments. The bridge was completed in 1898 at a cost of about $25,000. It was built by the Department of City Works, Division of Construction and Repairs, Brooklyn, N. Y., under the administration of Mr. Peter Milne, commissioner, and Mr. P. M. Fielding, deputy. The design was made by Mr. Joseph Mayer; Mr. E. S. White was the engineer in charge, and Mr. J. S. Langthorn was resident engineer of construction. Messrs. Deane & Westbrook were the general contractors, and the superstructure was built by the Canton Bridge Company.



Harway Avenue Bascule Bridge Over Coney Island Creek, New York.

A Rippling Channel, so called, 500 feet long and 5 feet wide, having its bottom covered with sharp-edged pottery fragments, was introduced between the bacteria beds and the river receiving the effluent from the sewage disposal plant of Waltham, England. In flowing through this open channel the effluent is thoroughly agitated so that suspended gases are dispersed, particles of carbon from the beds are arrested, and the fluid is thoroughly oxygenated and aerated, producing a clear, bright and sparkling effluent, odorless, non-putrescent and capable of supporting the respiration of coarse fish. The normal flow is about 150,000 gallons of sewage per day. The plant, as described in "The Surveyor," comprises a scouring chamber, duplicate detritus tanks 34½ feet long, 16½ feet wide and 8½ feet deep, used alternately, open septic tanks of 75,000 gallons capacity, and two circular bacteria beds, 60 and 65 feet in diameter, fitted with Adams' patent revolving sprinklers. The fluid is eight hours in the detritus tanks, twelve hours in the septic tanks and fifteen minutes in the bacteria beds.

The Cleaning and Flushing of Sewers.

So much interest was taken in this subject at the annual meeting of the Sanitary Section of the Boston Society of Civil Engineers, held March 2, that it was thought profitable to continue the discussion at a special meeting held April 13. The report of the annual meeting was printed in The Engineering Record March 12.

In describing the sewerage system of Melrose, Mr. W. D. Hunter stated that the city is 7 miles north of Boston with a population of about 14,000, of which 13,000 contribute to the sewers. The system, begun in 1894 and completed in 1898, consists of 35 miles of pipe from 2 feet to 6 inches in diameter. Manholes were placed at junctions and 250 feet apart on straight lines. Many of the sewers are laid on flat grades, two-thirds of the system requiring under drains. House connections are 5 inches in diameter, and connections to house plumbing are made by Y's. Running traps are required by the board of health, and these catch the grease. The ventilation of the system is satisfactory, being effected by four ¾-inch holes in each manhole cover. The streets are lined with trees, but stoppages from roots are almost unknown. Cleaning is done about once a year, largely by use of a steel hoe the shape of the pipe with a follower made of a bag or bundle of rags drawn through after the hoe. The cost of cleaning the system last year was $17 per mile, including labor, horse, etc. There are no siphons on the system.

Mr. Harrison P. Eddy stated that the system in the city of Worcester comprises 169 miles of sewers, most of which are 8 inches diameter or over, 69 miles being separate, 61 2/3 combined and 38 2/3 surface drainage sewers, with 6,380 manholes and 2,630 catch-basins. The cost of flushing and cleaning during the last six years has been, on an average $130 per mile, the lowest cost being $110.47, in 1898, the highest $155, in 1903. The cost of cleaning catch-basins has been $3.23 per cubic yard per year. A large portion of the flushing is done every five weeks, but it is not practicable to flush between December 1 and April 1. The maintenance department is in charge of one man who looks up all complaints from stoppages, has charge of the cleaning and flushing and the systematic inspections made twice a year. In the last twelve years there have not been more than six stoppages, not one of which was due to roots. With regard to the grade of sewers, Mr. Eddy said that a 0.4 grade will move fine clay and a 2.5 grade will move coarse gravel. He recommended providing a grade to give a velocity of 2.5 feet per second when running full. At all points below half full the mean velocity will not be reached, for, at a depth of 2 inches there may be a velocity of 1 foot per second and with 3 inches depth a velocity of 1.6 feet per second.

Mr. George A. Weatherbee said that the system in Malden consists of 47 miles of sewers ranging in diameter from 6 inches to 3 feet. In the Edgeworth district many of the sewers are laid on flat grades, one 8-inch pipe being on a grade of 1 in 500, another 8-inch on 1 in 900, a 15-inch on a grade of 1 in 750, and a 24-inch on a grade of 1 in 1,500. One of the 8-inch pipes laid 1 in 500 is cleaned once in winter and once in summer, and there have been no complaints from the other 8-inch sewers in the same district. The cost of cleaning and flushing last year was a little less than $5 per mile. Small sewers are connected with the water works pipes and cleaned annually, the large sewers being flushed by flushing manholes. There have been no stoppages from roots excepting in one house connection. Ventilation is made at present through open manhole covers. Mr. Weatherbee has experimented with ventilation and found that the current went downward through the manholes. There are three siphons on the system, which are cleaned once a year and have given no trouble. There is one manhole on each side with a sump from 3 feet to 3.5 feet below the line of the sewer. Two-thirds of the contents caught in the sumps are sand.

Mr. Arthur C. Townsend described the system in Lynn, which has 75 miles of combined sewers. It was started in the '70's, and many of the old sewers are in very poor condition, being neither in line nor on grade. There has been no trouble from the new sewers built in the last twelve or fifteen years. Inspection of the system is made on an average every three months and flushing is effected by means of the hydrant hose at the manholes, thirty or thirty-five sections being flushed every month. Mr. Townsend does not like to lay sewers to a grade less than 1 in 300 or 400, but sometimes it is necessary to build to a flatter grade. There has been little trouble from roots growing into the sewers. The annual appropriation for cleaning and repairing the 75 miles of sewers is $1,000.

In the city of Quincy, described by Mr. Ernest W. Branch, there are 40 miles of sewers on the separate system. The annual appropriation for cleaning the sewers is $1,500. There are 125 flushing manholes, none of which are automatic, and the sewers are flushed once a week. On flat grades they are troubled with a fungus growth, which is removed by use of a rattan brush. To remove the sand which falls through the holes in the manhole covers, Mr. Branch has devised a scoop, similar to a sugar scoop, but having two ends, there being different sizes for different sized sewers. The scoop is operated by means of a rope. All connections to houses are made with clean-outs in direct connection with sewer.

Mr. Patterson said that the system in Revere was laid by contract twelve years ago and has given a great deal of trouble, but the pipes laid in recent years have given no trouble. There are 15-inch and 18-inch pipes laid on a grade of 1 in 1,000 which have given no trouble, and from 2,000 to 3,000 feet of 8-inch pipes laid at the same grade which have to be flushed every two months. Flushing with good results is done by means of a fire hose through the manhole with 65 pounds pressure at the hydrant, reduced to 50 pounds at the manhole. Some trouble has been caused by roots growing into the pipes through the joints, especially in one 8-inch pipe, where they grew to a size of from 4 to 6 inches. A scoop has been used, with success, to pick up the sand accumulations.

Mr. Arthur A. Adams stated, that in Springfield there are 25 miles of brick sewers and 75 miles of pipe sewers. Flushing is done by means of connections to the water-works system with 1½-inch to 4-inch gates once in four to six weeks. There is not a great deal of sand or gravel in the sewers, the flushing being all that is necessary to carry such materials into the river. There have been one or two stoppages from roots.

Mr. E. C. Frost described the works in South Framingham. The system was designed and built in 1888, there being 15 miles of sewers on the separate system, costing $225,000. Flushing is done four times a year with 1½-inch hose connected to hydrants with 95 pounds pressure. Roots from 20 to 30 feet long, which stopped the flow, have been removed from sewers. Mr. Frost said that if roots grow in sewers it is because of faulty construction, and the best thing to do is to dig up the sewer and relay. To prevent the formation of grease he suggested putting a shovelful of potash into the sewer.

A Producer Gas Plant furnishes power for an electric railway running from Pugliano, near Naples, to a point about 325 feet below the actual summit of Vesuvius. The Dowson process is employed, and there are two 100-horse-power gas engines each driving a direct-current dynamo giving 137 amperes at 550 volts, and a storage battery having a 260-ampere power capacity over 1 hour. The dynamos, which are driven at 700 revolutions per minute, can be raised in pressure to 770 volts, it is said, for charging the battery without increasing the number of revolutions. The gas engines, which operate normally at 160 revolutions per minute, have cylinders 20¼ inches in diameter and 29.9 inches stroke. About 175 cubic feet of water are required per hour for the gas apparatus and for cooling the engine cylinders.

London's Sewage Disposal problems have more than a local interest, and this is true largely because much valuable experimentation and study has been carried on in connection with the works by eminent chemists and sanitarians. The bacterial treatment of sewage was begun on an experimental scale in May, 1892, and has been continued since that date uninterruptedly on an increasing scale. Various reports on these experiments have been printed from time to time, but are now difficult to obtain. Recently a volume entitled "The Experimental Bacterial Treatment of London Sewage," by Prof. Frank Clowes and Dr. A. C. Houston, summarizing the work from the beginning to 1903, has been published by P. S. King & Son, 2 Great Smith Street, Westminster, S. W., at a price of ten shillings, and will be of interest to engineers engaged upon sewage disposal undertakings. The book has an appendix which gives, also, data relating to the construction and operation of septic tanks and bacteria beds in many English cities. The purpose of the London experiments has been to settle the question of the relative efficiencies of bacterial methods as compared with the chemical processes in use at the Barking and Crossness works in removing solid matters from the sewage.

Letters to the Editor.

Railroad Field Cross-Section Books.

Sir:—Your issue of January 30 contains an article on railway construction by Mr. F. C. French, Assoc. M. Am. Soc. C. E. In this article is given a form of field cross-section book, of which Figure 1 is a copy.

The writer submits the form shown in Figure 2, which form he has used on all of his railway construction, and which he has found very convenient.

The points in favor of this form (Figure 2) are as follows:

1. The center cuts and fills, which are the difference between the grades and elevations, are placed next to the columns containing those items. In making the subtractions, the eyes do not have to travel clear across the whole width of the book and back again, but the figures can be written down with the least labor, and with some chance of being readily checked.

2. The end areas and cubic yards, both for embankment and excavation, show separately and distinctly under their respective heads, and the cubic yards between two stations are shown between their respective end areas.

3. The embankment column is placed next to the cross-sections in order to allow the cubic yard column under excavation to be placed next to the classification column, as embankments are rarely, if ever, classified. The classification of each cut can then be placed opposite to the total amount of yardage contained in that particular cut.

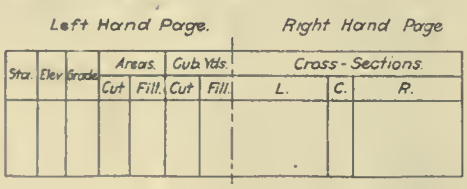


Fig. 1.

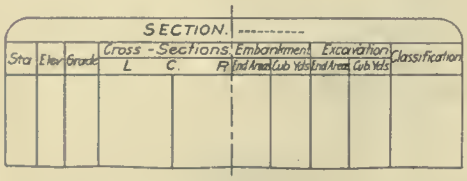


Fig. 2

Forms for Engineers' Field Note Books.

4. All field calculations are performed on the left-hand page, and all office calculations on the right-hand page.

5. This form of field book enables the engineer to refer at all times to a complete set of original notes, saves the labor and time of transferring the field notes to other books, and thereby eliminates at least one chance of making errors.

The writer has never seen a printed form of this kind, but has always been obliged to rule his own field books. He has found this form very convenient and a great time-saver when that particular article was short.

Yours truly, H. F. Wilson, Jr.,
Assoc. M. Am. Soc. C. E.
Birmingham, Ala., April 20.

Piers of the Greenfield Street Railway Bridge.

Sir.—I have read with considerable interest your well-written article on the Greenfield & Deerfield Street Railway bridge at Greenfield, Mass., in your issue of April 9, and write, not with a desire to criticize, but to inform your readers of the actual conditions of the bridge piers as built.

All the piers, with the exception of pier No. 3, were carried down to a rock foundation, and the cylinders were placed on a concrete foundation which was carried up around their footings. Pier No. 2, the one nearest the piledriver in your photograph, was cofferdammed with a double dam of matched 3-inch planking, and sunk to rock about 14 feet below low water level, at considerable expense caused by excessive and continuous high water. After reaching the rock a concrete foundation was made completely filling the cofferdam, on which the bottom cylinders were placed, after which the concrete was carried up to about elevation 9.0, and the cofferdam was left in place and rip-rapped to avoid scouring around the foundation.

Pier No. 3 was placed on a pile foundation and built as shown, with the exception of the 15x15-inch square timbers shown placed vertically in cylinders, which were omitted. The fact that we know very little of the lasting qualities of timber embedded in concrete and the difficulty of properly filling and ramming the concrete made it seem advisable to leave them out, and they were not used in either Pier No. 2 or No. 3, as shown. In the construction of Pier No. 3 the cylinders were first sunk by excavating from the interior and pumping. Piles were then driven as shown.

Yours respectfully, G. F. Merrill,
Engineer on Construction of Substructure.
Shelburne Falls, Mass., April 27.

The Passage of Pathological Bacteria through filters was the subject of some interesting experiments, by Dr. A. C. Houston, reported in the recently published fourth interim report of the Royal Sewage Commission, of England. The following notes on these tests are taken from a review of the report printed in "Engineering." Investigations were made as to the passage of pathological bacteria through sewage filters, the experiments being carried out at Hendon and at Leeds. The organism selected was B. pyocyaneus, and at Hendon a culture of this was added for a period of three minutes to the sewage flowing on to a Ducat's filter there. Seven minutes later the first specimen of the effluent was taken, and further samples were then collected at intervals of every five minutes for a period of five hours. The bacterium was noted in the first sample taken and in all samples up to the thirty-fifth, and occurred in twenty out of the thirty later samples examined. The rapidity with which the organism appeared in the effluent is remarkable, and the results thus obtained were confirmed in a second experiment, which was extended over ten days. In this instance sixteen samples were taken before the culture was added, and none of these showed the presence of the test bacterium, but nine minutes after commencing to add the B. pyocyaneus it made its appearance in the effluent and only definitely disappeared from the filtrate after the lapse of 154 hours. At Leeds the same organism was added to sewage as it flowed into a septic tank, the effluent from which had been proved by preliminary experiments to be normally free from this particular type. The bacterium was found to be present in the septic tank liquor two hours afterwards, and in the effluent from the filters through which the latter subsequently passed, and was still present in the latter at the end of nine days, disappearing totally only on the tenth. It is thus proved that pathological bacteria can traverse both water filters and biological sewage plant; but it is, nevertheless, evident that in neither case is the process conducive to the bacterial health, since in spite of the pabulum present in the filters, the bacteria in question tend to disappear.

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The Louisiana Purchase Exposition.

When Napoleon and Jefferson exceeded the constitutional limitations of their powers and brought about the transfer of the Louisiana Territory a little more than a century ago, neither of them could by any possibility foresee that within one hundred years this same territory would have a population so great and important that the nations of the world would combine in spending more than three times the purchase money of the tract in celebrating the centennial of its transfer. Napoleon recognized that the possession of this vast area would be a menace in the great struggle which was imminent. He saw that in the wars of France with the other countries of Europe. Louisiana would probably be lost or, at the best, could be retained only by a great struggle far from the scene of his more important operations. It was better to secure fifteen million dollars for an undeveloped tract of unknown future worth than to spend that sum in defending it against the countries with which France would shortly be contending. Jefferson foresaw the importance of the Mississippi Valley and its absolute necessity to the infant United States in the development of the great territory lying west of the Allegheny Mountains. He recognized that the mouth of the Mississippi gave control of the Gulf of Mexico and very naturally he stretched the Constitution to its utmost in bringing about this first great expansion of the nation. A trifle more than a century has now passed and in the Louisiana Territory there is a population to-day vastly greater than that of the United States in 1803. In that territory lie states which rank as high in general culture as any in the country, some of the most prosperous agricultural and mining sections, and industries of an importance which can only be recognized by an examination of the United States census returns.

It is fitting that the exposition commemorating the first great expansion of the United States should be held in the city which is the focus of the enterprise of the territory. It is equally fitting that this exposition should be the grandest ever undertaken, for it celebrates a peaceful acquisition of a vast territory more important than any ever acquired by force of arms in the past and destined to support a population that in many ways will shortly become typical of the nation. No one acquainted with the history of the Middle West can visit the Louisiana Purchase Exposition without being deeply impressed by the meaning of the Fair. It is a great deal more than a mere display of products and methods of manufacture. On every hand there are memorials of the country's history designed by artists who sympathize with the purpose of the exposition and have in consequence produced works calling to mind the development of the Louisiana Purchase Territory. It is not in the scope of The Engineering Record to point out how the history of this great tract is told at the exposition; it is enough to state that to the thoughtful observer the exposition is truly commemorative.

Elsewhere in this issue there is an account of the building of this fair. A great deal has been published in this and other journals on the subject. These articles have been more or less disjointed and for this reason a general account of the manner in which the site has been prepared is appropriate at the present time. Very few people have any understanding of the labor and expense involved in the preliminary work of such an undertaking before the day of opening. The illustrations which have been printed so widely of various buildings give some idea of the enormous structures that have been erected, but of the fair as a whole there has, up to the present time, been no concise statement. A mere list of the buildings or a general map of the ground gives little idea of what has been done by Director Taylor and his staff. They have, in fact, built a city in the last three years in the outskirts of St. Louis. They have provided it with two distinct water-works systems, with a complete separate system of sewerage, with roads, streets and walks having a superficial area as large as those in many cities and of a much better character than will often be found in places of fifty thousand population. They have built a railroad system of about 33 miles length, part of which is operated electrically, and they have filled low ground and razed hillsides so that the face of the country has been entirely changed. Very little of this work ever attracts the attention of the visitor. The great exposition buildings, which the department has erected, overshadow the rest of the work which has made the fair possible, and it is the purpose of The Engineering Record this week to explain these other undertakings which are just as important as the architectural construction.

It is believed that this description will be particularly interesting because it explains a great deal of temporary work. An engineer is rarely called upon to carry out such construction. His usual problem is to build something which will last at least ten years and often several generations. The Louisiana Purchase Exposition is to last only until 1905, when it must be removed and the grounds restored to their previous condition. Naturally the construction which is best suited for such a purpose is very different from that of a permanent nature, and it is believed that every civil engineer who visits the fair, and others whose engagements will prevent their doing this, will find the account of interest. The article is accompanied by an inset map which shows in a general way the civil engineering work which has been done on the fair grounds. In order to get all of the general features of this work on one sheet, it has been necessary to employ colors, but it is believed that the reader will have no difficulty in learning from the map the facts in which he is interested. It should be stated that this map has been prepared from many separate maps and a great deal of detail has necessarily been omitted from it.

The exposition as a whole is unquestionably the greatest undertaking of its kind and the most instructive. Not only have foreign nations participated with unusual liberality, but American exhibitors are showing more fully than ever before not only their products, but also the manner in which they are made. The educational value of such a fair is extremely great, and every one connected with it is to be congratulated on the success which has attended their earnest endeavor to make it fully worthy of its great historical meaning.

Lessons of the Hotel Darlington Failure.

Sufficient time has elapsed since the failure of the iron framework of the proposed Hotel Darlington on West 46th Street, New York City, to permit a cool and unbiased judgment to be formed regarding the main features of that type of building design. A most extended and thorough examination of the wreckage has been made by engineers and other experts, resulting in the production of a large amount of information of the nature of evidence as to the cause and manner of failure, subsequently analyzed and digested by an unusually intelligent coroner's jury. If any structural failure whatever can be made to yield an instructive lesson as to what should be carefully avoided in the design of a high building the teachings of such a failure as this should be most impressive. It is reasonable to suppose that the owners and builders of this class of construction would scrupulously avoid those features of design of the iron framework of the Hotel Darlington which resulted in such a disastrous failure, and yet at the present time there are being erected in the City of New York a number of buildings the frameworks of which are probably essentially as crudely defective, weak and dangerous as that of the wrecked hotel.

A most concise and clear description of the iron framework of the Darlington is given by Mr. H. de B. Parsons in the "Proceedings" of the American Society of Civil Engineers for April. Any careful reader of Mr. Parsons' description who is qualified to appreciate the technical features of that design can only wonder that that kind of a construction will ever stand alone long enough to permit the masonry walls to be built around it. All the columns of the building, intended to be twelve stories high, were of cast-iron, square in section and varied from six to nine inches on the side. As each story was ten feet ten inches high, the length of each separate column was from sixteen to nearly twenty-two times its width. The ends of the columns were faced and then the individual columns were simply stood one upon another in a vertical series throughout the twelve stories, or rather they would have been so placed throughout the twelve stories if they had not failed to stand up in this flimsy manner higher than the ninth floor. After the manner of such wretched design the ends of the columns were fitted on two of their sides with cast flanges through which, at each story, four rough bolts passed, each being about an eighth of an inch less in diameter than its hole. All ends of floorbeams were supported on brackets cast on the sides of columns near one end, so that every floor load in the building was greatly eccentric to these spindling cast-iron columns, thus subjecting the latter to heavy bending in addition to their direct loads of compression. The ends of these beams were also secured to their supporting cast-iron brackets only by rough and loose fitting bolts. This viciously bad design of framework was suitably rounded out by the complete absence of all lateral bracing whatever. There was absolutely not a member or even a detail of any kind to give the framework a vestige of real lateral stability. Every criticism of this character which could be made against the Darlington design is equally applicable to a number of building frameworks with small cast-iron columns now in process of erection in this city.

In the design of such buildings the length of column is considered to be the height of a story. As a matter of fact a cast-iron column is an unfit and unsafe structural member under any circumstances, but even if it were tolerable a length of twenty times the diameter is entirely too great. Independently of that consideration, however, the absence of all lateral bracing and the loose-fitting, rattle-trap character of the column joints permit every series of columns to deflect in such a way as to give it an effective length equal to its total height. In other words the actual effective column length in each series at the instant of failure was the total height of the nine stories. This statement may at first sight seem extravagant or to savor of exaggeration, but it is literally true. There was nothing whatever to prevent all series of columns bending together, i.e., parallel to each other, each series with an effective column length equal to its total height. It would be difficult to imagine a more dangerous condition for the framework of a building. Such a design ought not to be tolerated in any modern city, for it involves a gross and baldly ignorant violation of fundamental principles of rational design with which even every third-year civil engineering student in a reputable school is thoroughly familiar. The attempt to erect such a framework of a high building is dangerous and the standing wonder is that it holds together long enough to be erected.

It is time that this practice of viciously bad building design coupled with the use of such an unfit material as cast-iron for columns should be discussed in plain terms and called by its right name. As has frequently been stated in the columns of this journal, it is more than twenty years since civil engineers ruled cast-iron columns out of use in bridge building, and there is no reason for their exclusion from bridges which does not hold with equal force for their exclusion from high buildings. It has been demonstrated from the results of actual tests that steel columns for high buildings are more economical than those of cast-iron even where the latter succeed in carrying their loads. No trade prejudice or survival of ignorance should prevent the adoption of steel columns in all buildings hereafter and thus make failures like that of the Darlington impossible.

A Well-Paid Position.

The Engineering Record has recently learned of a position in the government service which will doubtless be of interest to a considerable number of its readers. The place has not yet been definitely authorized, it is understood, but that is not essential at the present time. One of the government bureaus finds itself in serious need of a young man who has a thorough knowledge of steam engineering, particularly the latest practice in superheated steam, and is also competent to design all the details of the electric plant in central lighting and power stations. He should likewise be familiar with heating work to some extent. As he will have to conduct acceptance tests, he should have had some experience in such trials and be competent to take entire charge of them. The salary which such services will receive is at present somewhat indefinite; it was recently stated that as the chief draftsman of this particular bureau is paid $1,800, the new position would doubtless carry a somewhat smaller salary, for the chief draftsman had been in the service a long time and it would not do to take on a new man at the same rate of pay. Moreover, he could not be put on the roll except on the per diem basis, along with the day laborers and charwomen.

It is most gratifying to learn the opinion of power plant engineering held by an important federal bureau having charge of a large investment in steam and electric plants. Everything that receives the seal of government approval carries great weight with many people. There are doubtless many parents in this country who are hesitating to send their sons to a technical school through a fear that the training will not be worth the expense. They should certainly rest content with the above statement, for it shows that in at least one of the bureaus, which prides itself on its engineering work, a man who has graduated from a technical school and then had some fifteen years' experience will be able to earn almost as much as a chief draftsman at $1,800 per annum. With such a princely income established by the government no one need fear concerning the future of engineering in this country. There are hundreds of engineers running threshing engines and saw mills, not to mention the plants in shoddy factories and the motive power of merry-go-rounds, who will deplore their lack of technical schooling when they learn what great inducements Uncle Sam holds out for the best men. This announcement will doubtless be felt by the correspondence schools of the country, and the demand for courses in superheated steam and power plant testing will probably become very large.

There will be some carpers who will say that a man acquainted with the best practice in steam and electrical engineering, able to design a plant costing half a million dollars and test it so that the builders cannot palm off overrated machinery, is really worth more than the salary mentioned. There are also critics who may even assert that it is absurd to put a man able to do such work on the same salary basis as the man who helps the bureau chief to pull on his overcoat. But it will always be thus in human affairs, for is not everything done by the government open to criticism even to such an extent that ordinary libel laws will not protect a public officer? The fact that such a set of qualifications makes a man worth from $5,000 to $15,000 to private corporations should have little consideration, for civil service does not cast its protecting wing over these privately employed men nor do they have the honor of serving the country in an official capacity. These two accompaniments of federal positions are of course above price, at least we are so told by standard authors, and, being above price, the government bureau probably feels justified in making its rate of hire for a steam and electrical expert somewhat—only a few hundred per cent.—lower than the current rate in private business.

The gentleman who was asked to find such a man for the bureau in question did not know of just the right party and suggested that The Engineering Record might give some publicity to the request. Any candidates who desire to have their names forwarded will be accommodated by addressing the editor. There are some preliminaries to be gone through, such as civil service examinations, but it will be an easy matter to brush up subjects of such an elementary nature as steam and electrical engineering. It might be added that considerable alternating current equipment has been discussed by this bureau in its recent work, and it might be well for the candidates to spend an hour or so reviewing that subject.

Municipal Accounting.

A number of years ago several self-appointed critics of municipal affairs experienced some difficulty in securing the data for their fulminations against various city officials. They found that the information in annual reports was compiled in such a manner that they could not compare the figures of one city with those of another. This terrible disregard of their convenience led to much criticism that interested themselves and amused those readers who had the time or an inclination to notice their articles. For a number of years the agitation for uniform municipal accounting was largely carried on by people who seemed to see in uniform accounts nothing but their usefulness as material for their studies. Very naturally any criticism of the bookkeeping of a city which was based on the complaint that such bookkeeping did not answer the purposes of these private individuals had less effect than a mosquito bite. From time to time, however, men engaged in the management of municipal affairs have discussed this subject in a rational manner, and at the present time there is a well defined and sensible movement on foot to introduce uniform methods of accounting. This movement is not based on any desire to furnish data for sociologists, but is intended to make the accounts of cities as simple, clear and comprehensive as possible.

Everybody knows that the bookkeeping methods in private companies have been growing more and more uniform. The great diversity that existed twenty-five years ago is fast disappearing, and although the methods by which the data are collected may differ, the data themselves and the way in which they are summarized are much the same in every trade and industry. It is natural, therefore, that this trend toward uniformity should extend to municipal affairs, for a city is nothing but a corporation and should be managed in some respects like a private company. The reason that much city bookkeeping is in such a peculiar form to-day can doubtless be found in the fact that it is a heritage from the past and there has been no competition to force municipal officers to introduce improvements in their auditing. In business, the auditing department is generally one of the most important and the manner in which it is conducted is carefully compared with that of other companies. An improvement in one corporation is soon followed by a similar improvement in others.

Several cities have of late years had some of their books examined by public accountants and these specialists have suggested marked improvements in the systems of keeping them. The value of these suggestions has been so well recognized that the work of the American Municipal League along this line is attracting a great deal of attention. Municipal accounting is now placed on a basis of common sense and not on theory. There is nothing sacred about the books of a city, and they should be kept like any other business affairs. The people to decide how they shall be kept are bookkeepers and not sociologists. Fortunately for the taxpayers of the country, eminent public accountants are much interested in this subject and are working in the American Municipal League to formulate systems of bookkeeping which will be clear, comprehensive and simple. It is doubtless surprising to some of the amateur critics who, in the past, in a few hours, have devised forms for books for a city department that these experts have worked a couple of years and are still in doubt about a great many features of municipal accounting. In order that the readers of The Engineering Record may know just how the matter stands among the people whose opinion on the subject carries weight, there is reprinted elsewhere in this issue the first part of a paper by Professor Cleveland, read before the American Municipal League. It is a statement of the business aspect of municipal government which is of great interest in view of the fact that the firm of Haskins & Sells, with which Professor Cleveland is connected, has made a careful investigation of the municipal accounting systems of the city of Chicago, and in this way has brought to general attention a system of bookkeeping that will be at the basis of recommendations for uniform accounting in the future.

A considerable part of this paper refers to subjects not of engineering interest, but in order that the whole subject may be properly presented, it is necessary to consider the entire system of accounts of a city. By so doing, the method of keeping the records of the public works department can be properly planned. Attention is drawn to this paper because a great many very poor and sometimes positively misleading articles on the subject have appeared, and anything that a man of Professor Cleveland's standing has to say on the subject will do much to clarify the hazy condition of the subject.

Unnecessary Opposition to the Additional Water Works for New York.

The Legislature of New York recently passed a bill, now before Governor Odell for his signature, which, if it becomes a law, will render valueless a large part of the work of the Commission on Additional Water Supply for New York City and prevent the construction of works which should be undertaken immediately. This bill practically prohibits the condemnation of any stream in Dutchess County which is the chief source of power or is necessary in the manufacturing processes of mills. It is evidently intended to safeguard the interests of the industrial communities in that county against any injury which will result from the utilization for New York's water supply, of the streams which pass through Fishkill, Wappingers and Poughkeepsie. It is apparently based on the belief that the engineers who prepared the project for these very important works failed to consider the industries in question.

As a matter of fact, the mills of Dutchess County, as well as those on the opposite side of the Hudson, were very carefully examined by the engineers, and the construction of the works for bringing an additional water supply into New York will leave these plants in better shape for manufacturing purposes than they are to-day. It is probable that the Hon. J. T. Smith, the father of this bill, does not understand the great importance attached by engineers in all work of this nature to a careful provision of compensating water or steam equipment for the water taken from existing mill privileges. As a matter of fact, this subject of compensation is one which has been more developed by engineers than by any other class of professional men, and a body of precedents has been established by centuries of such work in Great Britain, as well as in New England to a lesser extent, that affords entire protection to all who have any property rights in a water course.

The plans for the utilization of the streams in Dutchess County affect the runoff from about forty per cent. of the drainage basin of Fishkill Creek and fifty per cent. of the basin of Wappingers Creek. The development of these portions of the two basins will lessen the amount of water available for a number of industries, but the plans of the Advisory Commission of Engineers provide for ample steam power to take the place of the water power which will be rendered unavailable, and also provide ample water for all other industrial purposes. The amount of water which the new works will take from these two streams is very small compared with the quantity that is taken in many cases in Great Britain. In the latter country very often the entire stream-flow is condemned, with the understanding, however, that from the reservoirs of the water works an amount of water shall be turned daily into the rivers sufficient for the mills below. Such a plan is followed in hundreds of cases in Great Britain, and is considered there absolutely just and equitable to all concerned. The manufacturing plants are provided with steam equipment for their power purposes and the water necessary for carrying on their industries is furnished to them with greater regularity and in better condition than before, owing to the fact that it comes from storage reservoirs and not from the natural runoff of the catchment areas.

If the advocates of this bill were to talk with the Lancaster Mills, of Clinton, Mass., an industry which employs a larger number of people and represents a greater investment than any in Dutchess County, they would find that when the Metropolitan Water Board of Massachusetts condemned the waters of the Nashua River for the water supply of the Boston metropolitan district, the company was actually provided with a better equipment than it had before the water works were contemplated. This is true in every case where a great community is obliged to seek an additional water supply. The City of New York must have a great quantity of water, and the State of New York should not prevent its metropolis from securing this water where it can best be obtained. The condemnation of the streams on either side of the Hudson for this purpose will cause some changes in power equipment of a few manufacturing establishments, but such changes have all been provided for, will be made without interfering with the business of these establishments, and will result in a better equipment when they are completed than that which is now employed.

It is natural that residents of the county where some of these streams flow should fear that the reservoirs and aqueducts proposed for the City of New York will dry up their rivers and destroy their industries. The advocates of the bill now before the Governor doubtless fail to appreciate that nothing of this sort can happen. The question is merely whether the rather sparse population of these rural counties may enjoy the natural flow of the streams, most of which runs absolutely to waste, or whether the City of New York shall have the right to take half of the water in question, provided in so doing it shall fully compensate every one for any injury that such use may entail. The eminent engineers who have advised the city have provided for every contingency which will affect existing water rights on these streams. Any one interested in the subject will be given full information concerning what it is proposed to do to compensate them for any lost water. There is no concealment about the project, nor is there the faintest intention to take from Dutches County or any other county any natural advantages which now exist without giving full compensation for them. If the Smith bill becomes a law, it will work great injury to the largest city of the country; if it does not become a law, New York can build works necessary for its water supply and all existing interests at the source of this supply will be thoroughly protected. Most of them will probably be in much better condition after the works are finished than they are at present. It is a matter of common knowledge that whenever a city condemns property, it pays rates far in excess of what the property is worth.

The Union Engineering Building is now being planned by the six architects who have been selected for a limited competition under the general supervision of Prof. W. R. Ware, professional adviser to the conference committee of the three national societies interested. All plans are to be submited by June 15. The building will occupy about 10,500 square feet of a 125x100-foot lot on the north side of Thirty-ninth Street. Directly east of the lot Mr. Carnegie has bought a residence which will be kept at its present elevation so as to protect the Engineering Building's light on that side. The general scheme of the building sets apart the top three stories for the use of the societies which have been invited to participate in the advantages of the building. The next three floors are reserved for the three national societies, and here will be their respective offices with reception, board and committee rooms. Below will be a two-story library with a capacity of 300,000 to 400,000 volumes, although it is possible that when plans are finally selected the library may be transferred to the top of the building. The main auditorium, seating 1,000 on the floor and about 500 in the galleries, will preferably be as near the sidewalk as possible, and may have above or below it six small assembly rooms, seating 100 to 500 people. These are to be provided with gas, compressed air, steam, water and electricity so that experiments and demonstrations can be conducted. Lounging and smoking rooms are provided for, and arrangements are made for special banquets and occasional collations. A post-office and mailing department, public telephone and telegraph stations and similar necessary conveniences in a large building of this character are to be furnished and there will be three large elevators. The location of this building in the immediate vicinity of the Public Library naturally suggests the propriety of a cooperation of that institution and the societies in establishing a great free technical library in the Engineering Building. Such a library will be expensive in both first cost and maintenance, but public co-operation may render it possible.

The Festival Hall and Cascades.

THE BUILDING OF A WORLD'S FAIR.

HOW THE LOUISIANA PURCHASE EXPOSITION HAS BEEN CONSTRUCTED.

With Map Showing Civil Engineering Work on Grounds.

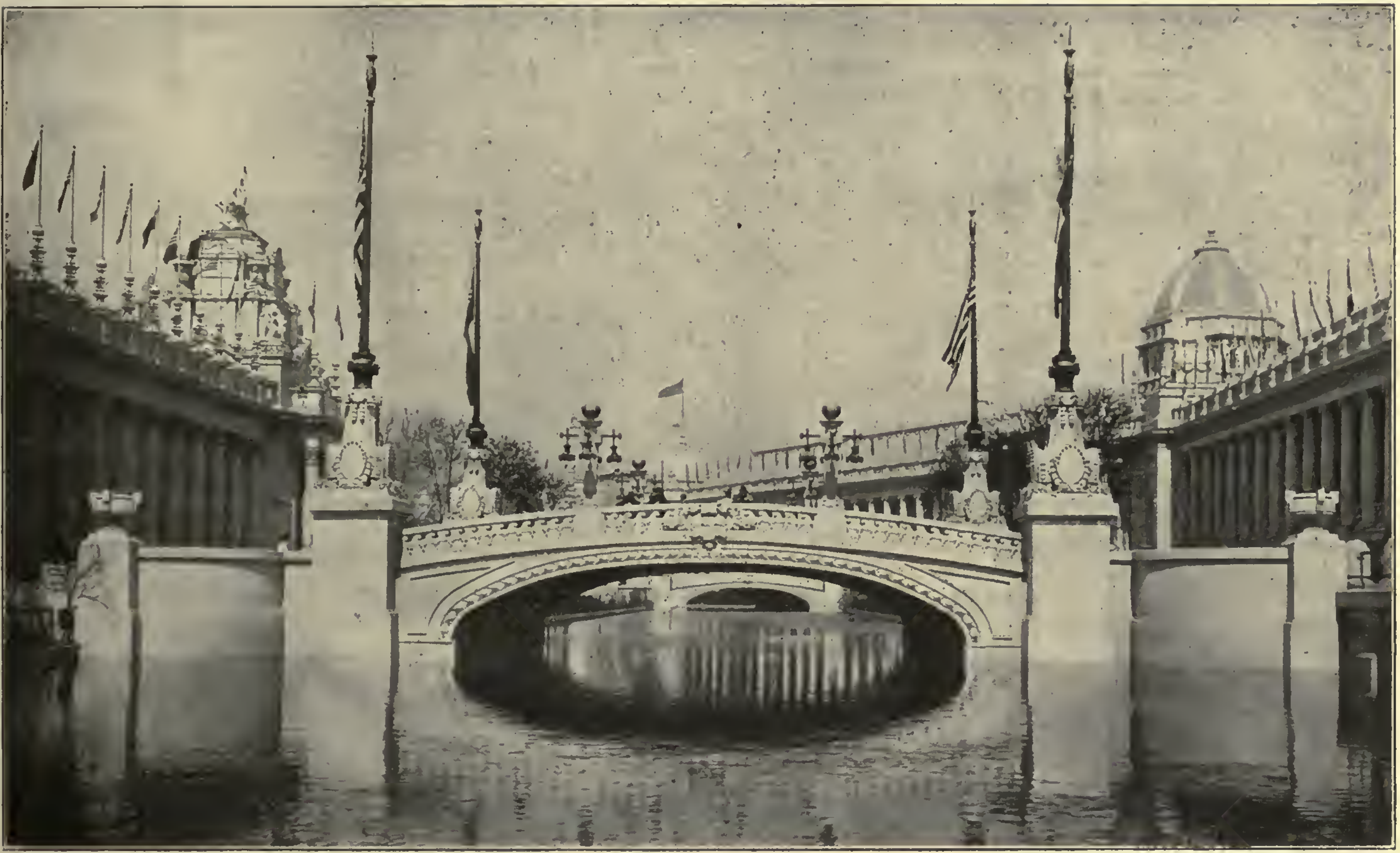
When the plan of the Louisiana Purchase Exposition was first worked out in its general details, it was proposed to invest in it about fifteen million dollars, the same sum that the United States paid France for the territory whose acquisition it commemorates. Originally it was not an extraordinary project, as such fairs go, for it contemplated the use of considerably less ground than is now occupied. The policy of the managers in making no charge for space and their encouragement of exhibits showing processes rather than products have made necessary great additions to the original plans. The demands for space soon exceeded anything expected by the most enthusiastic friends of the project. An indication of their amount is afforded by the statement of ex-Governor Francis, president of the Exposition Company, that the space desired by exhibitors of breakfast foods alone would fill the entire Agricultural Building, over a quarter of a mile long and five hundred feet wide. But the managers, owing to the absence of any charge for space, have been able to pare down the estimates of room which exhibitors presented at first. They have assigned many of the displays to places in the open air, and have thus reserved the roofed areas for the people who most needed them, and these people in turn have been assisted in concentrating their exhibits in the least amount of space consistent with a good appearance. The managers have been troubled to keep down exhibits and not to secure them, to make them representative rather than comprehensive. Even when they exercised all means in their power to restrict the exhibits to objects or processes legitimately within the scope of a world's fair, they soon found that more room was needed within the exposition inclosure than they originally intended. The area has accordingly been increased from the original rather modest tract to 1,240 acres, about twice the extent of the Columbian Exposition, four times that of the last Paris Exposition and that of the Pan-American Exposition, and over five times that of the Centennial. Within its boundary is included a tract large enough to include the Centennial, Columbian and Pan-American Expositions.

These figures are given to indicate the problem which the building of the fair presented. Nothing like it was ever before attempted in magnitude, and the management determined that in beauty it should surpass anything of the sort done previously. Instead of fifteen million dollars, as first planned, it will represent an expenditure of over fifty million dollars. Moreover—and this point is a governing one in considering the actual construction of the exposition—all this money represents a temporary city which must be cleared away next year. Hence all the construction, with the exception of a single building on the crest of land where the fine arts exhibits are grouped, is not enduring and has been so planned as to be amply efficient for its temporary purposes, but nothing more. Hence it is particularly appropriate at the opening of this great exposition to describe what is to many engineers its most interesting feature, the fair itself, apart from exhibits.

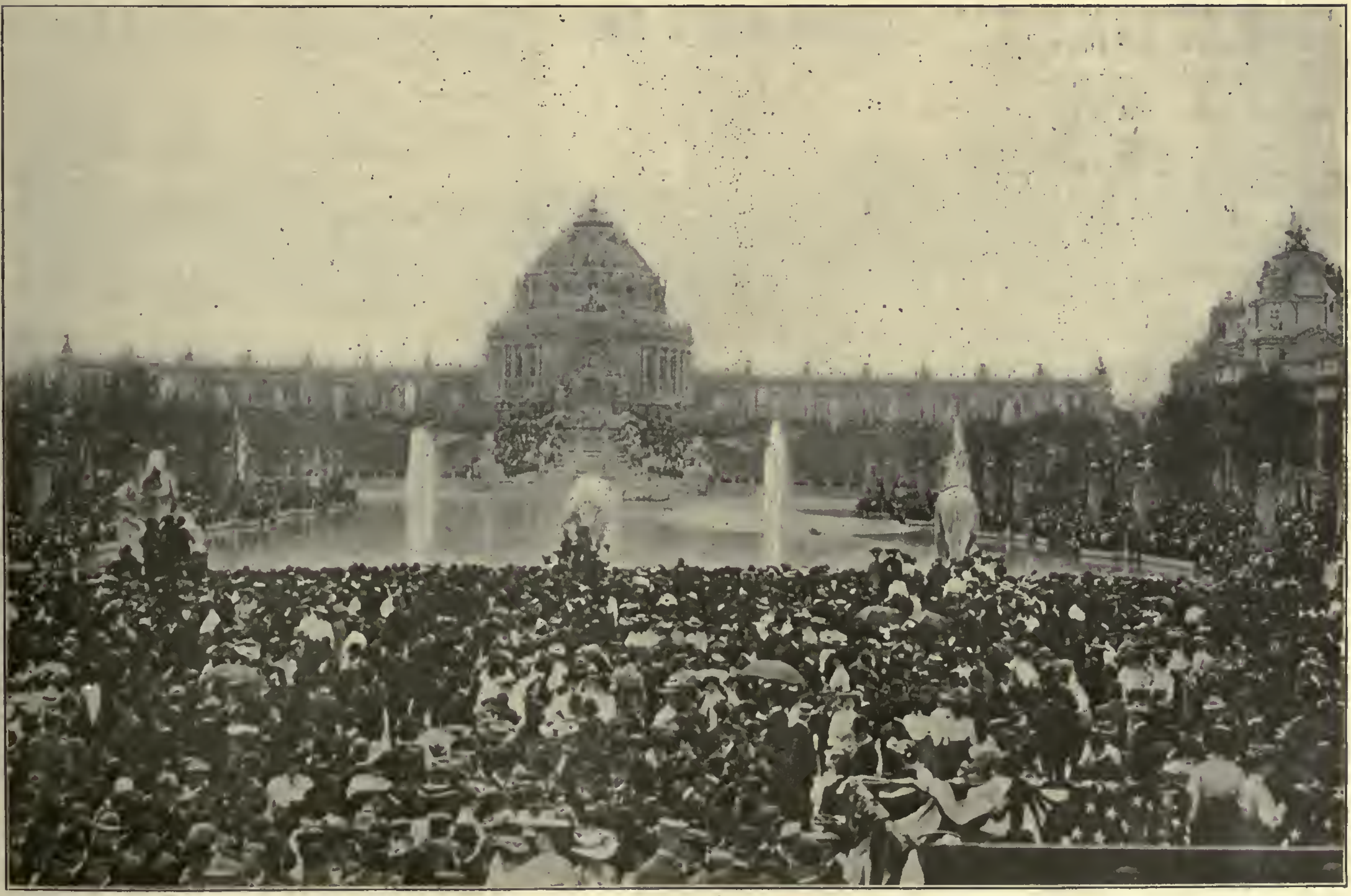
The site of the exposition lies about six miles west of the Mississippi river and embraces a part of Forest Park and some adjoining property including the attractive new home of Washington University. The new buildings of the university are, in fact, used at present as the administration offices of the Exposition Company. The grounds were largely wooded, and the portion of them covered by the main group of exposition buildings was a dense tangle of brush and trees, through which the River des Peres wound in a very circuitous channel. Some time ago, during the prevalence of hard times in the city, a local newspaper collected subscriptions for the construction of a pond at this part of the grounds, and this was dug by men who would otherwise have been without work. Its presence added to the difficulties of construction. The most important feature of the site is its undulating character, which has been utilized in making the exposition picture far more impressive than anything possible on the flat plains where previous fairs were held.

The laying-out, design and construction of the exposition have been in charge of Mr. Isaac S. Taylor, director of works. His architectural work in St. Louis is too well known to need mention here, but it is certainly proper to put on record the forceful manner in which the building of the fair has been pushed along by his energy. An architect is expected to be an artist and a builder, but he is not commonly ranked as an administrator as well. Yet the Louisiana Purchase Exposition to-day is a monument to the executive ability with which Mr. Taylor has carried out a work foreign to his previous experience on a scale that many people with a knowledge of world's fair complications have all along predicted to be impracticable. In the execution of his plans he has been assisted by several men peculiarly fitted for the work. Mr. Emmanuel L. Masqueray, chief of design, after winning distinction at the Ecole des Beaux Arts, attracted much attention in France by his projects for the restoration of famous buildings, which led to his appointment as a member of the National Commission on Historic Monuments. He developed the landscape architecture and many of the buildings of the fair, and has been Mr. Taylor's assistant in the artistic features of the undertaking. The civil engineering work of the exposition Mr. Taylor delegated to Mr. Richard H. Phillips. At the outset of the work there was no department of this character, and Mr. Phillips was rated simply as a topographical surveyor, but little by little, as the streets, water and sewerage systems, lagoons and other works had to be taken up, it was found that an exposition of this size without a civil engineering department was impossible. Mr. Phillips' title is chief civil engineer, and a large part of this article relates to the work he has done. That it has been accomplished at all is doubtless due to his absolute refusal to worry over the many annoyances and delays incident to the execution of such a complicated undertaking. Few people who have not been behind the scenes during the building of a fair can form the faintest conception of the difficulty of keeping order among the contractors, day laborers, concession holders and others. An army without military discipline is a rabble, yet here in the outskirts of St. Louis was a veritable army of workmen, not only without discipline, but often commanded by men whose interests clashed. The management of such a force by men without previous experience in exposition building speaks volumes for the skill with which the staff was selected. In such positions executive ability is as important as technical attainments and more difficult to obtain.

The location of the main group of buildings was settled by topographical conditions at the northeast corner of the grounds. The great palaces have been spread out like a fan, with its hinge on the top of the knoll which is crowned by the Festival Hall and the Fine Arts Palace. The three main streets of the exposition are directed toward the cascades and the beautiful structure at its crest, and the main picture of the fair is deeply impressed in this way on the most hurried visitor. It is inter-



ONE OF THE BRIDGES OF THE LAGOONS.

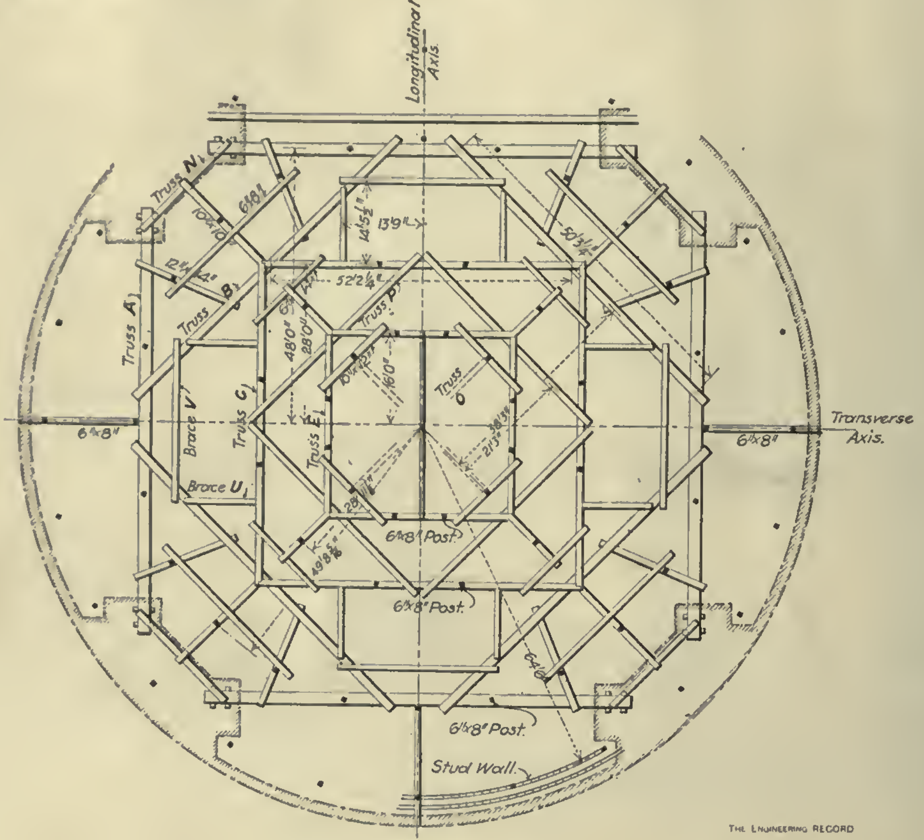


A VIEW OF THE CASCADES AND FESTIVAL HALL ON OPENING DAY.

esting to notice that the center lines of the three main streets converge at a point 300 feet back or south of the point of convergence of the axes of the buildings.

At the outset of the enterprise the general features of the main buildings and the grounds were determined by a commission of architects, of which Director Taylor was chairman. The various architects then developed the exterior details of the buildings, while their structural design was worked out by the Division of Works. It was decided to have the eaves line of the principal structures uniformly 60 feet above the ground and to have the prevailing exterior tint an ivory white, in order to avoid the glare which characterized the Chicago fair buildings and the dusty appearance of those at Buffalo. Although it was originally intended that the general style of architecture should be a free treatment of the Renaissance, some of the buildings, while filling admirably their places in the main picture, would hardly be called Renaissance by most critics. The main facts concerning the principal buildings are given in the table on page 580.

Structurally the buildings resemble those at Buffalo, which had wooden frames, rather than those of Chicago. The system of construction which was followed at the Pan-American Exposition has been adopted at St. Louis. Timber is used everywhere for columns and trusses, except in the Government and Fine Arts Buildings. The construction of the Pan-American buildings was so fully described in The Engineering Record that it is unnecessary to go into it in detail at this time.



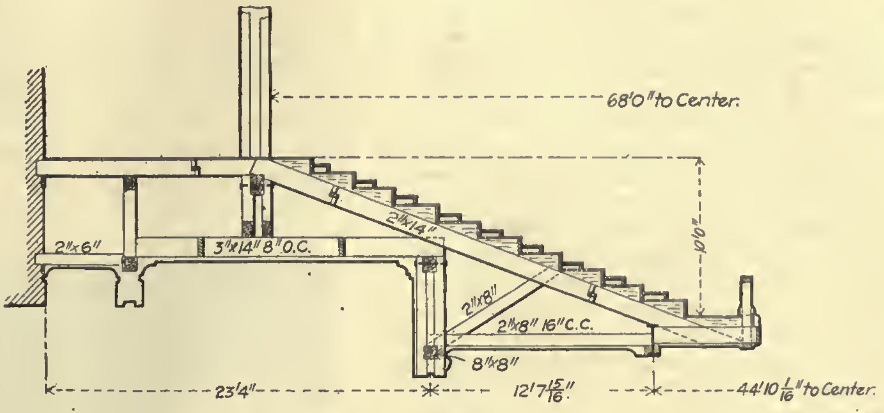
Plan of Trusses.
Diagram of Framing of Festival Hall Dome.

Copyrighted, 1904, by Louisiana Purchase Exposition Co.

Court of St. Anthony, Showing Temporary Bridges for Construction Purposes over Lagoon.

The central feature of the exposition, the Festival Hall, has, however, a great dome which is unusually interesting from a structural point of view. This beautiful building, of which Mr. Cass Gilbert was the architect, is intended for musical performances on the largest scale, and its interior was specially planned under the direction of Mr. Masqueray. The auditorium has a floor inclined downward toward the stage, which has a wide proscenium arch and an organ chamber at its back 72 feet long by 29 feet wide. The ceiling is far below the exterior dome, and so it has been possible to use a novel system of construction in the building.

The dome framing is carried by four pairs of columns, one pair near each corner of a square measuring approximately 96 feet on a side. Each column consists of four 8x8-inch timbers with 2x10-inch lacing. Special precautions were taken to give them a thoroughly firm support. They rise to an elevation of about 76½ feet above the floor of the lowest boxes and there

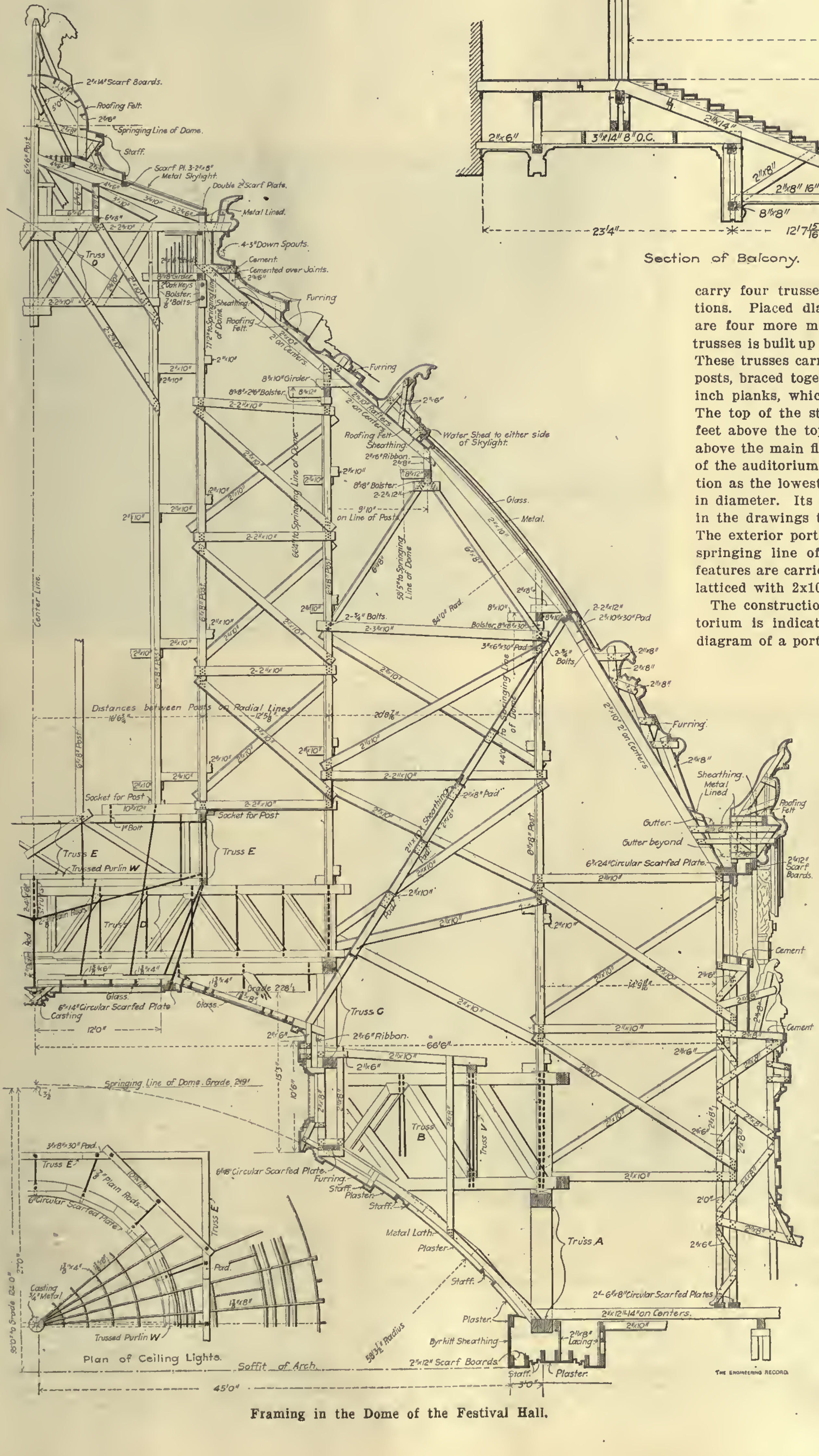


Section of Balcony.

carry four trusses, marked A in the illustrations. Placed diagonally across these trusses are four more marked B, and this system of trusses is built up cobhouse fashion for five tiers. These trusses carry a large number of 6x8-inch posts, braced together in all directions by 2x10-inch planks, which support the exterior dome. The top of the structure is approximately 125 feet above the top of the columns or 200 feet above the main floor level. The domed ceiling of the auditorium springs from the same elevation as the lowest tier of trusses and is 95 feet in diameter. Its construction is so well shown in the drawings that it need not be described. The exterior portion of the building up to the springing line of the dome, and the interior features are carried by groups of 8x8-inch posts latticed with 2x10-inch plank.

The construction of the balcony of the auditorium is indicated in a general way by the diagram of a portion of it over the entrance to the main floor opposite the stage. The usual construction differs somewhat from that shown. About 19 feet inside the main wall of the hall is a circle of columns about 11 feet apart on centers. Each column is 2 feet square and consists of four 8x8-inch posts latticed in the usual manner. Between the wall and this curved line of columns is a promenade carried by 2x10-inch floorbeams about 18 inches apart. They rest at the wall on a 10x14-inch horizontal beam and at the other end on an 8x14-inch beam securely bolted inside the columns. The balcony is of cantilever construction. The inclined piece carrying the floor is a 3x14-inch timber. At the outer end it is braced back to an 8x8-inch horizontal timber connecting the columns by a 2x8-inch timber, and a similar timber runs down from the center of the 3x14-inch top plank to the same 8x8-inch girder between the columns. The balcony projects about 25 feet from the face of the columns and the vertical distance between the 3x14-inch and 8x8-inch girders at the line of the columns is about 10 feet. These cantilever frames are spaced about 2 feet on centers and near their projecting end are framed into a 20-inch I-beam.

All structures excepting this building, the Government



Framing in the Dome of the Festival Hall.

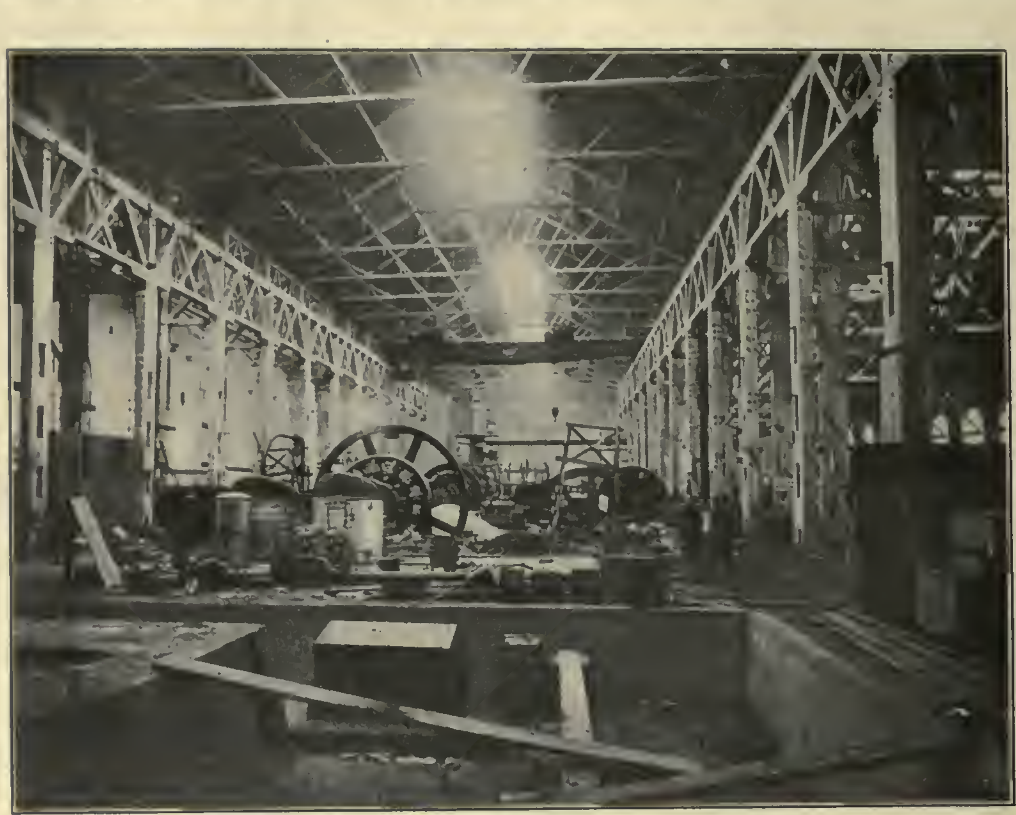
and Fine Arts Building are designed with the same general system of timber construction which was found so successful at the Buffalo fair. The work was done under the immediate direction of Mr. W. H. H. Weatherwax, chief draftsman, and Mr. Philip Markmann, chief engineer, of the department of architecture. For the benefit of readers not familiar with the series of articles in this journal describing the details of construction at the Pan-American Exposition an illustration is given of the interior of the Transportation Building at St. Louis, which shows a typical form of this timber framing. In figuring stresses 20 pounds wind pressure was assumed, 30 pounds dead load on the roof rafters and 40 pounds on the trusses. For yellow pine a working stress of 1,800 pounds in tension and bending was assumed.

The general method of construction of the exteriors of these buildings has been the subject of so many articles that it is unnecessary to describe it again. It is interesting to notice, however, that the size of the individual staff castings is gradually being reduced, and large columns and such work are now made in sections and the joints finished after the pieces have been nailed in place. The staff for each of the 60-foot columns of the Varied Industries Building, for example, was in twelve sections.

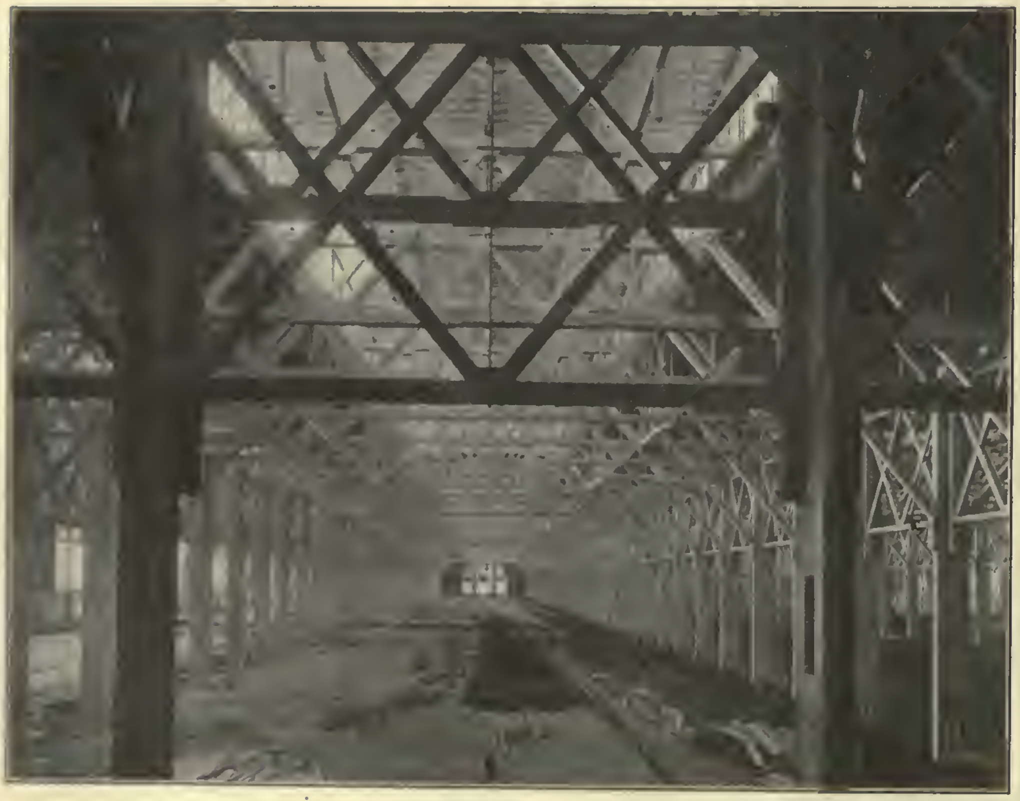
Many of the buildings are carried on pile foundations, as the ground in the northwest part of the exposition tract, where the River des Peres lies, is more or less soft. The longest piles are 30 feet, but a considerable proportion are much shorter, as a shale rock lies not far below the surface. Steam piledrivers were used on the foundations of some of the buildings, but ordinary drop-hammers were generally employed. Where the ground was good, the foundations were made of timber cribbing.

Preparing the Site.—When the general plan of the fair had been determined work was immediately started by Mr. Phillips on a topographical survey of the grounds. Lines were first run on 1,000-foot squares and later these were subdivided into 50-foot squares, and elevations read at all intersections as well as at intermediate points governing the contours. Some portions were covered by a stadia survey, which checked up very satisfactorily. The results were plotted on maps of three scales—50, 100 and 300 feet to the inch. Progress maps on heavy drawing paper and on tracing cloth have been kept so that it is possible to tell at any time the condition of the work. The accompanying inset sheet has been prepared from one of these maps, and on this account does not show the work done in the last six weeks; except in a few details it is believed, however, to give a strictly accurate summary of most of the civil engineering work on the exposition grounds.

As soon as the topography was plotted the work of grading and clearing was undertaken. One of the accompanying illustrations gives the general character of the grounds before any work was undertaken, and indicates better than any words what the clearing of the site involved. The timber as it was felled was cut by contract, and a large part of it was used later for temporary trestles, bridges, drains and similar purposes.



View Showing Wooden Crane Girders in Machinery Hall.



Interior of Transportation Building, Showing Wooden Framing.

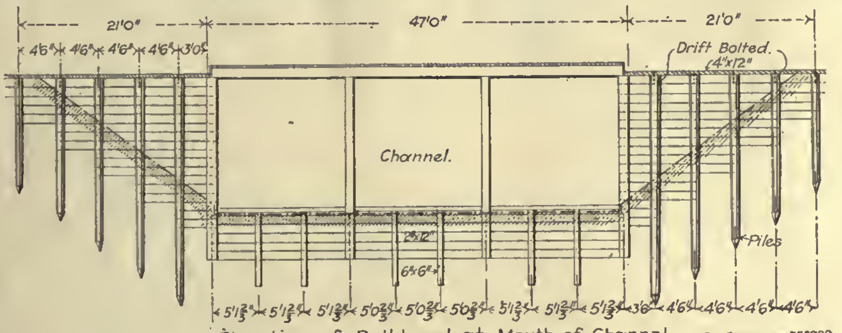
The soil as a rule is a hard clay covered with a foot or two of rich earth, which was carefully saved in all grading operations for top dressing on new surfaces. The clay is fairly stiff, but has certain peculiarities which must be taken into account. The German commissioners learned this to their sorrow when they attempted to bring a bank of the material to a slope which most clays will support but this will not. The bank slid badly and a considerable amount of regrading was necessary.

In the grading, which amounted to something over two million cubic yards, care was taken to use the spoil so far as possible for fills in the immediate vicinity. In the case of the Cascades, for example, the material from one side of the declivity was employed in bringing the other to grade. The top soil was removed generally by wheel and drag scrapers. The clay was handled by grading machines drawn by eight double teams or by traction engines, each machine digging about 200 cubic yards in ten hours. In the heaviest cuts, about 25 feet deep, one-yard steam shovels with one-yard dump cars drawn by locomotives were used. The leading grading contracts were undertaken by Malony & Morrison and the Southern Paving & Construction Company.

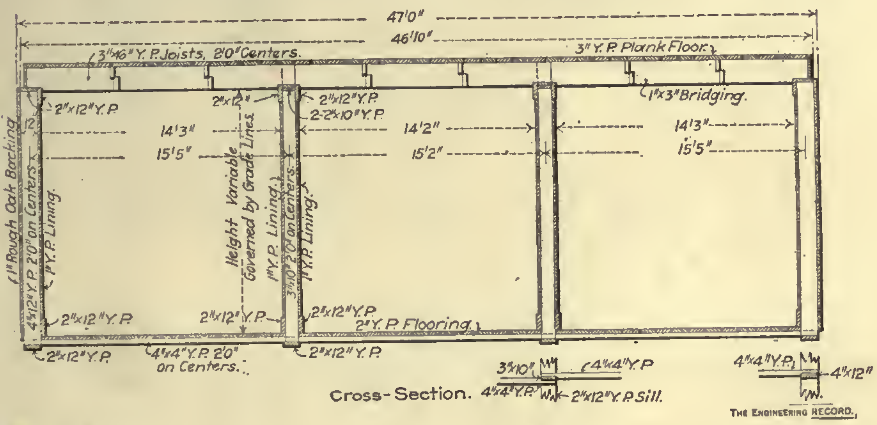
The River des Peres Diversion.—It has already been mentioned that the River des Peres flowing in a winding course in the northeast portion of the grounds was one of the most troublesome problems to be solved in preparing the site. During dry weather the channel was practically without water, but after heavy and protracted storms it overflowed its banks. The channel has a very slight fall, as is readily understood from the fact that the elevation of the ground at the Liberal Arts Building is the same as that of the sidewalks at the Southern Hotel in the heart of the city, several miles distant. The drainage basin above the exposition grounds has an area of about 13,200 acres, and with a rainfall at the rate of 3 inches an hour it was estimated that the new waterway would have to carry about 5,200 cubic feet per second.

The twisting course of the old channel is shown on the inset map and also the location of the new waterway, which has shortened the old course 4,650 feet. The waterway is a large timber culvert 47 feet wide over all and divided inside into two channels of 14 feet 3 inches and one of 14 feet 2 inches, and of a depth varying with the grade of the surface of the ground in which it lies. The bottom is made of 4x4-inch yellow pine sills spaced 2 feet on centers and covered with 2-inch yellow pine plank. The sides have 4x12-inch yellow pine uprights on 2-foot centers, 1-inch rough oak plank on the outside and 1-inch yellow pine plank inside. The posts of the inside partitions are 3x10-inch yellow pine on 2-foot centers and covered on each side with 1-inch yellow pine plank. In this way each of the three channels is made independent of the others. At the top the posts are connected by 3x16-inch yellow pine joists on 2-foot centers, with two lines of bridging over each channel. The flooring on the joists is 3-inch plank on which a 1½-inch coat of asphalt was laid where the waterway was under a street so paved. At the lower end of the waterway, 25 feet east of the boundary of the exposition grounds there is a bulkhead and set of hinged gates, one across each channel, of which complete details are given on this page. Similar hinged gates are placed in the channel every 500 feet to stop drafts in case any portion of the waterway should catch fire.

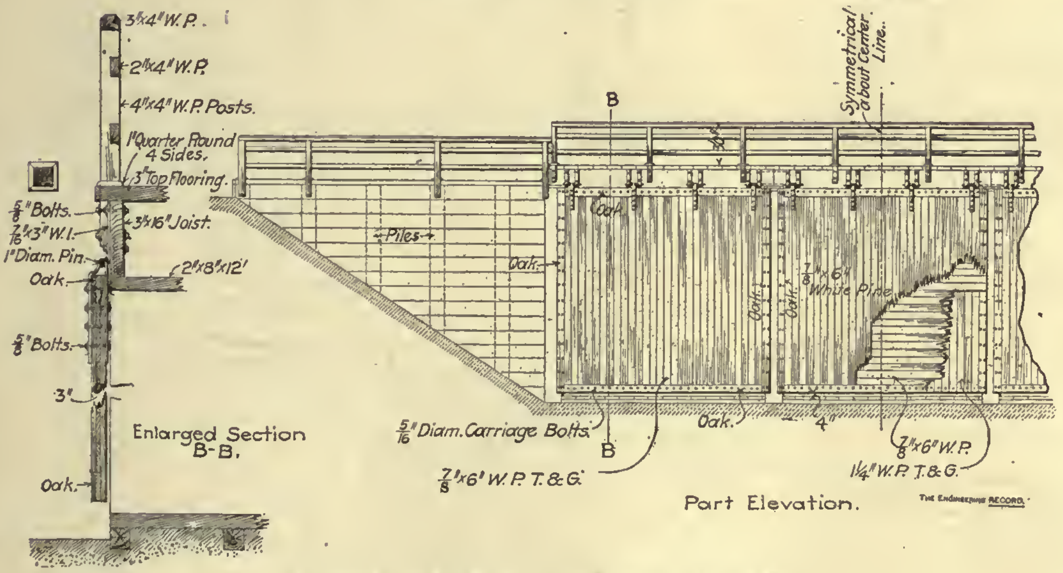
The excavation for this waterway was made largely with steam shovels, the clay standing nearly vertical until the timber lining could be put in place. The contract was executed by the Rich Construction Company. The waterway not only reduces the former course inside the grounds nearly one-half, but also affords a much smoother channel for the water, and on this account some expensive improvements had to be made in the river below the exposition. A number of bends were removed and several bridges reconstructed. As a result, during a very heavy storm about two months ago which was far more severe than anything actually anticipated, no part of the waterway or the rectified river below it was taxed to its full capacity, while the territory above the fair grounds was flooded in the heretofore customary manner.



Elevation of Bulkhead at Mouth of Channel.



Cross-Section.



Enlarged Section B-B.

Part Elevation.

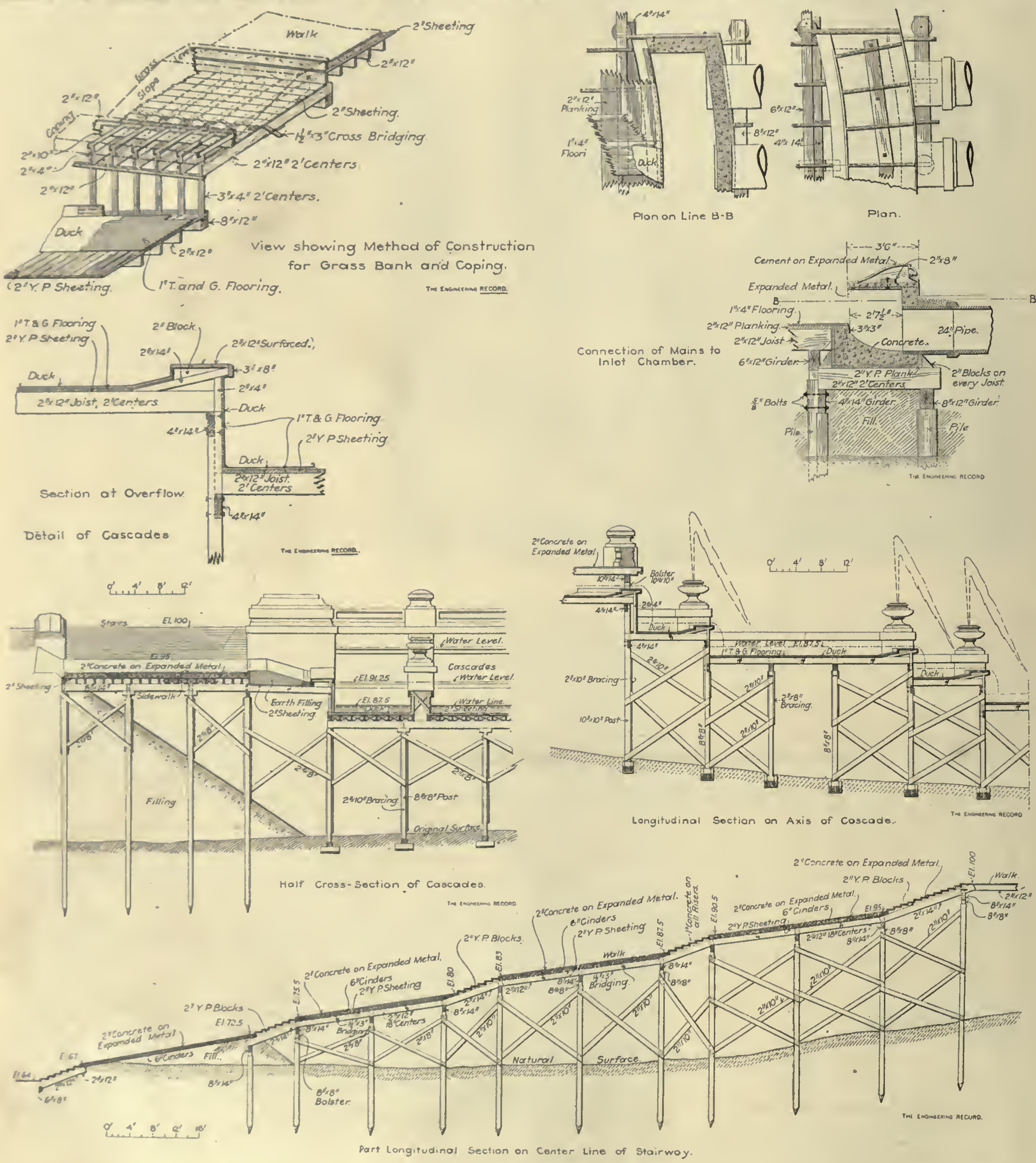
The Covered Waterway for the River des Peres.

Water Supply.—One of the first features of the work which received attention was naturally the water supply for the grounds. Not only was a large amount of water needed for use during the building period, but later the demands of the fire underwriters would call for a lavish provision of hydrants and mains. After careful consideration of all features of the problem it was decided to construct two entirely independent water-works systems. One of these is a low-pressure network of pipes receiving its supply directly from the city mains, and the other is a high service system operated with the aid of fourteen fire pumps in the Steam, Gas & Fuel Building. The piping system is under Mr. Phillips's charge, while the pumps come within the electrical and mechanical department, of which Mr. Henry Rustin was the head until he retired on account of ill health, his successor being Mr. Edward B. Ellicott. It should not be understood from the use of the term "low-pressure" in connection with the first mentioned system of piping that the water is not supplied under a good head. As a matter of fact, the three city mains which furnish the water were able in March to produce hydrant pressures of 88 to 93 pounds at the Liberal Arts Building, 56 to 59 pounds at the Fine Arts Buildings, 49 to 56 pounds at the Horticultural Building, 83 to 86 pounds at the Transportation Building and 83 to 85 pounds at Lindell Avenue. With such a record of hydrant pressures and with several fully equipped fire department stations in the grounds, the necessity of an independent fire-protection system does not appear very pressing.

The water is furnished through meters by a 36-inch city main on Concourse Drive at the west of the grounds, a 12-inch main running along Skinker Road, now called University Boulevard, and a 12-inch main along Lindell Avenue on the north side of the grounds. The cast-iron low pressure piping is all of the St. Louis Water Department standard weight and form down to 3 inches diameter, below which wrought-iron with screw couplings has been used. All pipes were required to be laid at least 3½ feet below the finished surface of the ground. A few hydrants were made after the St. Louis patterns for use on the low-pressure system only, but they were considered clumsy and were not self-draining. The specifications were accordingly changed to admit standard makes of self-draining hydrants. The valves and the flush hydrants are set in boxes of rough oak plank and scantling, with cast-iron covers.

The high pressure system was constructed of regular wrought-iron "line" pipe outside the buildings and of extra heavy pipe inside, all joints on mains of 12 inches or less being made with screw-end couplings and those above that size with cast-iron flanged connections. The piping was subjected to a 24-hour test of 300 pounds at the pumping station, after being laid. The mains of the Laclede Gas Company are run as a rule in the same trenches as the high-pressure water mains. The outdoor hydrants used on this system are of a different form from those on the low-pressure mains, in order that no confusion between them may arise. The high-pressure hydrants were especially designed by the manufacturers from specifications written by the Department of Civil Engineering and samples were submitted for approval before makers were allowed to fill the orders. The outdoor hydrant has two 2½-inch hose nozzles and a 4-inch steamer nozzle, the former having independent gates to open and close them. The hydrants inside the buildings are provided with one or two 2½-inch nozzles. The high-pressure pipes are carried in trenches about the interior as well as exterior of the buildings, as indicated in the large inset map, their size within the buildings ranging from 3 to 4 inches. Lines are taken from them up to the roofs, where there are connections provided for 1½-inch hose, and in addition there are sprinkler systems in some of the buildings, which have exterior steamer connections as well as the regular connections with the interior piping. As there are frequent cross-connections between the high and low pressure mains and the provision of hose lines and Babcock fire extinguishers inside the buildings is lavish, it hardly seems possible that any fire can ever get beyond the easy control of the regular appliances. In case this should happen, however, in most of the main buildings there are 2-inch or 3-inch turret monitors, such as are used on fire-boats. These throw powerful streams a great distance and will never be used except in case the safety of an entire building is at stake, for the jet from one of them will immediately wreck any ordinary exhibit it strikes.

The water supply for the fire pumps is furnished from the 12-inch main along University Boulevard or from Arrowhead Lake, a basin of 9,000,000 gallons capacity supplied from that main, which serves as a storage reservoir as well as a feature of the Philippine exhibit. The lake supplies the pumps through an independent 24-inch suction main. The pumps are the standard 18x10x12-inch Worthington underwriter's pump equipped with Fisher governors set to maintain a pressure of 150 pounds on the mains. They are located on the north side of the Steam, Gas & Fuel Building, and discharge into a 20-inch main which soon branches into two 16-inch lines.


View showing Method of Construction for Grass Bank and Coping.

Plan on Line B-B

Plan.

Connection of Mains to Inlet Chamber.

Section at Overflow

Detail of Cascades

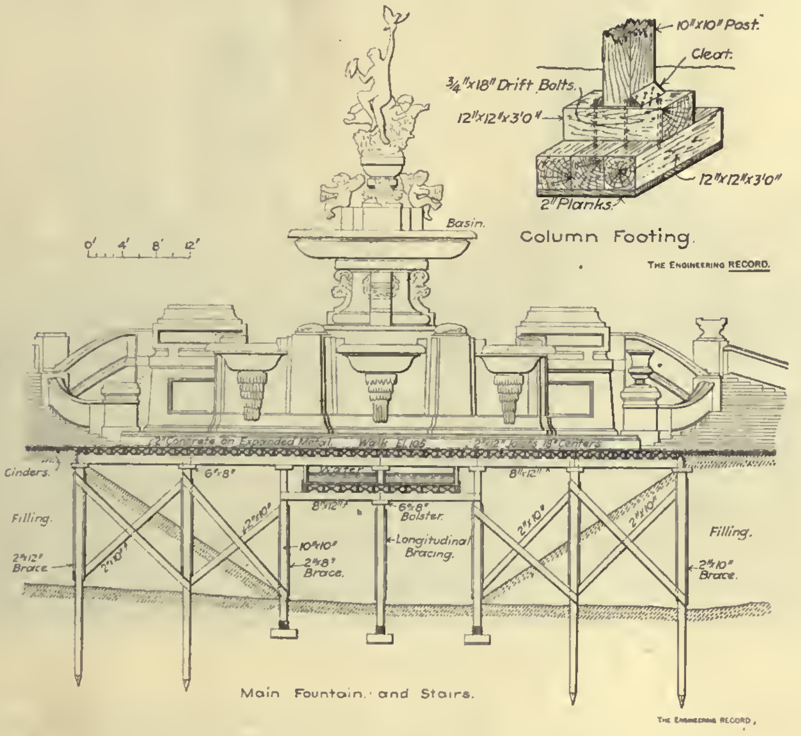
Half Cross-Section of Cascades.

Longitudinal Section on Axis of Cascade.

Part Longitudinal Section on Center Line of Stairway.

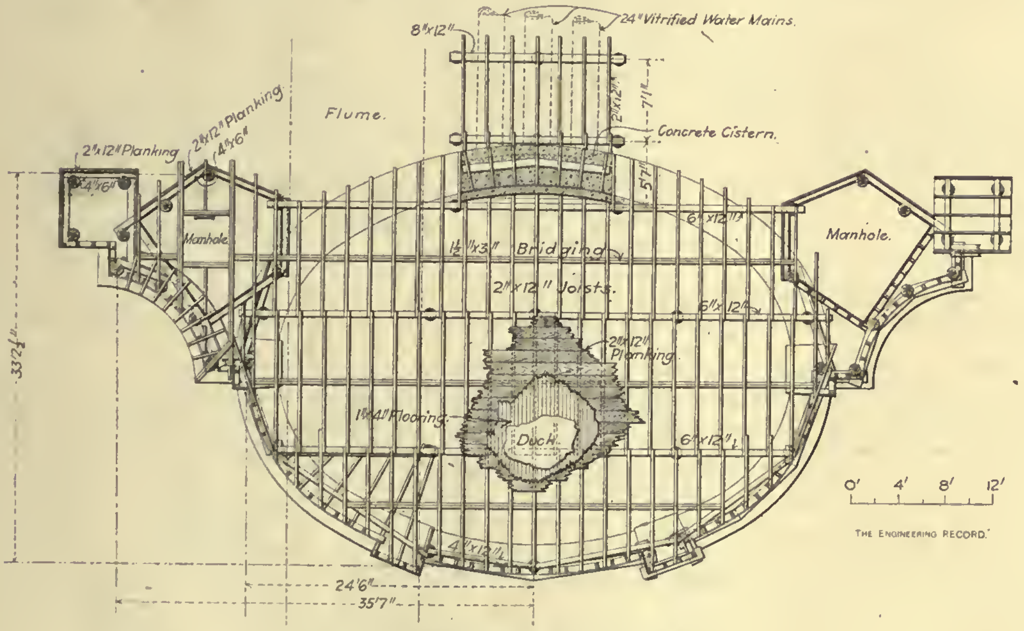
The Structural Features of the Cascades.

The Cascades.—The Cascades descending the gentle slope between the Festival Hall and the Grand Basin form the leading monumental feature of the exposition, and must be seen to be appreciated in all their beauty. They are the joint product of Mr. Masqueray as architect, Mr. Phillips as structural and constructing engineer and Messrs. Rustin and Ellicott as engineers of the mechanical plant. The water for their use is pumped from the Grand Basin and it is expected that the lagoons will be kept fairly fresh by the circulation thus produced in them as well as by aeration in its frequently broken fall down the steps. At the top of the hill in front of the Festival Hall and each of the restaurant buildings there is a fountain, that in the center being the largest.



Column Footing.

Main Fountain and Stairs.



Framing for Basin at Foot of Cosdade.

Details of Construction of Cascades.

The width of the central cascade at the top is about 40 feet, which increases to 160 feet at the foot, to which there is a total descent of about 90 feet, including a sheer fall of 21 feet into the basin. The cascade is made of three sheets of water separated by two curved division walls. Wide curved promenades with series of shallow steps border both of its sides. The two side cascades resemble it in general features, but are much smaller and have only single sheets of water about 18 feet wide at the top and 50 feet at the foot. They are also bordered on each side by low steps which, unlike those of the central cascade, are carried by a bridge acros the lower part of the fall. Beyond this bridge there is a wide curved basin in which the water comes to rest before it passes through an underground conduit to an elliptical basin about 60 feet long on the opposite side of the main promenade. From this basin the water flows through a concealed outlet into the grand basin. The central cascade is designed for a flow of 51,000 gallons a minute; provision is made for eighteen 1¼-inch jets and ten 1-inch jets which are delivered to it from the sides and bases. The two side cascades are each designed for a little over half the total flow.

The cascades and their adjacent promenades are elevated from 5 to 20 feet above the finished grade and are built of timber. The construction consists essentially of horizontal and slightly inclined platforms supported on transverse and longitudinal beams and girders carried by trestle-bents of vertical posts and piles. Both promenades and cascades are built with a solid wooden deck which, in the former case, is covered with a colored concrete wearing surface. The construction of the fountains at the summit, the curved basins at the feet of the side cascades and the oval basins on the margin of the Grand Basin are all of the same character, affording space for storage, mechanical installation and other purposes beneath the walks and sheets of flowing water.

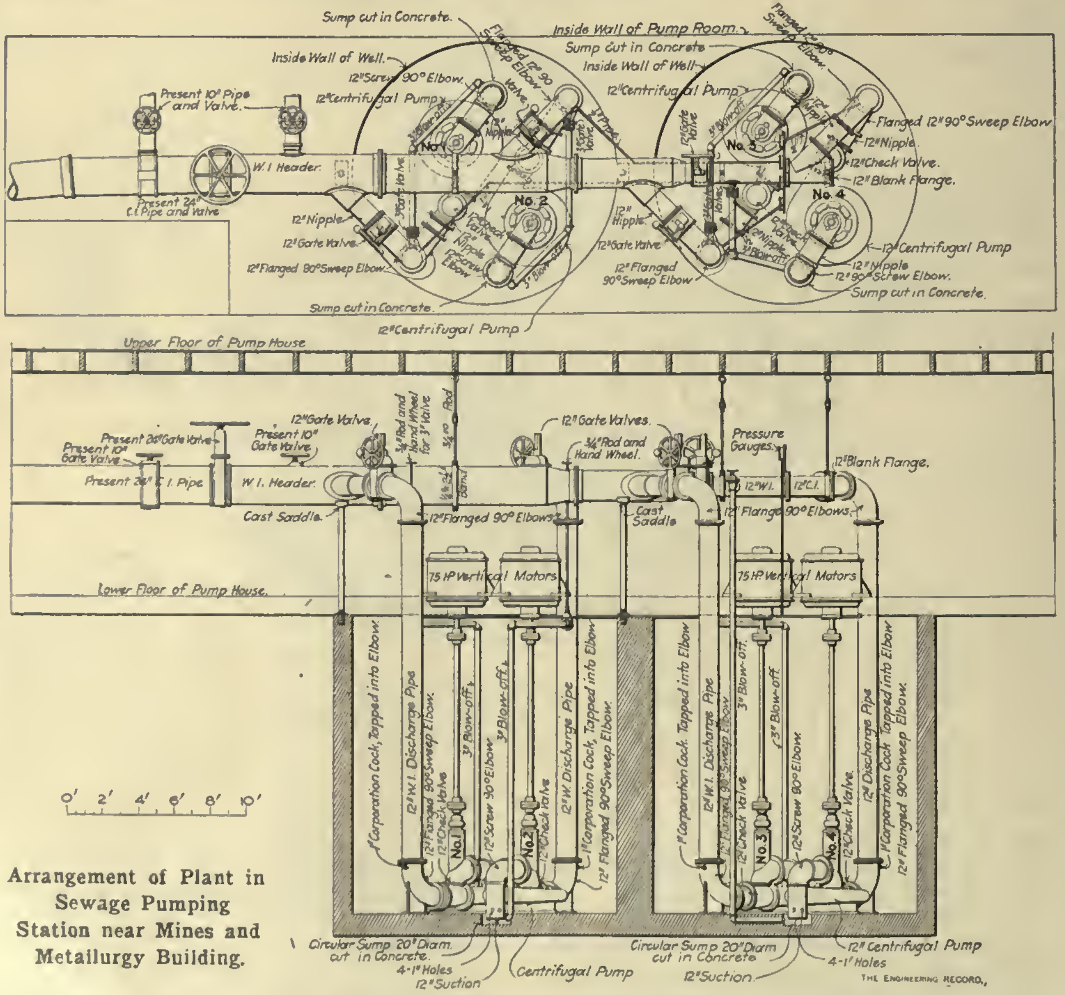
The details of timber work are simple and the main features throughout are similar to those shown by the partial transverse and longitudinal sections taken near the head of the main cascade. The vertical posts are X-braced with 2x10-inch planks spiked on at an angle of about 45 degrees in every longitudinal and transverse panel. Where the panels are high there are two sets of braces in each. The tops of the posts and piles are capped with transverse corbels 3 feet long which serve to slightly reduce the spans of the girders and afford prolonged support for their spliced ends. To protect the space underneath the cascades from moisture, special pains were taken to devise a tight deck or flooring. In all cases where there is a sheet or fall of water this is made with a lower course of 2-inch transverse sheeting covered with heavy-painted duck carefully lapped and slushed with paint at joints and protected by an upper floor of 1-inch tongued and grooved boards very carefully fitted at all joints, angles and intersections. The sides of the cascades are made with a single thickness of 1-inch tongued and grooved boards. The copings of the side walls for the three sheets in the center cascade are made with a wooden framework covered with expanded metal and plastered with cement mortar finished in imitation of white marble to correspond with the surrounding architecture. The side copings are protected on their outer edges by a solid concrete curb which retains an earth filling from 6 to 12 inches deep and 4 to 5 feet wide, separating the coping from the promenade. Underneath this filling there is only one course of deck boards and these are 2 inches thick.

The promenades are made in sections which are alternately flat slopes graded about 1 in 10 and easy flights of shallow stairs. The slopes are sheathed with 2-inch transverse boards above which there is a 6-inch layer of cinders covered with 2 inches of fine stone-concrete reinforced by expanded metal. The stairs are made with 1-inch treads and risers covered with Portland cement concrete 1 inch thick plastered on expanded metal lath. The bed of the waterway in the central cascade consists of a series of shallow basins at different levels. The water flows from one to another over horizonal weirs which have an overhanging edge as shown in the partial longitudinal section. The widths of the successive pools or basins vary from about 10 to 50 feet.

The construction of the side cascades is similar to that of the main cascade, but the dimensions are smaller. At the head of the cascade the promenade is carried over the water, as shown in the general cross-section. Here the structure, although supported on piles, is level with the finished grade. This is because it was thought best to provide a solid timber structure rather than to attempt forming the beds and promenades on soft fill. It was, therefore, built on trestle bents and afterwards the earth was filled in to grade on both sides, leaving, however, a considerable opening under the center of the cascade. The curved basin at the foot of the side cascade is nearly 200 feet long and has a horizontal floor of double planks covered with painted duck as described for the cascades. The floor is carried on 3x4-inch sleepers 24 inches apart laid flat on the level earth. The revetment walls are about 2 feet wide and are sheathed with 1-inch boards covered on top with 2 inches of concrete and expanded metal lath. Opposite the foot of the cascade a small concrete cistern is built in the edge of the basin and receives the upper ends of three 24-inch vitrified pipes through which the water from this cascade is carried under the promenade to the oval basin on the border of the Grand Basin and several feet above it. The construction of the oval basin is similar to that of the larger curved basin, except that its floor is supported on piles. In both basins the concrete coping of the revetment wall is moulded to a curved surface by means of transverse blocks nailed to the framework to receive the expanded metal, as shown in detail at the cross-section through the cistern. The spaces under the oval basins are accessible by manholes at each end.

View Looking toward Machinery Building, Showing Unfinished Lagoon Work.

The water from the lagoons returns through a wooden flume in the Grand Basin to the pump room under the platform of the east cascade, where the hydraulic and the electric plants are installed. There are three Worthington centrifugal pumps 11½ feet high with 40-inch suction and 36-inch discharge pipes. They are operated by 25-cycle three-phase Westinghouse induction motors of 2,000-horse-power capacity, which are said to be the largest of that kind yet built. The pumps discharge into a 100,000-gallon steel tank having an air cushion maintained by a special air pump at a pressure of about 60 pounds per square inch to provide a uniform flow and force the water to the upper fountain. Provision is made for draining each of the basins in the fountains and cascades if necessary and for draining the Grand Basin and Lagoons through outfalls to the waterway if desirable. The rough construction of the cascades including the grading, timber work and concreting, cost about $125,000, which does not include the cost of the machinery and of the ornamental balustrades, stairways, statuary and sculpture.



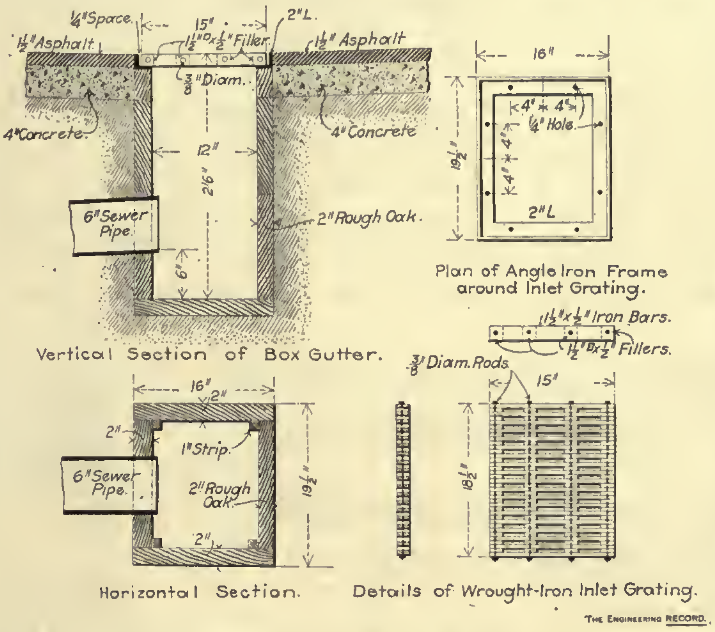
Arrangement of Plant in Sewage Pumping Station near Mines and Metallurgy Building.

The Lagoons.—No American exposition is considered complete without ample water effects and those have been provided at St. Louis on a lavish scale. The area of the grounds is so great that the extent of these channels and basins is dwarfed on the map. The depth of water in them is only 3½ to 5 feet. They are crossed in many places by submerged pipes and conduits, which it was desirable to place no deeper than absolutely necessary, and this reason as well as a wish to keep the amount of excavation at a low figure led to this choice of depths of water. As the passage of boats in such shallow basins and lagoons would stir up the clay bottom and keep the water muddy, the bottoms have been covered with gravel. A fair idea of the work is afforded by the accompanying view taken looking toward the Machinery Building.

The sides of the lagoons are protected by a wooden bulkhead or revetment. The construction consists of 6 x 8-inch posts on 8-foot centers, tied back every 8 feet or so, depending on the location, to anchor posts 12 feet from the face. The main line of posts is capped by a 4x12-inch oak timber and a 2x10-inch waling piece. This construction supports the plank bulkhead which retains the earth filling behind it. The bulkhead has two 1-inch faces back of which there is about 10 inches of clay puddle.

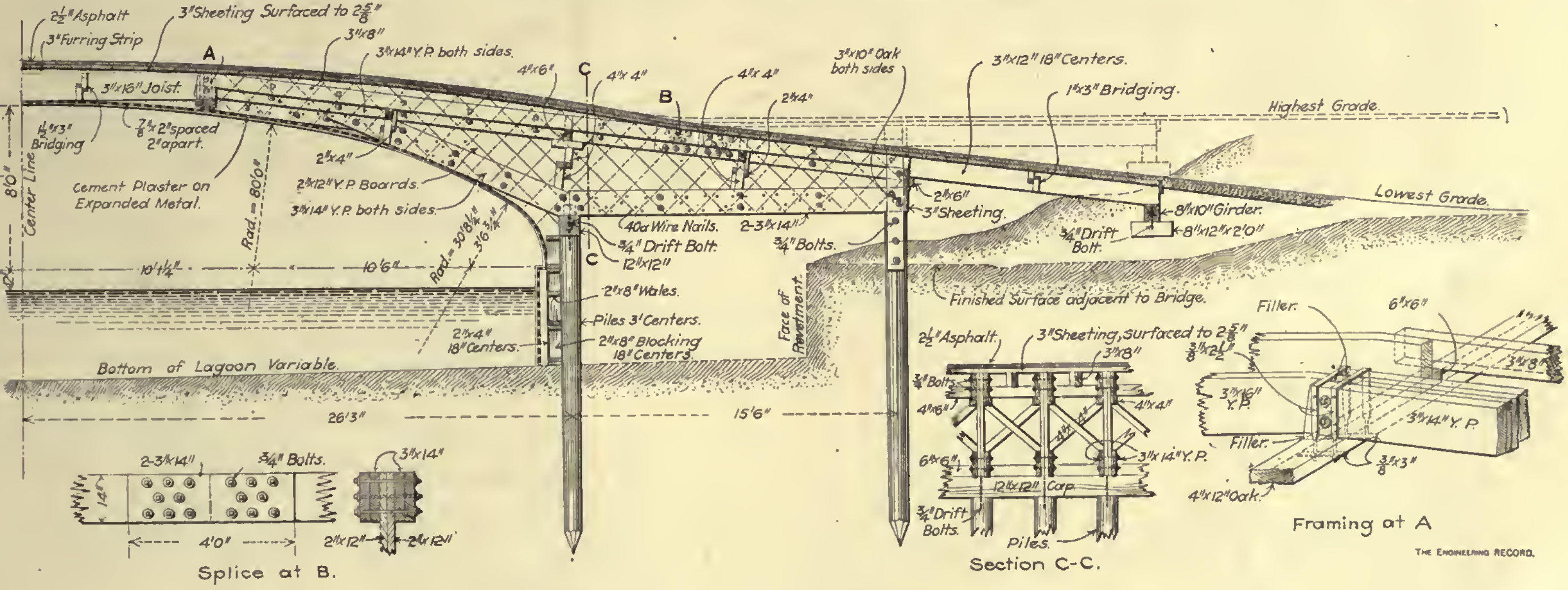
The upper part of these bulkheads is covered with cement on expanded metal, shaped to the appearance of heavy cut stone. The simplicity which characterizes the design of all the decorative features of the revetments is very successful in its effect. It in no way draws the attention of the visitor away from the main views by any eccentricity, and gives an impression of massiveness to the entire water picture, wherever it is seen.

Pavements and Walks.—The civil engineer who visited the Exposition a month ago had an opportunity to learn more concerning the behavior of different pavements under heavy traffic than would be acquired in the average city in several years. Every street was crowded with carriages, wagons and heavy trucks, while automobile omnibuses and heavy fire engines were occasionally seen. Some of the roads had been graded in the winter and were still settling. Railways, which will soon be covered over or removed, cut across the carriageways in many places. Trucks heavily loaded with machinery drove first over an unfinished sea of sticky mud, and then over fresh macadam, which was naturally torn up under the combined action of the mud and heavy wheel loads. In some cases the Department of Works had been directed by the Executive Board for reasons of policy to lay brick pavements before a subgrade and foundation could be properly prepared, and such streets could be seen going to pieces under the heaviest loads. The work was largely temporary, designed to facilitate teaming while carrying the final roadway construction gradually forward toward completion, but was nevertheless unusually interesting to the student of roads and pavements. Anyone who has observed the effect of the passage of an army over country roads can appreciate the wear and tear of the Exposition streets the last few weeks, yet visitors now will hardly recognize the mud-covered roads of spring in the trim pavements and drives about the grounds.



Vertical Section of Box Gutter.
Plan of Angle Iron Frame around Inlet Grating.
Horizontal Section.
Details of Wrought-Iron Inlet Grating.

Standard Catch-Basin Details.



Splice at B.
Section C-C.
Framing at A

Details of Standard Truss for Bridges over Lagoons.

The different classes of streets and drives are indicated on the inset map. Their aggregate length is about 35 miles. It will be seen that broken stone and gravel roads are most used, and these were built by day labor under the direct supervision of Mr. Phillips. Where a good subgrade could be secured the standard cross-section calls for a 2½-inch bottom course of coarse crushed limestone, a 1½-inch top course of finer stone and a wearing surface of screenings. On soft fills and for work done in wet weather the standard plan called for a 3 to 7-inch bottom course of large stone or riprap, then a 2½-inch layer of macadam stone, and finally a wearing coat. Many of the completed roads are 50 to 75 feet wide, but when first opened they were made 20 feet wide for construction purposes. No attempt was made to finish them when heavy teaming was being done, particularly in places where drainage was difficult. All that was proposed was to keep enough broken stone on the roadways to render them passable. In wet weather enough mud would soon be dragged over the stone to bury it completely out of sight, and the cheapest remedy for the situation, since the roads had to be kept open, was to put on more broken stone. Consequently there are places where over a foot of crushed rock exists, although these are of course uncommon.

The broken stone was delivered by cars on the service tracks to large storage bins, from which it was hauled as needed. It was originally proposed to use screenings, but Mr. Phillips noticed what an excellent surface can be secured with burnt clay, such as is used for railway ballast, and that is now extensively employed. The pleasing dull red finish this material affords will prove one of the most interesting features of the grounds to the visiting engineer.

A large amount of asphalt pavement has been laid by the Barber Asphalt Paving Company. In some places the existing macadam was covered with 3 inches of 1:2:5 Portland cement concrete, on which a 1½-inch asphalt wearing course was laid. The specifications for the standard roadways called for a 4-inch foundation of 1:2:5 Portland cement concrete for heavy traffic streets and 1:2:5 natural cement concrete for light traffic streets, covered with a 1½-inch asphalt wearing course; as a matter of fact, the contractors used Portland cement on all the work. The asphalt sidewalks have a 1¼-inch wearing surface on a 1:3:6 cinder concrete foundation 4 inches thick. The sub-grades were consolidated by steam rollers on all this work. There are also some cement walks.

Brick pavements have been employed to some extent. It was intended to lay them on a concrete foundation in every case, but the Department of Works has been compelled against its judgment to use timber foundations in some places, and occasionally allow the bricks to be placed on rolled sand and broken stone. The Pike, along which most of the attractions of the concession holders are grouped, is an example of these brick streets. It is 90 feet wide between curb lines and pitches toward a 3-foot concrete gutter in the center, the slope being 5 inches in 43½ feet. The rolled subgrade as covered with 1-inch rough plank to support the 1½-inch cushion of sand, on which the brick were laid on edge. Much of this road is on a fill and it has been badly torn up at frequent intervals in order to put in pipes and conduits to the various "midway" shows. Under the circumstances its condition during the exposition season will be watched with much interest.

The tearing up of the streets after being laid has been very frequent, and must inevitably affect their condition. In work planned on such a large scale by so many people and executed in a short time, it is unavoidable for a large number of pipe connections to be overlooked until the buildings are nearly finished. These connections must be made by trenching, and it is important to bear this fact in mind in considering the condition of the streets.

All curbing throughout the Exposition grounds is 10-inch oak plank, usually 3 inches thick. It is held on edge by 2½x2½-inch oak stakes 3 feet long spaced 4 feet apart.

A pleasant feature of the main walks will be the rows of trees, mostly maples, which have been planted in single and double lines along them. These were procured on the grounds, and have trunks 9 to 16 inches in diameter. In digging them up, the roots to a depth of 3 feet and a diameter of 8 to 12 feet were carefully protected from any injury, and the native earth was kept about them so far as possible. They were then slung horizontally on large trucks and hauled to their new position by traction engines, or teams of 6 to 8 horses. A large nursery for smaller trees and shrubs was established by the Landscape Department and has proved very useful in the improvement of the grounds.

Sewerage and Drainage System.—The separate sewerage system of the grounds includes previously disconnected sections of city sewers built in a haphazard manner to serve districts which were put on the real estate market in the form of building lots. For example, there was a 3½-foot brick sewer just west of the Philippine village, which has been connected with the sanitary sewerage system, and a number of other sections which have been incorporated in the drainage system.

The sanitary system includes about 9 miles of vitrified pipe sewers 8 inches and upward and about a mile of brick sewers. There is also a small system in the northwest part of the grounds, which connects with a septic tank built by Washington University. The main system discharges into a well close to the northwest front of the Mines and Metallurgy Building. From the well a 24-inch relief sewer runs to the covered waterway, but this will probably never be used. From this relief sewer two branches run into the 18x60-foot sewage pumping station, which contains duplicate plants arranged as shown in the illustrations. There are two 12-inch Worthington centrifugal pumps in each well driven by 75 horse-power Westinghouse motors; the connections of the pumps are so well shown by the illustrations that it is unnecessary to explain them further. The sewage is discharged through a 24-inch cast-iron pipe into a city sewer in De Giverville Street, about 3,500 feet distant, the total head on the pumps being about 20 feet. The pumping station building was designed in Mr. Phillips' private office.

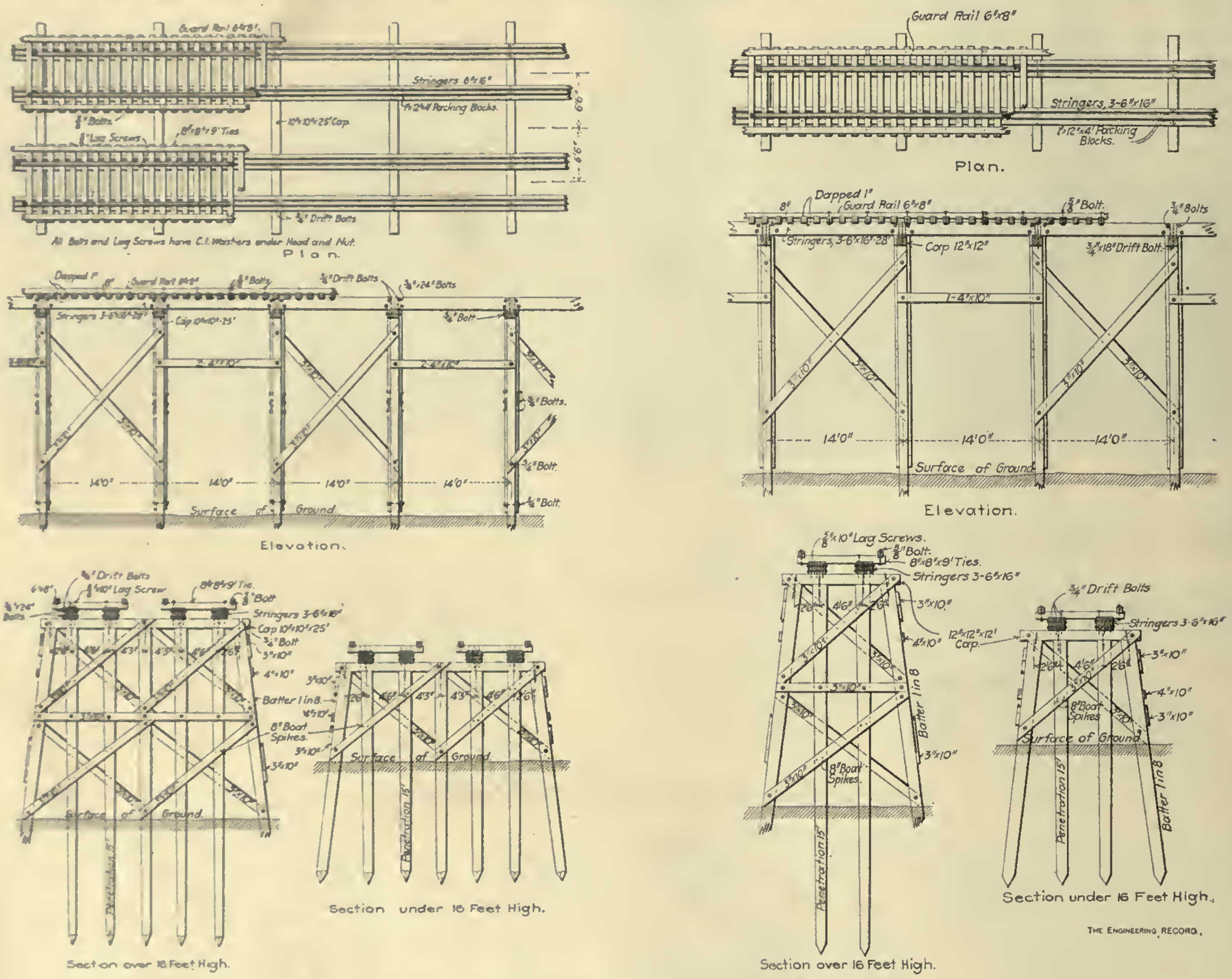
The sewers inside the buildings are cast-iron and steel and are laid so far as possible in the same trenches with the low-pressure water pipes. The plumbing in the buildings has been carried out in harmony with the St. Louis regulations.

The surface drainage system is very elaborate. The discharge from the roofs has been figured on the basis of a 3-inch rainfall, and the design of the system for this purpose on buildings as large as some of those at the Exposition was no small problem. The surface water is collected in wooden catch basins, of which a standard type is illustrated. The gratings of these basins are generally made of wood instead of iron, as shown in the drawings. On side hills and other situations where a flat inlet is undesirable, a vertical inlet has been introduced, having an opening along the curb line about 8 inches high and 2 feet long, guarded by ten slats. The storm water passes from the catch-basins through vitrified pipes to covered wooden drains, some discharging into the covered waterway and others into valleys outside the grounds.

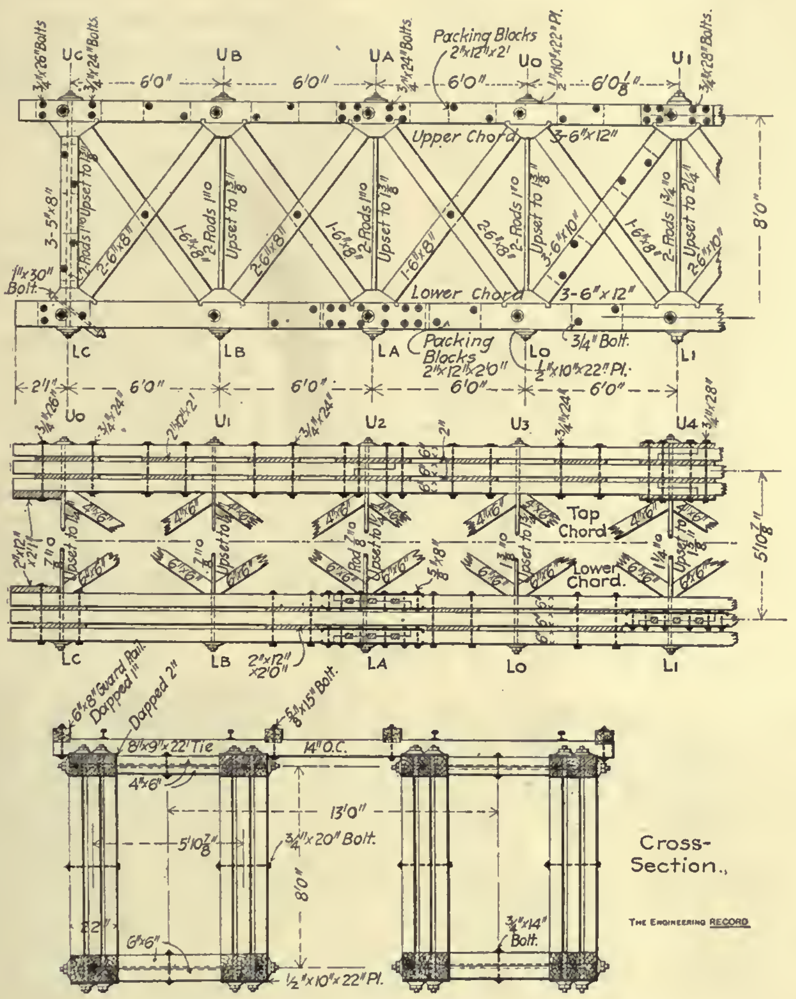
The trenches for the larger sewers were made by two Austin sewer digging machines hauled by traction engines. The earth was delivered to dump cars hauled on narrow-gauge tracks by locomotives to places where it could be used for backfilling over the completed sewer. The smaller trenches could be opened in the stiff clay without any sheeting.

Bridges.—The bridges of the Exposition are mostly built in accordance with a standard plan, differing only in their width and consequently in the number of trusses required. Their general construction is shown completely in one of the accompanying drawings. Externally, their architectural treatment has varied considerably, and the statuary and other decorative features have been modified for each structure so as to be in harmony with the surroundings and with the importance of the bridge. All of the structures are of the arch type, which is the only one having the necessary æsthetic value for such a purpose.

The trusses are 3 feet apart on centers and are supported on each side of the waterway on two rows of piles 15½ feet apart. Each truss consists of top and bottom chords of two 3x14-inch timbers with a solid web of two courses of 2x12-inch plank. At the center, where this construction is impossible on account of the low depth of the trusses, 3x16-inch joists are used, which are framed to the arms running out from the shore in the ingenious manner shown in the drawings. The trusses are braced



General Plans of Framed Trestles on Intramural Railway.

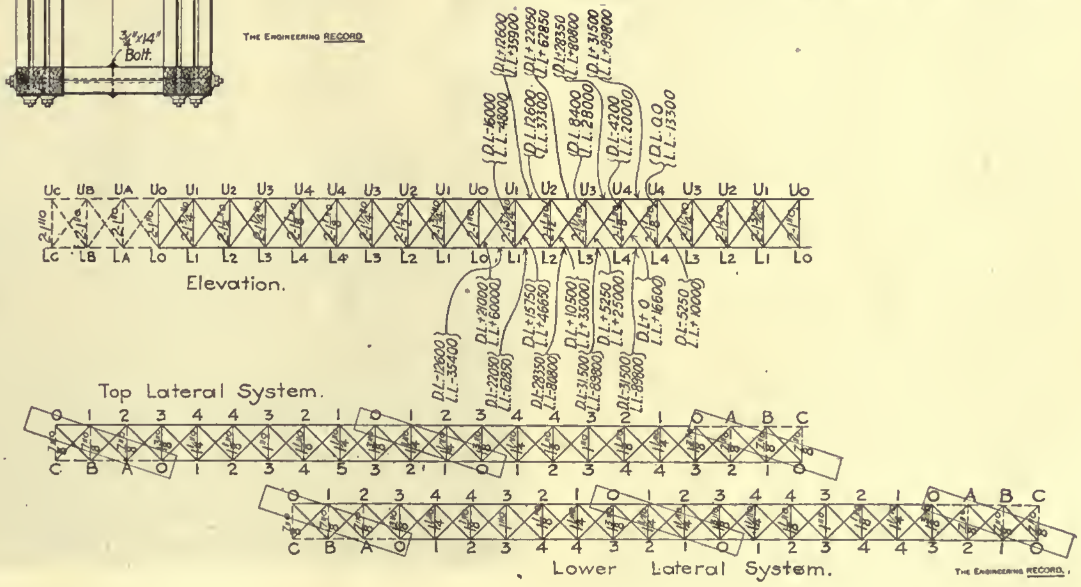


laterally by bridging at frequent intervals and also by diagonal cross-bracing. In many cases the details of the approaches vary from the standard truss on account of the necessity of raising the grade of the flooring; in such cases the flooring and the joists on which it rests are lifted on blocks without affecting the general structural design.

This system of construction has proved very stiff and satisfactory under the heavy loads which were imposed by the construction teams. Many of the bridges were not open to such traffic, however, and temporary pile trestles were built alongside them for railroad use and bent bridges for this use. The trusses are covered with close 3-inch sheeting surfaced to 2⅝ inches, on which a 2½-inch asphalt wearing coat was laid.

Railways.—Among the civil engineering features of the Exposition which impressed the visitor during March, there was none of more evident value than the railways within the grounds. The manner in which the transportation problem was handled by the Department of Works may be said to have saved the Exposition in one sense, for without the facilities it afforded it would have been impossible to have been ready to open the Fair last Saturday. There are three railway connections. On the south the Missouri Pacific and the 'Frisco systems enter the grounds; at the northwest corner a spur from the Wabash Railroad allows cars to be run into the grounds, and at the center of the north side is a spur from the St. Louis, Kansas City & Colorado Railroad. The Wabash connection will have to be closed as soon as the Fair is in full swing, and the same is probably true of the connection with the Colorado Railroad. Probably it will be possible to cover these tracks so that they need not be taken up and will thus be available for use during emergencies and after the Exposition has closed. The connection on the south side will doubtless be maintained for use throughout the season of the Fair.

While the buildings were under construction a large amount of trackage was put down temporarily for service purposes. Some of this was taken up and relaid elsewhere. On April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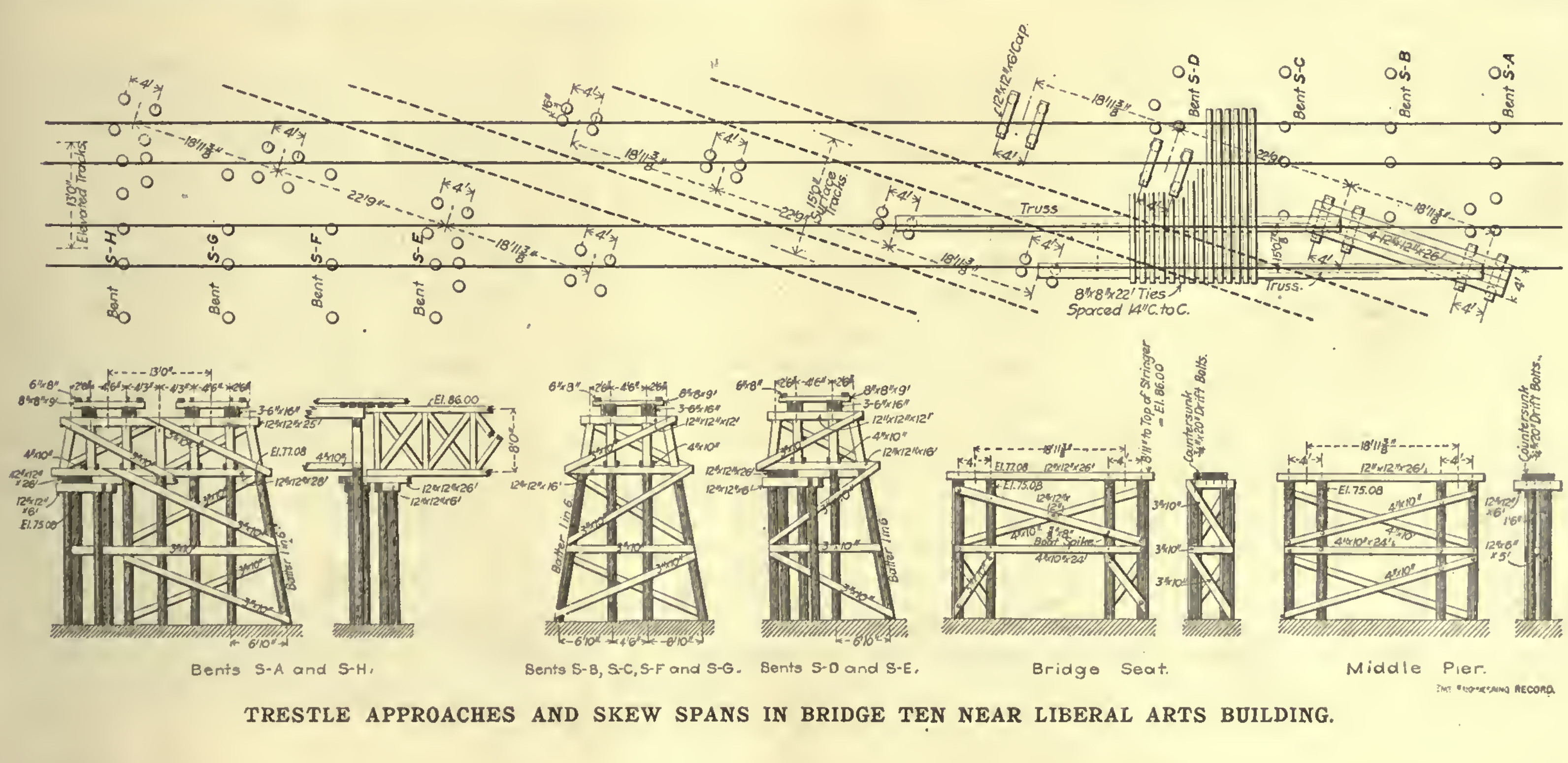
Elevation.
Top Lateral System.
Lower Lateral System.
The Engineering Record.



TRESTLE APPROACHES AND SKEW SPANS IN BRIDGE TEN NEAR LIBERAL ARTS BUILDING.

4 the trackage within the grounds comprised 20.83 miles of main line and spurs belonging to the World's Fair Terminals Railroad and 12.6 miles belonging to the Intramural Railroad. The inset map shows the location of these two systems very clearly. It will be noticed that the Intramural Railroad acts as a belt line running around the grounds, with cut-off lines across some of the large branches which afford direct connection by means of spurs with all the main buildings, except the Education Building, which contains no heavy exhibits. The tracks of the World's Fair Terminals Railroad have a practical storage capacity of 1,322 cars, and without such a capacity it would have been practically impossible to handle the exhibits satisfactorily. The main storage yard is in the southeast corner of the grounds beyond the Philippine enclosure, where a large provision of warehouse capacity has been made. These warehouses will be useful in receiving the late exhibits which must be teamed to the buildings. At the present writing the yard is comparatively little used, and the cars are delivered directly to the buildings where they are to be unloaded. This will, of course, be impossible very soon, because it will be out of the question to have switching trains run about the grounds while they are thronged with visitors.

The key to the railway situation is the Intramural Railroad. This was designed as an attractive feature of the Exposition, to be operated electrically with rather light cars. When work on the grounds had been fairly begun, Mr. Phillips recognized that no light construction would be possible, and as a result the entire line has been built for heavy freight traffic. Had this not been done, it is impossible to surmise what would have been the difficulties of installing the exhibits; to team them from the storage yards as proposed at one time would have been fatal to a punctual opening of the fair.

The road was constructed in many places on fills and the task of keeping it in good condition has been a trying one. The trestles and bridges are of the heaviest construction and a number of drawings illustrating them are reproduced in some of the accompanying cuts, which show at a glance how much stronger this intramural railway is than the line constructed years ago at Chicago. There is, in fact, no comparison between the two roads, as the St. Louis line is practically a standard road which is merely incidentally provided with trolley poles for its eventual operation electrically with passenger cars. These passenger cars, it might be added, have no steps, the platforms of the stations being on a level with the floors of the cars. This construction made it necessary to put in gauntlet tracks at every station, some distance farther from the platforms than the intramural tracks, so that the regular cars passing over the lines during construction would not tear away the station platforms.

The preceding notes give in a general way an account of the civil engineering work that has been necessary to bring the exposition to a finished condition. It goes without saying that the details of this work have necessarily been passed without comment, for each class of construction could be made the subject of an interesting article by itself. The success of the work has been due in no small measure to the co-operation of the heads of the various departments of Mr. Phillips' organization. These engineers have all worked without regard to regular hours or personal comfort in order that the grounds should be ready for visitors on the opening day. Mr. Phillips' principal assistant in charge of office work is Mr. H. R. Fardwell. The sewerage, water supply and fire-protection works have been under Mr. C. E. Young; the roads, lagoons and cascades, under Mr. E. R. Kinsey, and the railroads under Mr. C. H. Coleman. Mr. E. D. Williams was in charge of the stadia surveys in the earlier part of the work and subsequently acted as chief draftsman of the department.

Power.—The building of the fair also includes, of course, provision of power plant for the Exposition use as well as for exhibitors. As this feature of the work has been described at considerable length in recent issues of this journal, it will be very briefly summarized here. The Exposition Company has had built an 8,000 kilowatt service plant from the plans of Westinghouse, Church, Kerr & Company and has contracted with the Union Electric Light & Power Company for about 7,500 kilowatts more. These two sources furnish 25-cycle, 6,600-volt current. In addition there will be exhibited engines and generators with a capacity of about 20,000 kilowatts at various voltages, but the steam plant is insufficient to run all these engines at one time. It is proposed to put as many of the units in service as possible, for the characteristic feature of the fair is the display of machinery in operation.

Data Concerning the Largest Buildings at the Louisiana Purchase Exposition.

Name.	Size.	Cost.	Architect.	Contractors.
Transportation	525x1,300	$696,000	E. L. Masqueray.	H. W. Schlueter.
Manufactures	525x1,200	712,399	Carrere & Hastings.	John J. Dunnavant & Co.
Varied Industries	525x1,200	604,000	Van Brunt & Howe.	Rountree Construction Co.
Machinery	525x1,000	496,000	Widmann, Walsh & Boisselier.	Smith & Eastman Co.
Mines and Metallurgy	525x 750	490,000	Theodore Link.	Hill & O'Meara Construction Co.
Liberal Arts	525x 750	475,000	Barnett, Haynes & Barnett.	Kellermann Contracting Co.
Electricity	525x 750	399,940	Walker & Kimball.	Goldie Construction Co.
Education	525x 750	319,399	Eames & Young.	John J. Dunnavant & Co.
Agriculture	500x1,600	529,940	E. L. Masqueray.	Caldwell & Drake.
Horticulture	400x 800	228,000	E. L. Masqueray.	Caldwell & Drake.
Forestry, Fish and Game	300x 600	171,000	E. L. Masqueray.	Kellermann Contracting Co.

A Typical View of the Exposition Site before Work Began.

The service plant comprises sixteen 400-horse-power Babcock & Wilcox boilers equipped with Roney stokers, mechanical draft apparatus and two 4,000-horse-power Cochrane feed-water heaters made by the Harrison Safety Boiler Works; this apparatus, with the Worthington feed pumps, is located in the Steam, Gas and Fuels Building. The steam mains run through a tunnel to the Machinery Building, where they supply four vertical Westinghouse Corliss compound engines, two direct-connected to Westinghouse alternators of 2,000 kilowatts each, and two to General Electric machines of similar rating. The 6,600-volt current is delivered directly to the distributing mains through a switchboard which also controls the purchased current. Two Worthington barometric condensers are employed. The overflow water from their hot wells is led through pipes in a tunnel to the hot well of the four cooling towers.

The distributing mains are run in large wooden tunnels reaching the main buildings. In each building there is a sub-station with transformers, and rotary converters where necessary. The outdoor lighting will be done by incandescent lamps, a large part of them of 8-candle power. The buildings will be outlined with them, while the Cascades are provided with special lighting effects so that the main picture is as beautiful at night as during the daytime. Indeed, to those who were unable to see the Pan-American Exposition, the illumination at night will prove a revelation of the possibilities of electric lighting.

As before stated, the electrical and mechanical department of Mr. Taylor's work has been under the charge of Messrs. Henry Rustin and Edward B. Ellicott. The actual operation of the service plant is in the hands of Mr. Charles E. Foster. Mr. Thomas M. Moore is chief of the department of machinery and Prof. W. E. Goldsborough, chief of the department of electricity on the staff of Mr. F. J. V. Skiff, director of exhibits; the operating exhibits furnishing current are under their general supervision.

Thirteen Model Tenement Houses, built for the City and Suburban Homes Company, of New York, were opened for inspection this week. These houses are divided into two, three and four-room apartments, with fireproof halls. Every room has light and thorough ventilation. Each apartment has private hall and toilet, steam radiators, gas range, two porcelain tubs and other conveniences. The rents are moderate.

The Effect of Pressures on the De Laval Steam Turbine.

The effect of the initial and final pressures on the performance of the nozzles of the De Laval steam turbine, and the value of superheating with that form of turbine were discussed before the Society of Arts of the Massachusetts Institute of Technology by Mr. Charles Garrison of the De Laval Steam Turbine Company, on December 31 of last year. The address in full, which includes a description of the turbine, is given in the current issue of the "Technology Quarterly."

Regarding the design of the nozzle he explained that with a given initial and final pressure, the divergence of the nozzle must be definitely and accurately determined, in order to get the maximum velocity of the steam at the periphery of the wheel. He assumed a case where the initial presure is 150 pounds, by gauge, and the vacuum is 26 inches of mercury, represented by about 1.9 pounds pressure absolute. Under these conditions the speed of the steam will be 3,800 feet per second. If the terminal pressure is varied to 20 inches vacuum or about 4.9 pounds presure absolute, with the same nozzle the point where the 4.9 pounds pressure occurs is well within the nozzle and the full expansion has been completed at that point. The steam then has to travel a certain distance along a diverging path, and therefore, he says, its speed is diminished appreciably by the time it reaches the periphery of the wheel. As the energy delivered to the wheel is proportionate to the square of the velocity of the steam, the power drops off very rapidly.

Suppose, he says, the initial pressure is changed from 150 to 100 pounds, leaving the final pressure 26 inches, or 1.9 pounds, as in the first case. With the same nozzle the effect in cutting down the power will be very small, and could be compensated for by opening an additional nozzle so as to give a greater steam admission area. The reason that the terminal pressure makes a great difference while the initial pressure makes a small difference he explains by considering the volumes dealt with under the differing conditions. At 150 pounds gauge pressure the volume of the steam is 2.75 cubic feet to the pound, and at 1.9 pounds pressure absolute it is 190 cubic feet, so that the admission area of the nozzle must allow 2.75 volumes to pass at a very low speed, while at the discharge end 190 volumes must pass at a very high rate of speed. For the 20 inches vacuum, the corresponding volume is 75, so that, the point where this volume passes is well up in the nozzle and there is a constant loss of speed during the rest of its journey, its elastic property having ceased at that point. With the lower steam pressure of 190 pounds and the vacuum of 26 inches, the volume at admission is changed to 3.86, while the volume at discharge is still 190, so that the difference in initial volume is but a small part of the total volume on emission.

A Typical Scene on the Exposition Site during Grading.

The actual loss of power he calculated in the following manner: The velocity under the first case where the nozzle was suited to the conditions was 3,800 feet per second. The velocity under the second case, with 20 inches vacuum, he found was 2,800 feet per second, so that the power delivered to the wheel fell in the ratio of the square of these velocities; that is, the value of the square of 2,800 divided by the square of 3,800, or nearly one-half. With the change of steam pressure from 150 to 100 pounds, the loss in power was 8 per cent., due to the admission area being too small for sufficient steam to pass through the nozzle at this lower pressure. The turbines are designed, he stated, so that the combined nozzle area will allow a 10 per cent. continuous overload and this, he asserted, will care for 25 per cent. momentary overloads without decreasing the speed of the wheel more than a slight amount.

The effect of the terminal pressure, as outlined, is taken advantage of in a device attached to the turbine governor when the machine is operated condensing. When the speed tends to become excessive, air is admitted to the wheel chamber and the vacuum reduced from, say, 26 inches to 10 inches, or lower, and immediately the velocity of the steam is greatly diminished and the speed of the wheel cut down below its normal, even though there is no load on the turbine and the throttle is wide open. To show this action he described the case of a 150-horse-power turbine started with all nozzles open, the nozzles being designed for 150 pounds pressure and 26 inches vacuum; when the condenser was shut down and the turbine exhausted against the atmosphere, the turbine would not come up to full speed with no load.

In illustration of its comparative freedom of danger from water he described the case of a 30-horse-power turbine generator. The boiler tender left the pump running until the boiler was full of water and the turbine was working like a Pelton water wheel. No damage was done, the turbine merely slowing down. As soon as the steam was free from water the turbine resumed its normal pace.

With regard to the subject of superheat he feels that superheated steam reduces the fluid friction loss to a considerable degree by allowing fewer particles of water to come in contact with the revolving parts. Under adiabatic expansion in a diverging nozzle, the steam, while starting on its journey in a saturated condition, condenses as expansion proceeds, so that under such conditions, as, for example, 150 pounds boiler pressure and 28 inches of vacuum, 23 per cent. of the steam is emitted, he stated, in the form of water. This part of the steam has, therefore, given up its latent heat in useful work, that of increasing the velocity of the particles. In estimating the saving expected by the use of superheat with the De Laval turbines, 8 per cent. is allowed for 100 degrees Fahrenheit and 13 per cent. for 200 degrees. Mr. Garrison believes that the increase in economy is probably largely due to the reduction of friction, as the percentage is greater than would be due to thermodynamic causes. He does not venture to say at what degree of superheat the highest commercial economy occurs, but he places the upper theoretical limit not far from 1,470 degrees Fahrenheit, as with steam at 150 pounds pressure this means a temperature of over 1,800 degrees, which is near the point of dissociation of the steam. Superheat of about 600 degrees Fahr. (based on the supposition that the specific heat of superheated steam under these conditions would be 0.80) with 150 pounds gauge pressure and a 28-inch vacuum, would give saturated steam at the buckets of the wheel, so that he comes to the conclusion that while they gained by diminution of fluid friction, there is a loss from lack of condensation and from not freeing the latent heat units.

As to high vacuum he stated that with a 300-horse-power wheel operating with 150 pounds gauge, the gain from a vacuum of 22 inches to one of 28 inches is about 6 per cent. per inch, the percentages being figured from the next lower vacuum. The condenser problem is one that he considers needs special consideration, as it takes large cooling surfaces and a great volume of water to produce a vacuum of 28 inches of mercury. He mentioned a De Laval 300-horse-power turbine in operation in Dakota with a vacuum equivalent to 29 inches, using an Alberger condenser and steam delivered with 225 degrees of superheat.

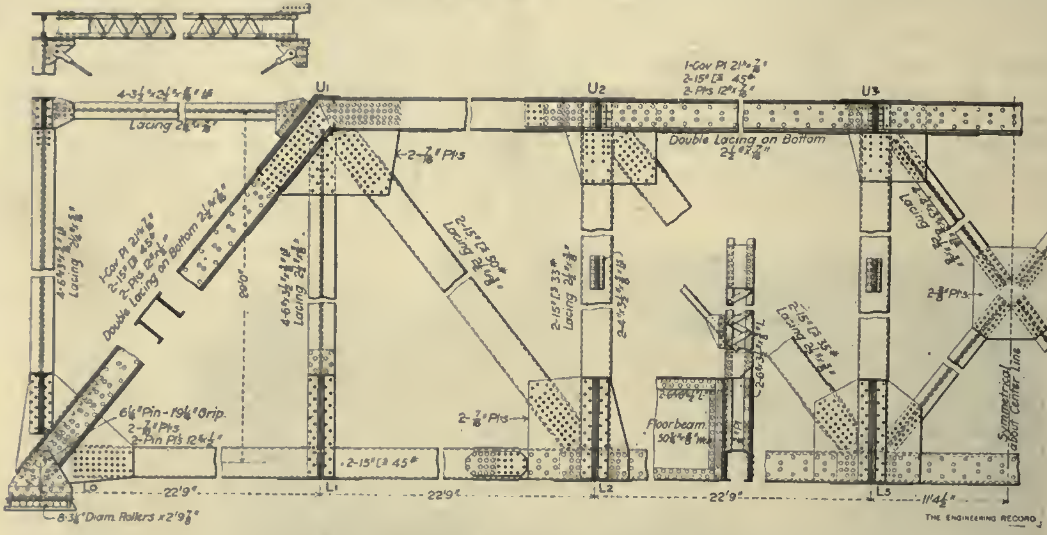
The Largest Boring for Water-Works purposes in England was recently completed for the Gainsborough Urban District Council. According to "The Engineer" this borehole is 1,515 feet deep and was not sunk without some annoying delays. One of these was particularly serious. When a depth of 725 feet had been reached, the rope carrying the boring tool broke, and buried the tool. This accident caused an interruption of no less than twenty-two months, but eventually the tool was recovered, and the boring completed to its full depth in 1900. Pumping machinery designed to have a maximum capacity of 70,000 gallons per hour has been installed over the borehole.

The Fraser River Bridge, British Columbia.

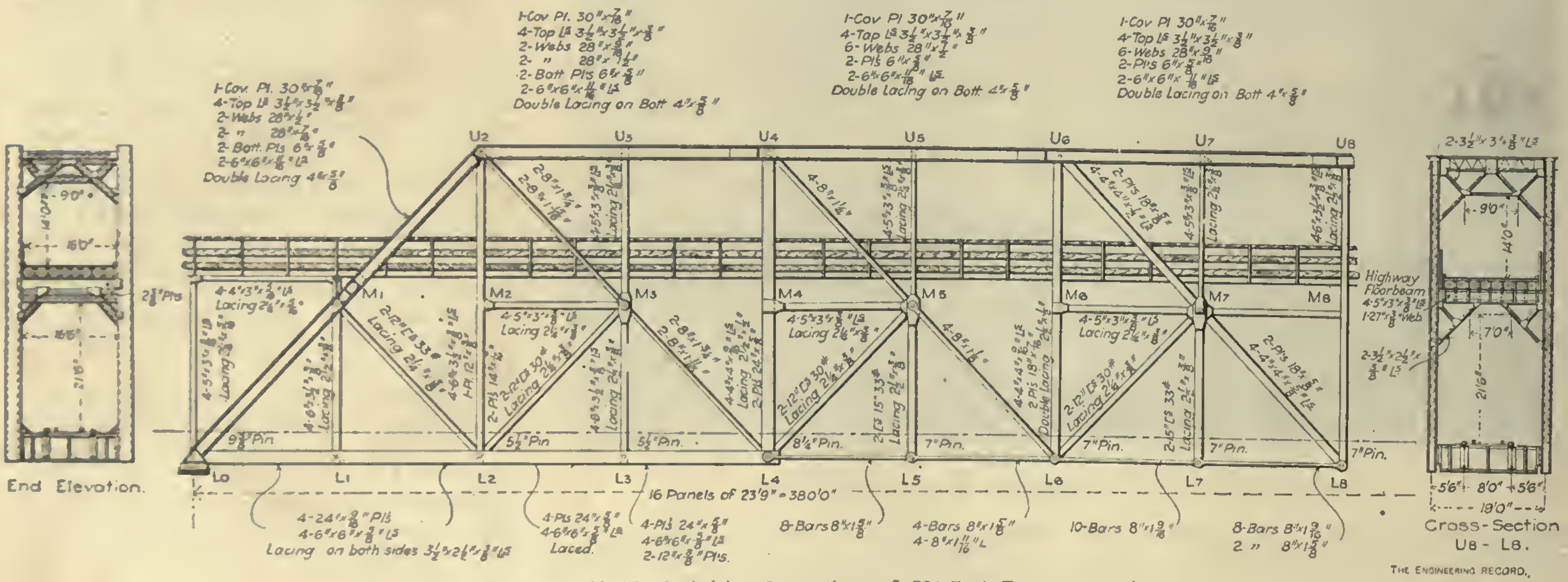
Part II.—Fixed Truss Spans.

The 159-foot span has Pratt trusses with top and bottom chords, end posts and principal vertical and diagonal members made with pairs of 15-inch channels latticed. The end vertical post and the center-panel diagonals have I-shaped cross-sections made with two pairs of angles back to back, latticed. All web members are field-riveted to wide connection plates shop-riveted to the outsides of the bottom chord and to the inside of the top chord webs. The ends of the trusses have pin bearings in riveted shoes. The lower floorbeams are 51 inches deep with ⅝-inch webs and 6x6-inch flange angles without reinforcement plates. The lower flanges are flush with the lower edges of the bottom chords and the ends are cut square and field-riveted through their vertical web-stiffener angles to the webs of the bottom chord and to the vertical post. The top floorbeams are plate girders 15 inches deep made with ⅜-inch web plates and pairs of 5x3-inch flange angles. The top flanges are flush with those of the top chords, and the floorbeams are web-connected to the top chord channels. A lateral strut and kneebraces made with pairs of 3x3-inch angles are riveted to the bottom flange of each top floorbeam. The portals are of special design and consist of double web plates 45½ inches deep riveted to the flanges of the inclined end posts and stiffened on the lower edges with single 3x3-inch angles latticed together. The upper edges are riveted to bent flanges on horizontal plates stiffened by transverse angles latticed together. The struts thus develop both vertical and transverse stiffness and serve as end upper floorbeams.

At the shore end of the bridge the roadway is deflected abruptly to one side so that it can descend clear of the railroad tracks. The platform between the end of the span and the inclined roadway is carried by a special cantilever floorbeam which has a tapered end projecting 16 feet 9 inches beyond the center of the truss. The web of this floorbeam is field-riveted to the tops of a pair of vertical posts which engage the end lower chord pins. The extremity is braced to the end panel point of the top chord by a horizontal diagonal I-beam 20 inches deep.



Half Outside Elevation of 159-Foot 3-Inch Span.



Half Outside Elevation of 380 Foot Truss..

The Fraser River Bridge: Detail Elevations of the Fixed Truss Spans.

The 380-foot fixed span has pin-connected Pratt trusses 50 feet deep and 19 feet apart on centers. They have sub-divided panels with full-length verticals and half-length diagonal and horizontal struts. There are top and bottom lateral systems with X-bracing of pairs of angles in every panel. The highway floor is carried just above the center of the vertical posts and there are open-web portal struts built with pairs of angles over the railroad and highway. The top chords have reinforced webs with two flange angles on the upper edge and one flange angle on the lower edge. Splices are made about 3½ feet from pin centers on the sides toward the ends of the truss. Each joint has top and bottom flange cover plates and two outside and two inside plates on each web. All these are field-riveted to the pin ends of the chords and are shop-riveted to the opposite ends so as to form jaw plates engaging the chord sections when assembled. Horizontal connection plates are riveted to both top and bottom flanges at the principal panel points to receive between them the transverse struts and lateral diagonals. The bottom chords have two full panels of 47½ feet long which are stiff members made with built channels 24 inches deep. The webs are reinforced to a thickness of 1¼ inches, and the flanges are made with 6x6x⅝-inch angles latticed and connected at panel points by tie plates with their edges stiffened by transverse angles. The sub-diagonals are made with pairs of 12-inch channels latticed and have pin-connections at both ends. The intermediate longitudinal struts have I-shaped cross-sections made with two pairs of 5x3-inch angles back to back latticed, and at the ends are field-riveted between jaw plates on the vertical posts.

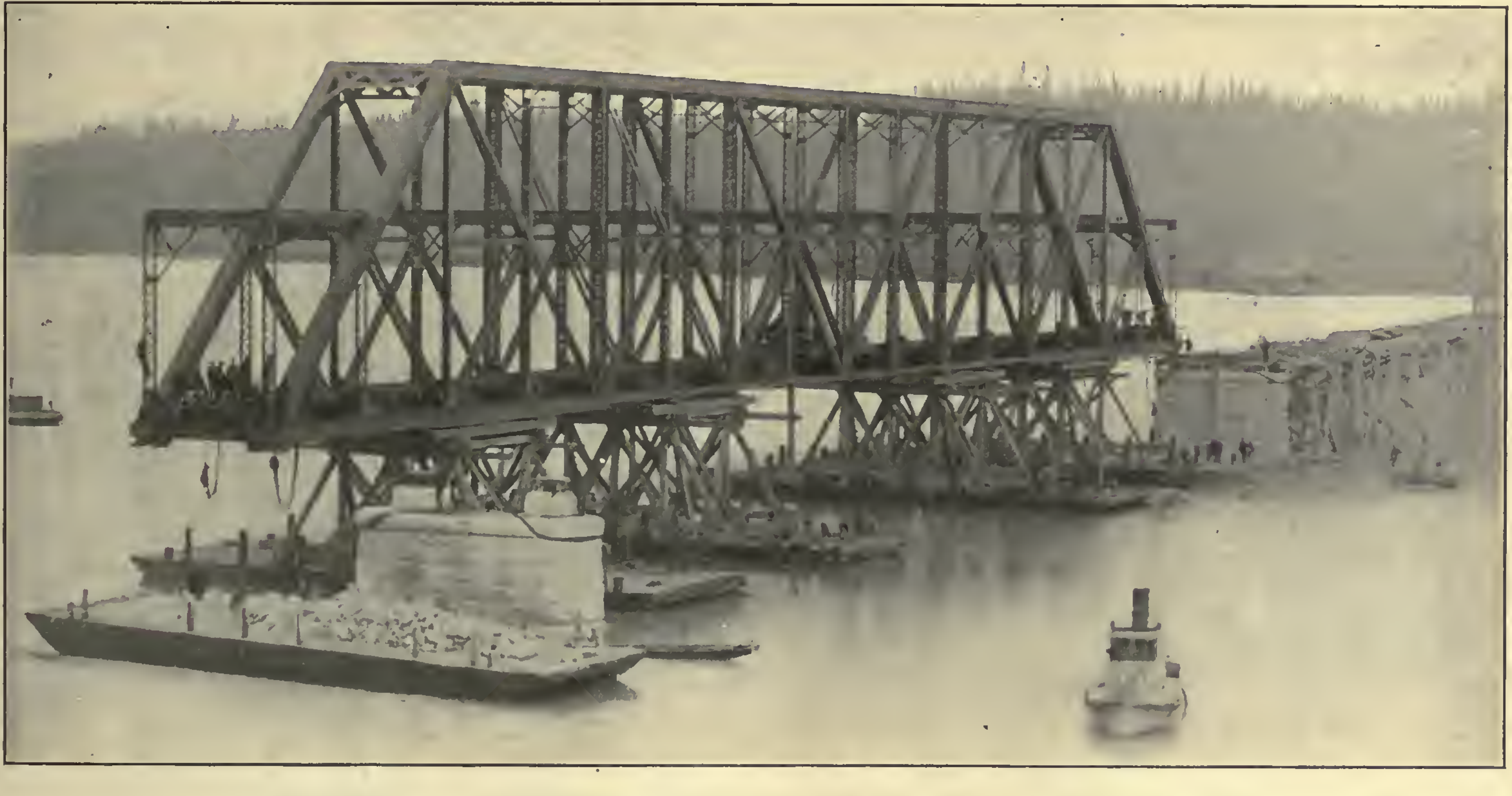
The main diagonals in the center panels are stiff members made with pairs of built channels latticed. The top lateral braces have I-shaped cross-sections made with pairs of 3½x2½-inch angles back to back latticed and kneebraced at each end with pairs of angles reaching nearly to the middle of the strut. The lower portal has two solid web plates 39 inches deep with 4x3-inch single flange angles on the insides. Both top and bottom flanges are latticed. The outside plate extends across the cover-plate of the end post and is riveted to it. The inside plate is about 5½ feet shorter and clears the flanges of the inclined post. The roadway portal is built up with pairs of heavy angles latticed together. The highway floorbeams are 27 inches deep with ⅜-inch webs and 5x3-inch flange angles. They have square ends riveted through the web-stiffener angles to the vertical posts and are kneebraced by pairs of angles at each end.

The railroad floorbeams are 51 inches deep, with their webs made in three sections each. The end sections are inclined upwards to engage the vertical posts above the lower chords. Both top and bottom flange angles are made continuous from end to end, being bent at the web splices. The lower corners of the web project beyond the lower flange angles and have their edges stiffened. The bottom flanges are connected with the vertical posts by horizontal plates field-riveted to both members to receive the diagonal lateral braces. The expansion ends of the stringers are seated on bearing plates in deep wide pockets riveted to the vertical web stiffener angles of the No. 7

floorbeams. All of the stringers have their ends faced and are riveted solidly to the floorbeam webs.

The ends of the floorbeams in this span and in all other spans are faced where they are riveted to the vertical posts. The expansion shoes are seated on segmental rollers that have cast-steel pedestals with curved upper surfaces and a longitudinal web to prevent lateral displacement of the rollers. Special vertical plates are tap-bolted to the sides of the roller beds and project above them with short upper flanges engaging the planed surfaces of Z-bars which are riveted to the base plates of the shoes to form sliding joints excluding dust from the roller beds. The pedestals under the fixed shoes have planed upper surfaces and are 23 inches high to compensate for the absence of high roller beds and allow the masonry to be kept the same height on both piers.

All of the truss spans, except the 225-foot spread span and the 380-foot fixed span, were erected in the usual way in their required positions on pile trestle falsework with an ordinary striding wooden tower traveler. At pier 3 the depth of the water was so great and the tidal current so strong that it was considered impracticable to build falsework to support the adjacent spans during erection. They were, therefore, erected on falsework near the south shore and floated into position. Separate falsework trestles were provided for the divergent trusses of the 225-foot span adjacent to piers 8 and 9 clear of the west side of the bridge. The regular falsework was driven for the 380-foot swing span, but before the span was assembled thereon, the 380-foot fixed span was erected on it complete.



The Fraser River Bridge: Seating the Three Hundred and Eighty-Foot Fixed Span on Its Piers.

At the morning low tide, November 11, 1903, four scows were floated under the bridge in spaces left for the purpose, between the falsework bents. A timber tower on the deck of each scow reached nearly to the bottom chord of the bridge, and, with the rising tide, was lifted high enough to engage both ends of two floorbeams. Long timbers 24 inches square were laid transversely on the tower caps to receive the weight of the span which was carried through the floorbeam connections, thus reversing the regular functions of the members and making the floor support the trusses. Some of the secondary members of the trusses were temporarily reinforced by timbers bolted on to enable them to endure the erection stresses, and some of the main diagonals had filler pieces clamped between their eyebars to give them compressive strength.

When the bridge was lifted from the falsework, it was towed transversely by two steamboats and swung clear of it and the piers. It was then moved parallel to its axis and brought back to the required position between piers 2 and 3, on which it was deposited by the falling tide, and by admitting water ballast to the scows. The weight of the span alone was 788 tons, and the weight carried by the scows was 825 tons, including track timber, blocking, etc. The work was rapidly and successfully accomplished, and only 40 minutes elapsed from the time the span was moved clear of the falsework until it was ready to be lowered to its seats on the piers. The scows were floated under the span at 3 o'clock in the morning, and the work was virtually completed at 11 A. M. Before the commencement of operations the scows were partially filled with water ballast which was pumped out to expedite lifting the span from the falsework. The span was moved at slack water of high tide when there was little difficulty or danger in controlling it.

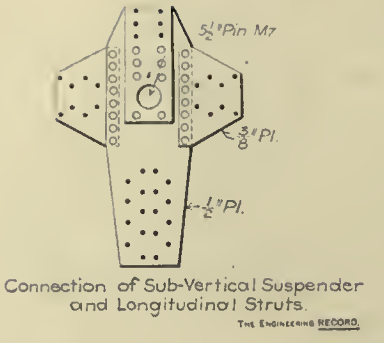
The bridge was designed by Messrs. Waddell & Hedrick, consulting engineers, Kansas City, Mo., who inspected its manufacture and supervised its erection. The Dominion Bridge Company, Montreal, Mr. Phelps Johnson, manager, built and erected the superstructure, and Messrs. Armstrong, Morrison & Balfour, of Vancouver, were the contractors for the substructure.

Asphalt on Table Mountain, near Cape Town, South Africa, has been discovered in a large deposit, estimated to contain approximately 500,000 tons. An experimental pavement laid on a small area of one of the streets of Cape Town is reported to be satisfactory.

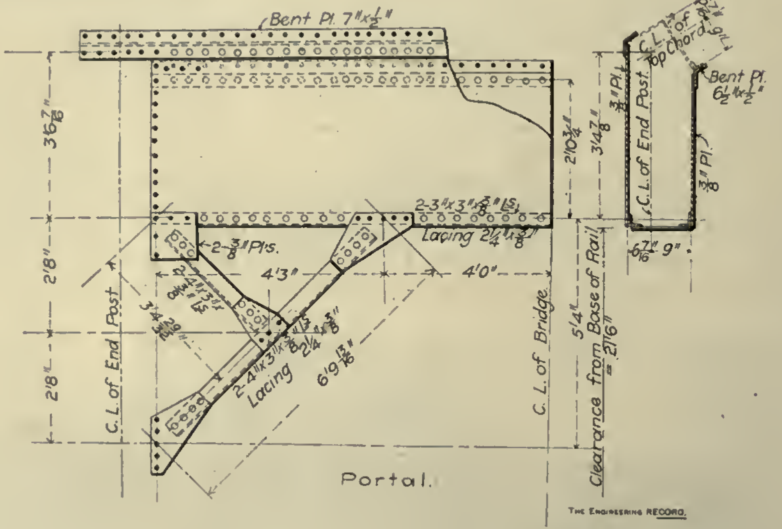
An African Cableway.

The line of the Cape to Cairo Railway intersects the Zambesi River in Africa a little below the famous Victoria Falls, where the gorge is about 430 feet deep and will eventually be crossed by a steel arch of 500-foot span. The width at water level is about 220 feet, and one bank is nearly perpendicular, while the other is inclined at an angle of less than 45 degrees from the vertical. In order to transport about 40,000 tons of railway construction plant and materials across the river at this point before the bridge is built, an electric cableway is to be installed with an estimated capacity of 800 tons a day. This will have a single main cable 8⅛ inches in circumference and 870 feet long between the centers of the steel towers when unloaded. One tower will be a pyramidal structure 36 feet high and about 10 feet square at the base, with the top guyed to anchorages on the shore side. The other tower is an A-shape rocker-bent or shear legs with two inclined columns 79 feet long, having tapered rectangular cross-sections made with four angles latticed on all sides. Their normal position is in a plane transverse to the cable and inclined about 45 degrees from the vertical.

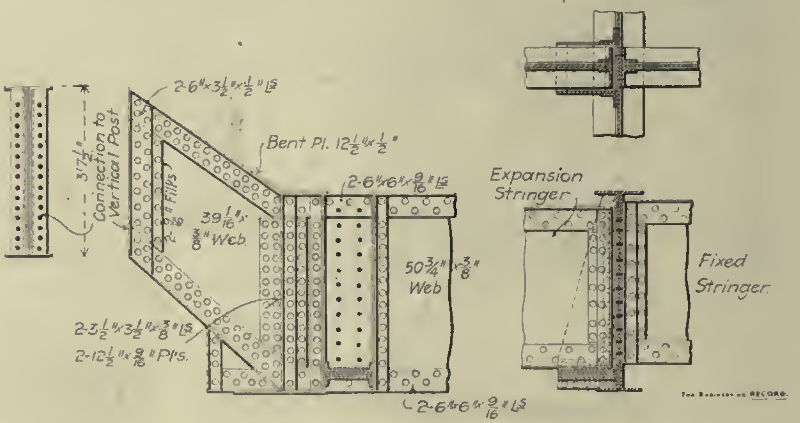
The end of the cable is made fast to the top of the shear legs, and from the same point a scale pan containing a 60-ton counterweight is suspended. The effect of this arrangement is to provide a constant compensating tension on the main cable, which tends to reduce its deflection under the live load. Under dead load alone the cable has a deflection of 6½ feet at the center point. Under the 10-ton live load, which is the capacity of the cableway, the deflection is 43½ feet more. The feet of the inclined tower posts are seated in concrete reaction piers and the tops are anchored against the cable strain by a guy rope, which is slack when the cable is unloaded. The hoist is operated by an independent electric motor, carried on its two-wheel trolley and receiving current from a copper conductor adjacent to the main cable, thus dispensing with all carrying and hauling ropes. The motor has one terminal connected to the conductor through a starting switch and resistance and the other terminal connected to the frame of the apparatus. The trolley carries a cage for the operator and is traversed by locomotive gear. The hoist is provided with two independent lifting ropes, so that the load can be tilted if necessary. The cableway was designed by Mr. R. A. Poole, Westminster, England, and was built at the works of the Cleveland Bridge & Engineering Company, Ltd., Darlington, where it was erected and tested before shipment. It was illustrated in a recent issue of "Engineering."



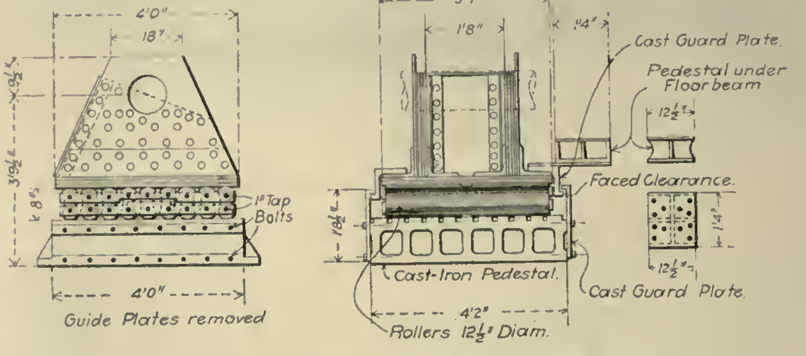
Connection of Sub-Vertical Suspender and Longitudinal Struts.



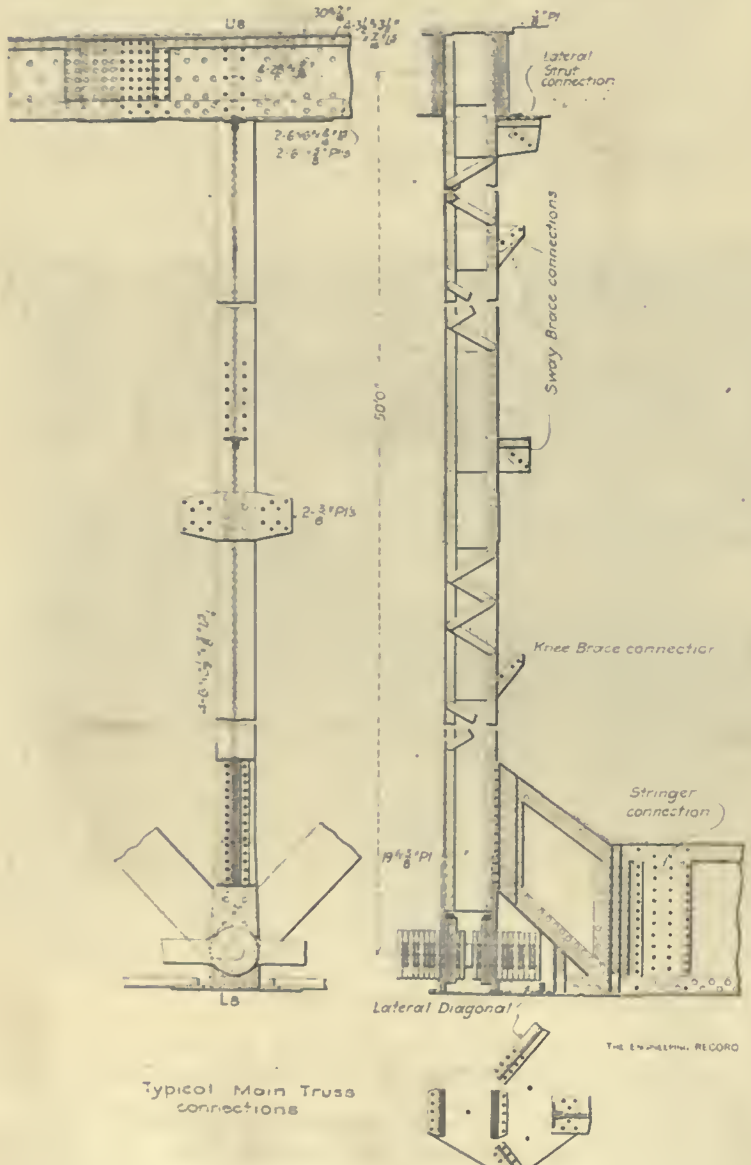
Portal.



Floorbeam and Stringer connection at L7.



Shoe Roller and Pedestal for 380 Foot Span.



Typical Main Truss connections

The Fraser River Bridge: Details of Connections, Roller Pedestal and Portal in the Fixed Truss Spans.

Typhoid Fever Epidemic at Waterloo.

The city of Waterloo, Ia., containing about 16,000 inhabitants and located on the banks of the Cedar River, in Black Hawk County, suffered from a severe typhoid epidemic in the months of January, February and March, 1904. There was a total of about 300 cases and 30 deaths and it has been estimated that the cost to the community was at least $300,000.

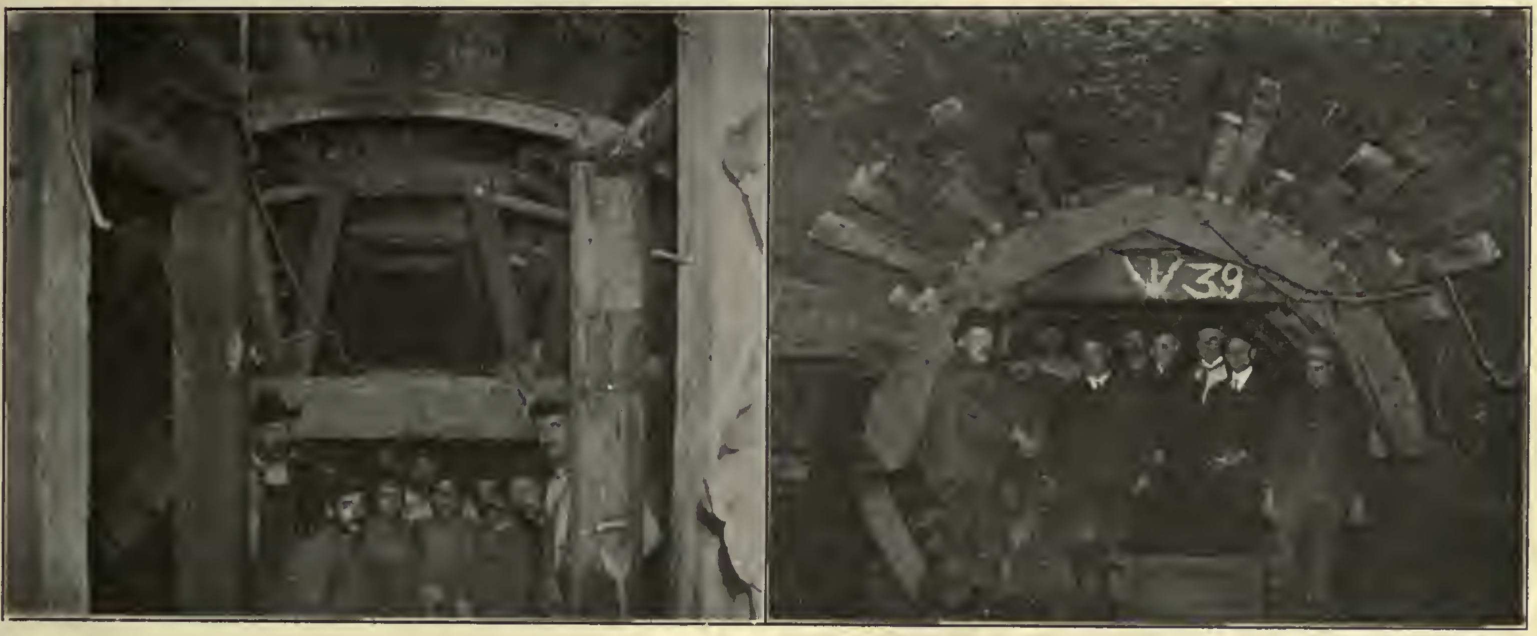
The water-works are owned by a private company, the source being the Cedar River and the intake being located in the heart of the city. The supply is filtered through five Jewell gravity filters, two of them being 17-foot filters and the other three 10 feet each. Alum is used as coagulant. The water supply was tested on March 1 by Drs. Bierring and Alberts of the State University, and both the raw and the filtered water were found to be very bad from a bacterial standpoint. Drs. Bierring and Alberts reported B. coli communis as present in the filtered water and claimed to have isolated the typhoid organisms in both the raw and the filtered water. Since the date of their examination the water has also been analyzed by Dr. J. B. Weems of the Iowa State College at Ames, and Professor Ross of Drake University at Des Moines, who united in pronouncing the filtered water very bad from a sanitary standpoint.

The city engaged Professor A. Marston, dean of the division of engineering at Iowa State College, Ames, to make a report on the entire water supply problem and the water company engaged Mr. Geo. A. Johnson of New York City to make investigations of the filter plant and report any needed changes. Both Professor Marston and Mr. Johnson advised certain changes in the filter plant which are now being made and Professor Marston has just made an exhaustive report on the future supply of the city in which he advised the sinking of three artesian wells to determine whether it will be possible to develop a pure supply from that source. In case this cannot be done he advises the installation of slow sand filters with a sedimentation basin of 24 hours capacity, arranged so that a coagulant can be applied when found necessary at the time of freshets and in the spring when the water is discolored from decaying vegetation. Professor Marston strongly advised that in connection with any filtration plant expert supervision and daily bacterial tests should be provided for, although the plant would be a comparatively small one.

Models of the New Croton Dam, the old Croton dam and the central gate-house at Jerome Park reservoir will be exhibited at St. Louis by the Aqueduct Commissioners, of New York City. The exhibit will include also enlarged photographs, maps and drawings showing the works and methods of construction and specimens of old wooden pipes.

The Extensions of the Brooklyn Sewerage System; Ninety-Second Street Trunk Sewer.—II.

In the preceding article the methods of driving, timbering and lining the 10, 10½ and 11-foot tunnel for the Ninety-second Street main trunk sewer were described and illustrated, and particular attention was directed to some of the novel features and advantages of the system of timbering used by the contractors. Additional photographs showing some of the details of this timbering and the centers for the brick arch supported by nailing to the roof segment timbers accompany this article. Although the tunnel is being driven through running material, for the most part, and some of the strata of sand and gravel bear water freely, the ground-water level is so low that it has been unnecessary to employ compressed air. With so large a bore, liberal-sized shafts and no headings more than 900 feet long, the natural ventilation has been excellent, so that not only has the air been clear most of the time for the instrumental work of the engineers, but it has been wholesome to breathe.



Brooklyn Sewers: Secondary Timbering Supported by Segment Timbers; Centers and Lagging for Arch Supported by Segment Timbers.

Last week it was stated that the contractors carried their electric light wires on the line of telegraph poles in Ninety-second Street. For this accommodation the contractors pay a slight fee to the telegraph company. The longest line of electric light wires is about 2,700 feet, and the lights on this line in the heading of shaft No. 3 are noticeably dimmer than those in the headings of shaft No. 2. The engine which drives the dynamo also drives a circular saw, a band saw and other tools from a jack shaft which is belted to the other main pulley of the engine.

Mention was made in the preceding article of the very deep manholes necessary on this tunnel sewer. Some of the drawings reproduced herewith show the details of their design. For about 4½ feet longitudinally each side of the manhole the thickness of the arch of the sewer is increased to 24 inches. The lower part of the manhole has a D-shaped cross-section with the manhole steps in the straight side, which rises perpendicularly from the springing line of the sewer. The upper part of the manhole is an ellipse in cross-section 5 feet 4 inches long and 3 feet 8 inches wide. At the manhole the sewer has haunch walls 30 inches thick at the springing line and carried down plumb, as shown. For the first 10 feet above the top of the sewer the manhole walls are 24 inches thick; for the next 10 feet they are 20 inches thick; for the next 12 feet 16 inches thick, and for the remainder of the distance to the surface of the street they are 12 inches thick. As indicated, the manholes are the points of connection for the collecting sewers, of which more will be said later.

With the fourth and last construction shaft completed and the headings started from it in both directions, it is anticipated that, with the excellent rate of progress made hitherto, the tunnel will be completed and cleaned by the first of October. Meanwhile the outlet will be constructed so as to be completed at the same time. Active operations at this end of the sewer are just being commenced at this date, May 7.

As previously stated, the outlet is located on the east shore of the Narrows of New York Bay at a point where the maximum depth of water below mean high tide, at the end of the sewer, is 15 feet. The range of the tides at this place is about 5 feet. No fear is entertained by the sewer department engineers that this outlet will be in any way offensive. The shore of this corner of Long Island is skirted by a wide pleasure road known as the Bay Ridge Parkway, extending along the top of the bluff from the United States Government reservation at Fort Hamilton for about three miles northwesterly, then turning inland. Consequently the point of discharge for the sewage will be not less than 500 or 600 feet horizontally from the nearest house, as well as being about 50 feet below it, as is shown by the accompanying profile of this portion of the sewer.

At the location for the outlet the bottom of the bay is covered with a coarse, shingly gravel which overlies a compact deposit of sand and gravel. The first step in construction is the dredging of part of the area to be covered by the outlet structure to an average depth of 5 feet, thus removing about 300 cubic yards of materials and bringing the higher parts of the bottom down to elevation —7, the elevation for the bottom of the concrete foundation. A considerable part of the area is already below the required elevation, as is indicated by the accompanying profile. The accompanying drawings show the arrangement and some of the details of the outlet structure.

The 11-foot regular section of the sewer terminates at a point about 250 feet from the outlet end, or practically at the base of the bluff, and is followed by a reducing chamber 80 feet long. One end of this reducer is an 11-foot circle and the other is an arched chamber 10 feet 5 inches high and 26 feet wide inside. From the larger end the three parallel conduits of the outfall extend 170 feet farther into the bay. Accompanying drawings show a horizontal section and a cross-section at each end of the reducer. It is to be made almost wholly of 1:2:4 Portland cement concrete, the interior being faced with 6 inches of mortar composed of 1 part of cement, ½ part sand and 1½ parts granite dust, so as to give a smooth granolithic finish. The outside of the top will also have a 6-inch layer of this granolithic mortar troweled smooth.

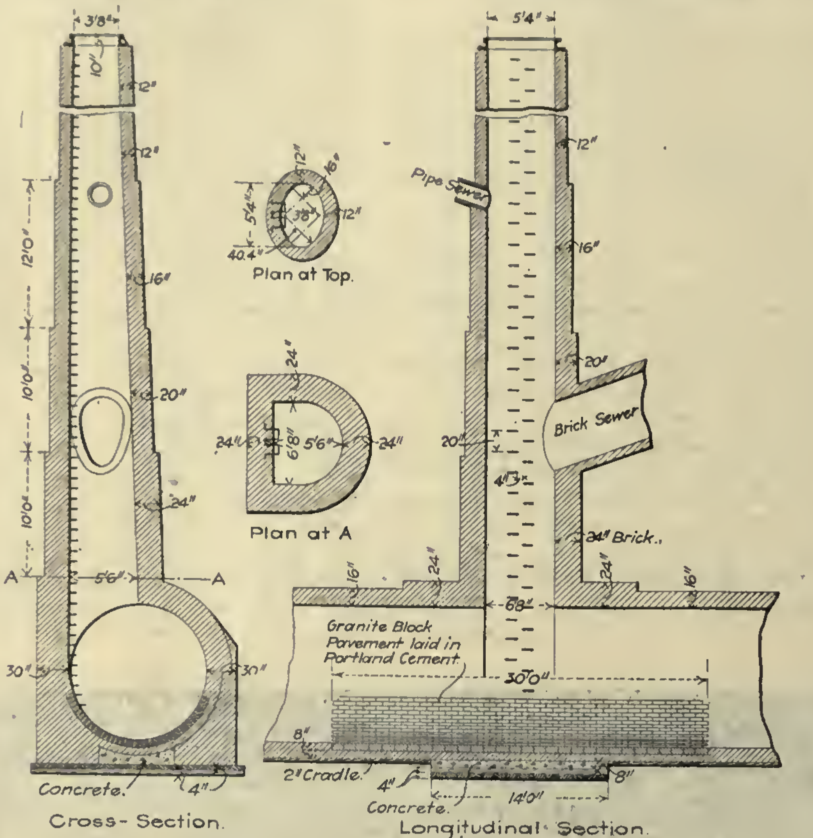
The invert of the sewer is level, at elevation —4, from the beginning of the reducer to the end of the outfall. The bottom of the reducer is changed very gradually from the circular form to a triple invert corresponding with the inverts of the three outfall conduits, two ridges being raised gradually in line with the conduit division walls, as shown on the drawings. The arch is to be reinforced with ¾-inch square twisted steel rods, or with ¾-inch corrugated steel bars, placed transversely and spaced 12 inches center to center, and with sheets of 6-inch mesh No. 4 gauge expanded metal laid on the rods. This reinforcing steel is to be bent to suitable radii and embedded in the concrete 6 inches from the inner face of the arch. The junction between the brick lining of the tunnel and the reducing chamber will be strengthened by extending the concrete about 8 feet on to the brickwork, as indicated.

The outfall structure will consist, as shown by some of the drawings, of three conduits side by side, each 7 feet 4 inches wide and 7 feet 4 inches high inside, with 16-inch brick arches, 12-inch brick inverts and brick walls, all enclosed in Portland cement concrete. The two division walls are to be 24 inches thick, and at the end of the reducer will have sharp cut-waters of dressed granite. The side walls are to be 28 inches thick. The last 8 linear feet of the masonry structure will be wholly of concrete. The concrete above the arches is to be reinforced with sheets of 6-inch mesh No. 4 expanded metal, bent to the form shown. The concrete bottom of both the outfall structure and the reducer is to be reinforced with double rows of ½-inch twisted square steel rods or ½-inch corrugated bars spaced 18 inches apart on centers, both longitudinally and transversely. The outside of the top of the outfall structure will be finished with 6 inches of granolithic mortar. Along the top of both the reducer and the outfall structure there are four level grooves or notches 12 inches wide formed in the concrete for the future use of the Dock Department, if it should be desirable to construct a pier at this point.

To support these two parts of the sewer 12-inch round spruce or pine piles are to be driven in rows over the whole area, spaced 2 feet 6 inches center to center longitudinally and 2 feet 5¾ inches transversely. These piles are to be cut off at elevation —6.5, and the concrete will extend 6 inches below their tops. The whole area for the reducer and outfall structure will be enclosed in 10x10-inch yellow pine grooved and splined sheet piling, forming a cofferdam, against the inside of which the concrete will be placed. These sheet piles will be cut off at first at elevation 5, but when construction is completed another foot will be cut off, thus leaving the tops sound at elevation 4. Two sets of 10x10-inch yellow pine inside and outside wales will be used with the sheet piles, one at elevation 2 and the other at elevation —4. Along both sides and across the outer end of the cofferdam 16-inch round oak fender piles are to be driven 8 feet apart on centers, so as to bear against the outside waling pieces. Through these piles and the wales there are to be 1¼-inch galvanized iron bolts extending 4 feet into the concrete from the inner face of the sheet piling. These bolts will have 6-inch square anchor plates at their ends in the concrete and large bearing washers on the outside of the piles, and there will be 1½-inch gas pipe casings or sleeves on the bolts within the concrete. There will be additional piles at each outer corner and four clusters of fender piles at the corners and opposite the division walls between the conduits.

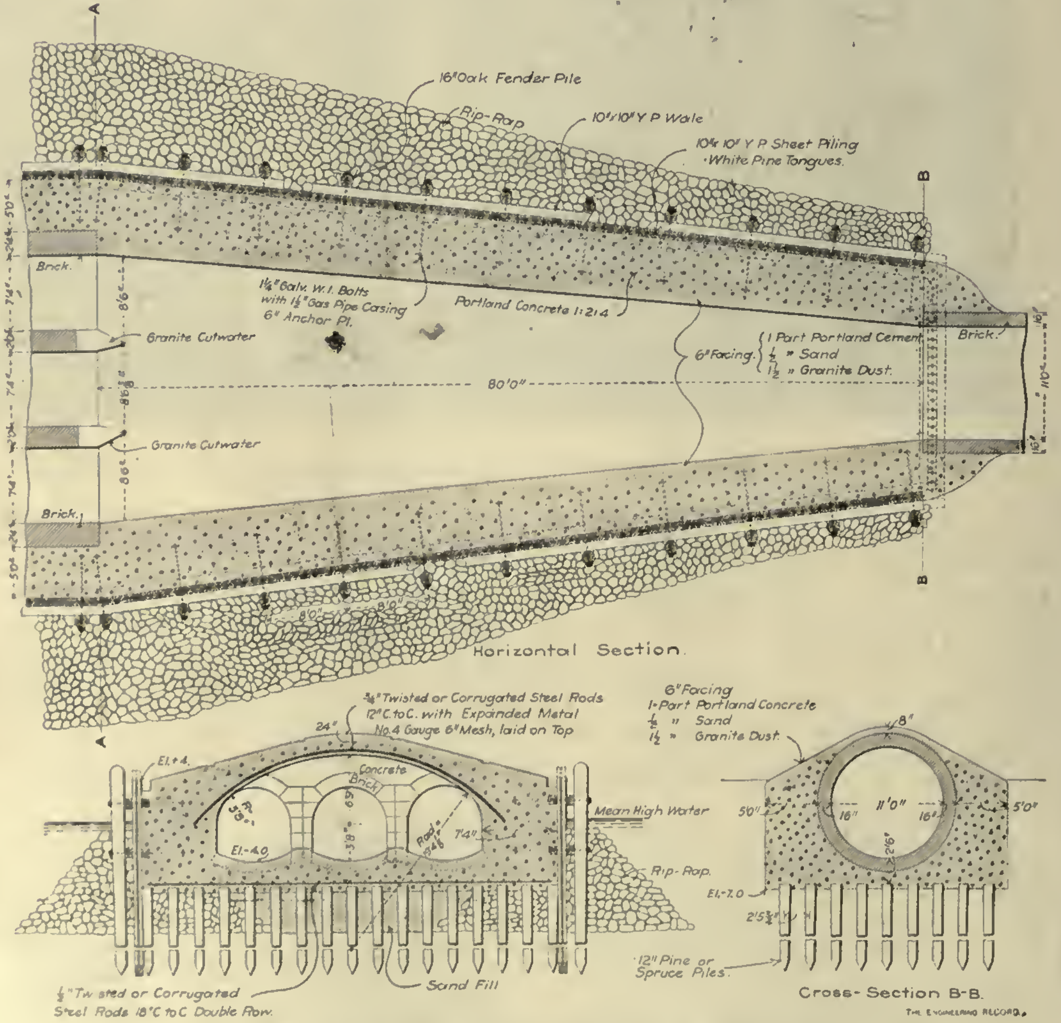
Where the bottom of the bay is below elevation —7 the space inside the cofferdam around the bearing piles is to be filled up to this elevation. The portion of the fill next to the sides and outer end of the cofferdam is to be of riprap 8 feet wide on top with a 1 to 1 slope toward the interior. The central part of the fill will be made of sand. Riprap of large stones will be placed across the outer end of the cofferdam and along both sides for a distance of 150 feet back from this end, as indicated in the drawing. The strong currents in the Narrows and the somewhat exposed position of the end of the sewer make necessary the massive construction shown and described.

It being impracticable to connect the street laterals directly with the deep tunnel sewer, a system of higher level collecting sewers over the tunnel is necessary. The extent of the territory drained by the trunk sewer, its area being nearly 3 square miles, makes necessary also secondary or lateral trunk sewers. Some of these smaller trunk sewers have already been built and others are under contract. A few miles of vitrified-pipe laterals have also been laid in some of the streets in the district. Since Ninety-second Street passes over a ridge, the collecting sewers drain in opposite directions from the summit. On the westerly slope the small sewers in Ninety-second street have connections only to the houses and catch-basins along that street, and therefore are only 12-inch pipes laid in sections between the manholes of the tunnel sewer and enter the downstream manhole in each case near its top, as indicated in the drawings of the manhole. Owing to the local topography of this part of the district, most of the laterals are comparatively short, and so they are to be mostly 15 and 18-inch pipes connected into the tunnel manholes. There is a 24-inch vitrified-pipe lateral collector, however, in Marine Avenue, which is to be connected into shaft No. 1.



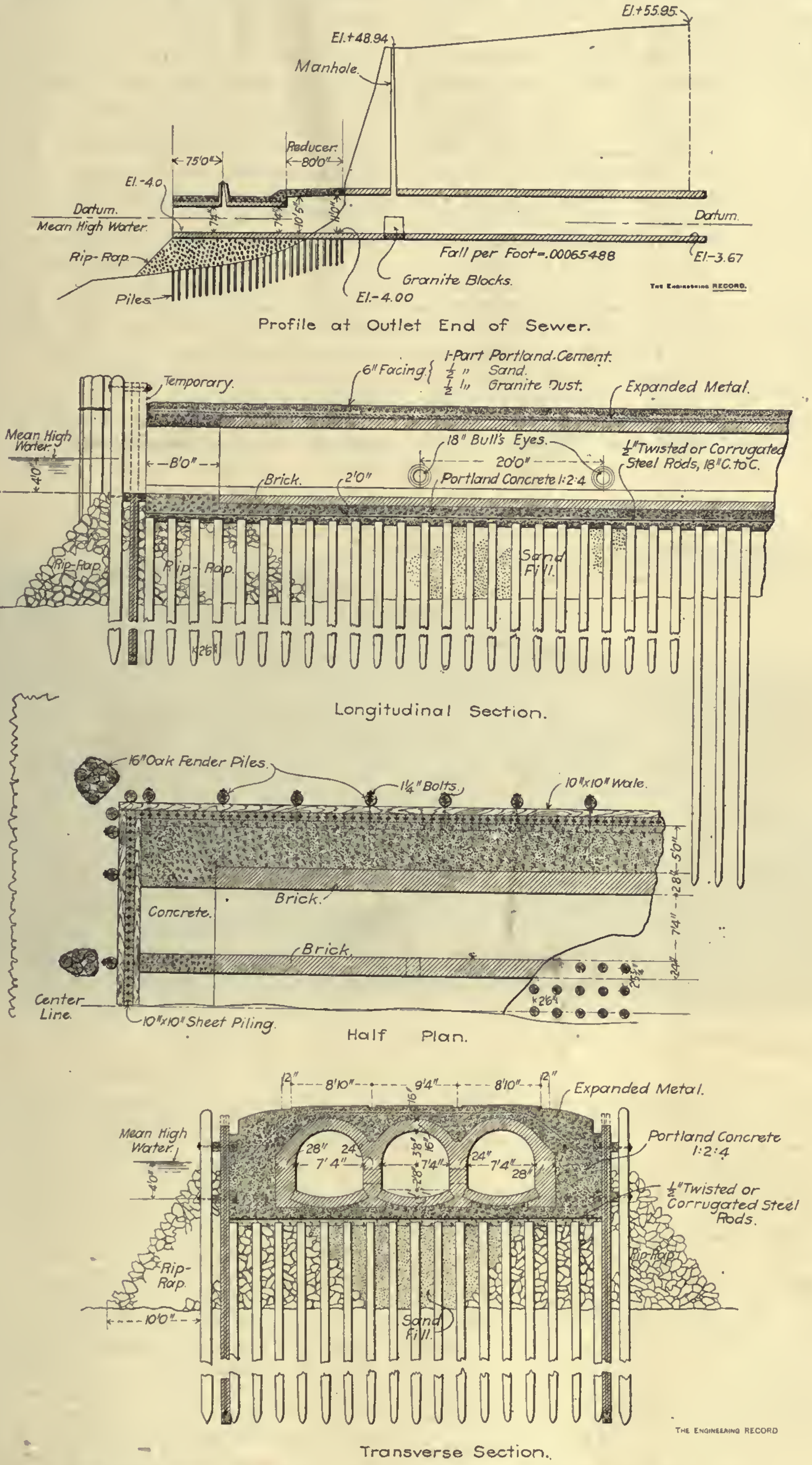
Details of Tunnel Manhole.

The Engineering Record.



Brooklyn Sewers: Details of Tunnel Manhole; Increaser Chamber at Outlet.

East of the crest of the ridge the tributary region is much wider, and so two or three lateral trunk sewers are necessary. In Fort Hamilton Avenue a 54-inch egg-shaped brick sewer has already been built and will be connected into the tunnel manhole located at that avenue for the purpose, the connection being made substantially in the manner shown by the manhole drawings, to which reference has already been made. The sewers in the easterly slope of Ninety-second Street are laid in sections between the tunnel manholes, similarly to those in the west slope, but they are larger because they receive directly the lateral sewers from some of the intersected streets. These sections of sewer usually increase from a 12-inch pipe at the upper end to a 24-inch pipe at the tunnel manhole, but one section has at its lower end 260 feet of 30-inch egg-shaped sewer to be connected into shaft No. 4.



Brooklyn Sewers: Profile and Detail Sections of Outfall at End of Tunnel.

Of course, these smaller sewers have manholes placed according to the usual practice, in addition to the manholes of the tunnel.

Some parts of the district to be drained by the Ninety-second Street trunk sewer have already been built up, and others are being developed, so that an outlet for the sewage and storm water is much needed. The principal quantities involved in the construction of the first section of the main trunk sewer are 45,000 cubic yards tunnel excavation, 20,200 cubic yards of brick masonry in Portland cement mortar, 6,500 cubic yards of Portland cement concrete, 66,000 linear feet of round piles, 2,000 cubic yards of rip-rap, 260,000 feet board measure of sheet piling and 7,000 pounds of steel for reinforcing the concrete; the contract price, based on the preliminary estimated quantities, is $655,000. The time allowed for the performance of the contract is 700 working days. This sewer was designed and is being built under the direction of Mr. Henry R. Asserson, M. Am. Soc. C. E., chief engineer of sewers, Borough of Brooklyn. The work was begun under Mr. William T. Bruorton as division engineer, but after his death, late in December, 1903, Mr. George W. Cadmus, his principal assistant, became division engineer. Messrs. James Malloy & Company, of Brooklyn, are the contractors, and Mr. J. F. Cogan, of the firm, is in immediate charge of the work.

Some Boiler Tests with Coke Breeze.

The combustion of coke breeze in steam boilers was the subject of two papers at a recent meeting in Cleveland of the Ohio Gas Light Association. One of these contributions was presented by Mr. M. E. Malone, of Denver, who gave the results of some eight evaporation tests and the other was made by Mr. C. H. Williams, of Madison, Wis. In the handling of coke, some 10 to 15 per cent. of it is reduced to breeze, which, it appears, contains 75 to 80 per cent. carbon. The tests of the first paper were mainly made with a tubular boiler, rated at 50 horsepower, having a shell 48 inches in diameter and 16 feet long with forty-eight tubes 3 inches in diameter and presenting 704 square feet of heating surface and 20.5 square feet of grate surface. It is not stated how the water was measured, but the results given in the accompanying table are based on tests of two, three, four and five hours' duration. In test Nos. 1 and 2 the breeze was burned on an underfeed stoker, in test No. 3 the breeze was mixed with slack coal, and in the remainder of the tests the fuel was burned on flat grates. In tests Nos. 4 and 5 the breeze alone was used with hand firing, with forced draft, the former admitting air into a closed ash pit through a pipe in the bridge wall and the latter through 9/16-inch holes in a 5-inch gas pipe in the ash pit. Test No. 6 was made with a mixture of breeze and coal under the forced draft conditions of test No. 5, while in test No. 7 lignite slack coal was employed. Test No. 8 was conducted on a 500-horse-power Heine steam boiler with natural draft of 0.65 inch of water in the stack and with breeze on a grate of ⅜-inch mesh. The draft in all tests but the last and the fourth was 0.3 inch and in the fourth it was ¼ inch. The last column of the table shows the fuel cost of the evaporation per 1,000 pounds of water under the actual conditions.

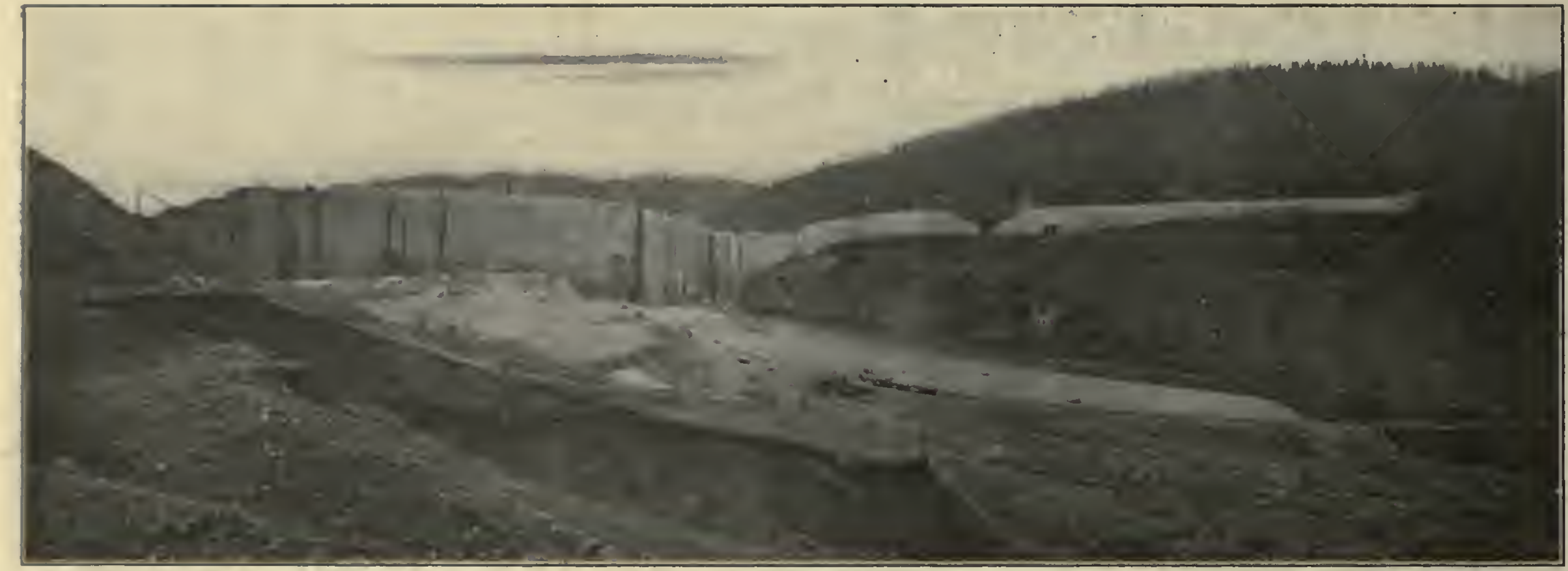
Evaporation Tests with Coke Breeze.

		Evaporation lbs. per hour.				
Test Number.	Fuel per hr.	Actual per lb. fuel.	Equiv. per lb. fuel.	Equiv. per lb. comb.	Water per sq. ft. htg. surf. lbs. per hr.	Fuel cost of 1,000 lbs. water, cts.
1....	264	5.77	6.31	8.26	2.16	0.201
2....	206	5.49	6.01	7.82	1.6	.22
3....	421	5.71	6.27	7.33	3.41	.203
4....	250	4.92	5.39	8.37	1.75	.272
5....	333	4.29	4.70	6.86	2.03	.347
6....	366	5.24	5.74	7.55	2.73	.241
7....	450	5.32	5.83	6.29	3.2	.235
8	1750	4.50	4.78	...	1.77	.319
9....	750	4.33	4.94	8.84	1.82	...

The 9th test is that reported by Mr. Williams. This was made on an 18-foot by 72-inch horizontal tubular boiler fitted with a grate designed for handling coke breeze. A Sturtevant forced draft outfit was provided and this delivered to the grate bars, which were made hollow for feeding air to the fuel at a uniform distribution. This boiler had a heating surface of 1,670 square feet and a grate surface of 30 square feet. The steam pressure was 81.6 pounds, while on the other tests the pressure averaged about 90, except on test No. 8, in which the pressure was 137. It appears that the power to operate the blower in the last case amounted to 8 kilowatts.

Progress Report on the Croton River Works for New York City's Water Supply.

The construction of the new Croton dam, well known to engineers as the largest masonry dam in the world and the most conspicuous feature of the new works for the further development of the Croton River for the water supply of New York City, was begun late in 1892, under the direction of Mr. Alphonse Fteley as the chief engineer of the Aqueduct Commissioners. Descriptions and construction progress notes of this dam, the new Croton aqueduct, the Jerome Park reservoir, the Muscoot dam, and the highway bridges across the reservoir have been published in this journal at various times since the inauguration of the undertaking. In the issue of April 23 the present stage of progress on the Jerome Park reservoir and the highway bridges in the Croton valley was described in some detail and shown by a number of photographs. The issue of June 20, 1903, contained a progress statement on the new Croton dam.



New Croton Dam: Upstream Face Showing Full Length of Dam and Spillway, Excepting Extension at South End, at Left.

October 15, 1903, Mr. J. Waldo Smith became chief engineer of the Aqueduct Commissioners, and, in response to a resolution of the commissioners, dated January 3, 1904, requesting a report of the status of the work now being prosecuted under their direction, he has recently presented a statement as of date of March 1. From this report the following extracts have been taken, relating principally to those parts of the works which were not described in the issue of April 23. To the report are appended several tables giving in very concise form a detailed statement for each division of the works, item by item, omitting the smaller items, and five diagrams showing the progress of the various principal contracts, according to the value of the work done. The delay of the work caused by the various investigations, the strikes and other difficulties is clearly shown in these diagrams, and also that there must be a material increase in progress in order to complete these contracts within the time expected and agreed upon.

Abscissas on these progress diagrams represent time and ordinates cost. An irregular line on each shows the actual varying rates of expenditure for work done from the beginning of the contract up to March 1; a straight red line indicates the average rate of expenditure necessary in order to have completed the given piece of work within the contract time, and other straight lines indicate the average rates necessary in order to complete the whole or particular parts of the work by a prescribed date, beginning March 1 or at some specified previous date. The slopes of these lines on the diagrams present the matter very forcibly.

Referring to the new Croton dam division, Mr. Smith states: "At the new Croton dam nearly seven-eighths of the masonry and about 400 linear feet of the main dam are completed. About 600 feet of the spillway are completed, leaving two gaps still to fill, which are approximately at elevation 172. [The elevation of the crest of the spillway is 196, and that of the top of the dam, according to the revised drawings, is 216.] Further work on these gaps, however, must be discontinued until the southerly end of the dam is brought up to this level, when they will be gradually filled, keeping their flow line at a lower elevation than the top of the portion of the dam under construction. This is to provide for the partial filling of the reservoir when the southerly end is sufficiently advanced, for it is evident that some place must then be provided for the escape of the surplus water to prevent it from going over this uncompleted portion of the dam.

"At the southerly end of the dam the excavation is now completed and is practically ready for the masonry. The work of building this portion of the dam was started on November 30, 1903, and is, of course, proceeding slowly on account of the unusually cold weather experienced. To build up this portion of the dam sufficiently so that the reservoir may be allowed to be filled, or partially filled, at the end of 1904, presents a very difficult and unusual situation. The total length from the present southerly end of the dam to the gatehouse [in the aqueduct on the southerly hillside] is about 250 feet, and the maximum height 200 feet. It is deep in the hillside, where it is difficult, on account of the contracted space, to handle large quantities of materials in a short time. There is still to be laid here about 100,000 cubic yards of masonry in one working season, and I consider that there is a *possibility* that this will be so far completed that the reservoir can be partly filled, but to do this will require unusual energy and facilities on the part of the contractor, as well as the special favor of the elements.

"This is an unusual situation and may require unusual methods. The dam and its reservoir, in my opinion, cannot be wholly completed in less than two years, although surely before that time the gates will be officially closed, the holes through the dam now carrying the water filled up and the reservoir partly full."

The creation of the large new Croton Lake necessitates a number of changes in the old Croton aqueduct, and the condition of the aqueduct itself, also, is such in some places as to demand repairs. Of the reconstruction of the old aqueduct between the old and new Croton dams the report says: "The loops around the ravines and the portions of the aqueduct to be entirely reconstructed are about one-third done. The contractors are at work reinforcing the invert and are pushing this work to such an extent that it will be completed early in March. None of the arch of the aqueduct has been reinforced, but a considerable length has been excavated down to the crown of the arch and for a short distance on the sides, ready for the reinforcement, and the work will proceed as soon as the weather permits. The contractors have been notified to use every effort to get the work which will affect the flow of water finished by July 1."

The Croton reservoir is not to be stripped of soil as the Wachusett reservoir of the Massachusetts Metropolitan water supply is being stripped, but the forest growths and other trees are to be cleared and houses and other structures are to be removed. As is pretty generally known, the policy of the engineers of the Croton supply has not favored the more complete stripping. Referring to the clearing of the basin, it is stated: "The contractors are still cutting the heavy timber, but none of the reservoir land has been cleared ready for the water."

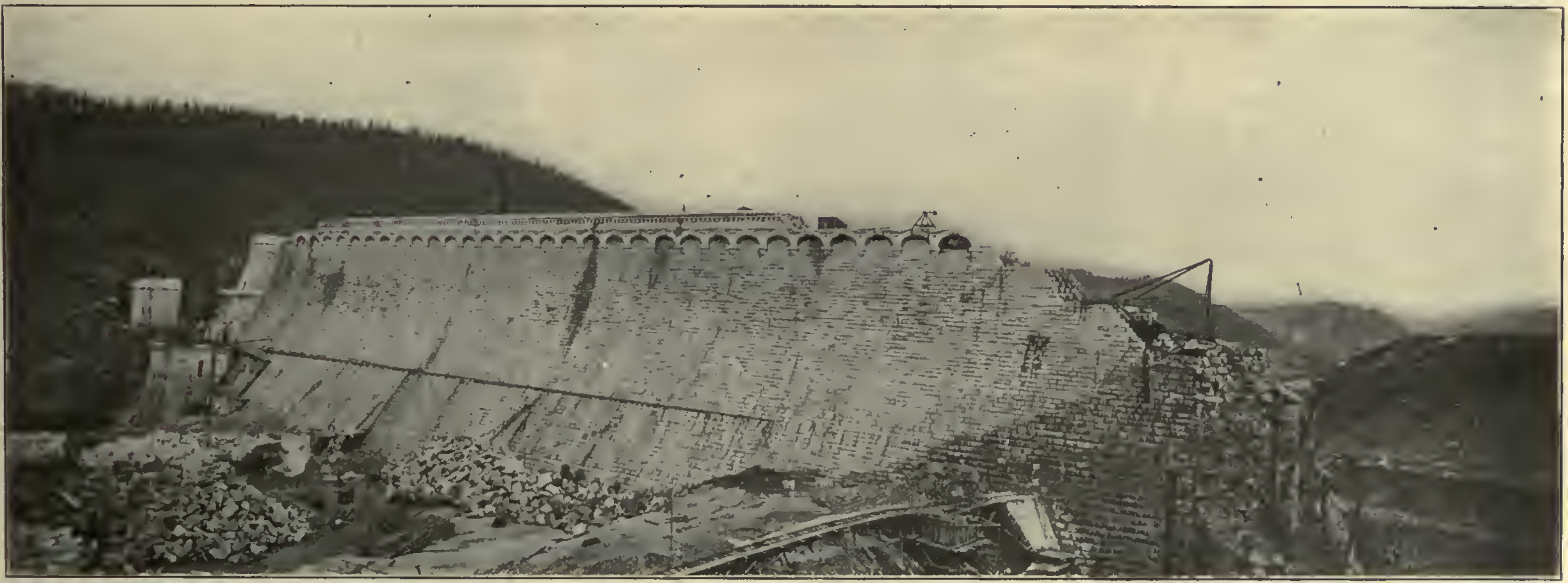
The Muscoot dam was described in this journal December 20, 1902. Of this part of the work Mr. Smith writes as follows: "Measured by the value of the work done this dam is a little more than half completed. At the outside the dam should not have required over two working seasons to complete, and the present contractors have taken three seasons to complete a little more than one-half of the dam. In view of this, steps have already been taken to re-let the contract to more energetic parties. The delay consequent to a re-letting of the contract and the organization of the work by a new contractor will make it very difficult or perhaps impossible to finish the dam this season."

Commenting upon the slow progress in the construction of the Jerome Park reservoir, Mr. Smith writes: "In work of this magnitude, requiring contracts running through many years, it is essential for the best interests of the city, in order to meet conditions developed in the progress of the work and to take advantage of the advanced and improved methods of construction and design, that the chief engineer should have the power to modify the plans to suit such conditions and improvements, and that the specifications be broadly drawn and interpreted accordingly.

"The various expert commissions which have been called upon to report as to the advisability of changing the plans have, of course, very seriously delayed the final completion of this work, and the charges of the Merchants' Association and the investigations growing out of them have very seriously interfered with the efficiency of the engineering corps and had a demoralizing effect on the contractors' energies. At any rate, they could not be expected to prosecute their work with vigor while the quality of it was being attacked. It is to be hoped that these investigations will soon be over and the engineering corps, as well as the contractors', will have nothing but the work in hand to occupy their minds."

The following paragraphs from the report relate to the conduct of the work in general: "The various changes made necessary by the reports of the distinguished expert commissions, which have been called on to give advice regarding the construction, have very materially added to the amount of work to be done and render the material hastening of the progress of the work at the present time very difficult. In the case of the new Croton dam particularly, the removal of the completed embankment and core-wall at the southerly end and the excavation of the defective foundation to a depth of 75 feet below its former level have created a condition where the volume of work which it is possible to do under the most favorable circumstances is limited, due to lack of space and accessibility, a condition wholly beyond the power of the commissioners or the chief engineer to control.

"Much of the work now in progress is far behind the rate of progress specified in the contract. This is due largely to a material increase in the volume of work contemplated at the time the contract was drawn, made necessary by conditions developed during the progress of the work. Besides this, the contractors have been delayed by strikes and labor troubles, as well as shortness in the labor supply.'



New Croton Dam: Downstream Face Showing Present Condition of South End, at Right, and Abutment for Arch Bridge over Spillway, at Left.

A number of photographs taken very recently to show the present condition of the new Croton dam are reproduced with this article. These will help to an understanding of the extracts from Mr. Smith's report, as well as showing in a general way the state of the work. The dam faces approximately to the west, so that the spillway is at its north end, and the new masonry portion of the main dam to replace the earth embankment with core-wall is at the south. The aqueducts, which start from the old dam about 2 miles upstream from the new dam, are also on the southerly slope of the valley, and the gatehouse is at the south end of the dam.

Laying Gas Mains across a River.

Extracts from a paper by Mr. H. C. Morris read before the eleventh annual meeting of the Michigan Gas Association, in Saginaw, Mich.

The city of Saginaw, Mich., is divided by the Saginaw River, and, after the consolidation of the gas companies in East and West Saginaw, it was found to be more economical to abandon the west plant and lay mains across the river. The pipe decided upon was the National Tube Company standard steel 12-inch line pipe with threads and couplings. The width of the river at the point chosen for laying the line is 1,500 feet. About 200 feet of this is a bayou, approximately 14 feet deep, with a middle-ground or island about 125 feet in width, and about 2 feet above the city datum or normal level of the river. The balance of the distance is a ship channel varying in depth from 8 to 14 feet.

The general scheme in the first attempt to lay a line was to make up the lengths of pipe on the middle-ground, and after plugging the end of the length first entering the water, float it across the river. The floating of the line was possible since the plugged pipe, when floating, had an excess buoyancy. The line being a low pressure one, it necessarily had to be laid with a fall in order to take care of condensation or whatever water might leak into it. Therefore, considerable dredging had to be done not only to get a proper fall, but also to get the line deep enough in the ship channel to conform with any possible change in depth in the channel that might be made necessary by future navigation. This depth was made 16 feet which was approved by the United States Government. The first attempt to lay the line was made in October, 1901, and was a failure.

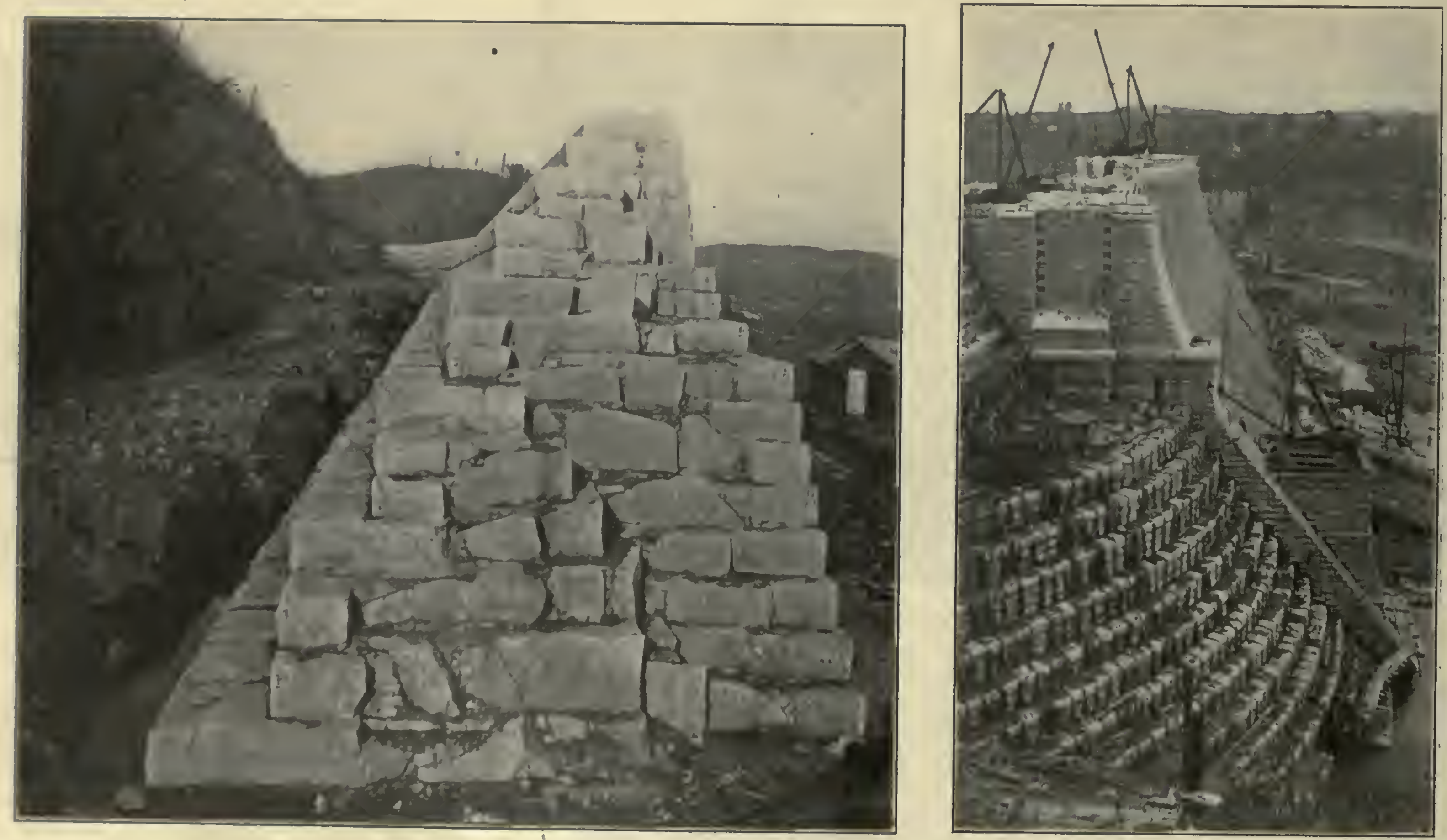
This failure can be accounted for by the fact that no strengthening sleeves of any kind were used over the pipe couplings; no systematic soundings of the river bottom were taken after the dredging had been done, and no means were adopted to keep the pipe in the channel dredged for it while being lowered into place, other than pieces of 4x4-inch timber in lieu of piles, driven for this purpose at intervals from shore to shore. These timbers were too light for the work required, with the result that when the whole line was lowered, a strain was placed upon the pipe at the couplings, and a greater strain upon certain couplings which were in that part of the line afterward found to be out of the proper channel. Odd lengths of railroad iron and large pieces of limestone saddled together with pieces of wire were used as weights to sink the pipe; and as there was nothing to hold the pipe to the surface of the water until these weights or ballast had been evenly distributed along its length, the pipe went down unevenly. This in itself did much toward straining the pipe at the points where the threads entered the couplings.

After the pipe had been lowered in the manner above stated, the engineer had the line filled with water, as he said, "To settle same." This was all very well until the time came to pump out the water, which it was found impossible to do. The next thing to be done, of course, was to try to locate the leak or the reason why it was not possible to empty the water from the line. This was done by a compressed air connection at the shore end of the line. By this method it was shown that the line was leaking in four or five different places. Marine divers were then secured and their examination demonstrated that it would be impossible to repair the breaks with river sleeves, and that it would be necessary to take up the line. The raising of the pipe was begun four or five lengths at a time, and the work made comparatively easy by means of a lighter, the pipe taken to shore and disconnected. This operation was continued until all of the pipe was again placed on shore. The season was now well advanced to the end of November, with ice forming in the river, making it practically impossible to continue work. Operations were, therefore, abandoned for the time being.

The following spring the 12-inch pipe that had been used in the previous attempt was taken to a machine shop and re-threaded, the threads having been damaged in the previous lowering of the line. New couplings were secured and protecting sleeves made to clamp over the pipe at each joint. These protecting sleeves were made similar to a split sleeve used for repairing ordinary gas mains with the exception that a recess was made in the center of sleeve in order that the sleeve would clamp around the pipe and clear the coupling. The sleeves were made of ¾-inch cast iron, weighed approximately 300 pounds and were cored for five ¾-inch bolts on either side; the length of sleeve was 22 inches.

The pipe and protecting sleeves were taken across the bayou to the middle-ground, and as the pipe could all be made up at practically one point, a small boiler and hoisting engine were procured and set up on the middle-ground to be used in screwing up the pipe. A compressed air pump was also placed on the middle-ground and used to test the line as it was made up. A heavy pipe tong was made, about 8 feet long, by using a piece of oak and a piece of chain about 12 feet long. The chain was bolted into the oak stick about 8 inches from the end, and the tong was used by wrapping the chain around the pipe and running a rope from the end of the tong to the drum of the hoisting engine. By the use of this apparatus the jerk and jar of screwing up the pipe, as with ordinary tongs, were avoided.

Details of Top of Dam.



New Croton Dam: Spillway above Gap, Showing Character of Masonry; Junction of Spillway and Main Dam.

While the pipe, sleeves, tools and other materials were being collected on the middle-ground, dredging was being done. Guides for the dredging had been made by driving numbered pieces of 4x4-inch timber 50 feet apart at intervals across the river. The dredge engineer was furnished with a chart showing the depths wanted opposite these guides. The dredging was accomplished with fair results by graduating in feet and half feet the dipper arm on the dredge. The dredge-man was checked after every move ahead. The only error that was made in the dredging was in keeping the depth too near that required, instead of having it a foot or one and a half feet deeper, as will be shown hereafter. In the channel the dirt brought up by the dredge was taken away on dump scows. The cut made by the dredge was from seven to nine feet wide, this width being necessary to prevent the filling-in again of the cut before the pipe could be lowered into it. After the dredge had advanced far enough from the shore, a pile-driver was started driving piles in pairs 12 feet apart, the distance between pairs averaging 60 or 70 feet. A bent was made by placing a piece of 6x6-inch timber across the piles, held in position by drift bolts. The 60 or 70 feet between bents was ample space for all navigation.

By using protecting sleeves it was found that each foot of pipe weighed 6.84 pounds more than the water displaced by it, therefore, cedar poles were rafted together near the middle-ground for us in floating the pipe as it was made up. This was unnecessary the year before as the pipe would float without any means other than keeping out the water. About ten men were used on this work, this number being required to handle pipe, etc., but on the last day, when the pipe was ready to be lowered, 22 or 23 men were used. As soon as the first bent of piles had been driven, work was started making up the pipe, and the hoisting engine used to perfection in doing this work. As soon as several lengths of pipe were made up and the sleeves clamped over the couplings, the pipe was launched. To avoid any possible danger from leakage, all pipe threads were thoroughly coated with black manganese and shellac, and the face of each coupling caulked with yarn and red lead before the application of the sleeve.

Each section of pipe was lashed between two parallel cedar poles as it was launched. This method was used until approximately 300 feet only of the river remained to be crossed. Of this 300 feet 200 feet was in an old log boom on the west shore, and 100 feet in the main ship channel which was in daily use. It was found that it would be necessary to close the channel to navigation for at least one day, and so, in order to save time, sections composed of two and three lengths of pipe were made up ready to screw into the line immediately after the closing of the channel.

After the line had been made up in its entire length and was about ready to be lowered, a rain storm came up and the level of the river was raised at least 2 feet. This necessarily increased the current and considerable sand and silt consequently washed into the cut that had been dredged for the pipe. In fact, about 100 feet of the cut was in this way filled from 12 inches to 14 inches higher than the chart would permit if the line was to be laid with the intended grade. The grade could not be varied in view of the fact that this was to be a low pressure river line, and would necessarily have to have a perfect fall from the middle-ground to a drip at the west shore to take care of any condensation and leakage. And inasmuch as the channel was practically closed, and it was impossible to use the dredge with the pipe on the surface of the water, it was decided to lower the line to the bottom, which would open up the ship channel again and permit dredging to be done alongside of the line. This second cut was made by the dredge as close to the line as it was safe to work the dipper without striking the pipe. When the cut was of sufficient depth, the sand and silt under the pipe were washed into it by the current, thus allowing the lime to settle to the depth desired.

The following method was used in lowering the line: As many measuring sticks as there were bents of piles were graduated into feet and quarter feet; two men were stationed at each bent of piles, one man to hold a measuring stick on the top of the pipe as it was being lowered, and the other to lower when signals were given. One-inch rope was lashed to the 6x6-inch timber across the piles and then passed under the pipe, and three or four wraps taken around the 6x6. The cedar floats were then taken away, which left the pipe suspended in the rope sling ready for lowering, which was regulated by signals given by the superintendent in charge of the work. The pipe was lowered 6 inches at every signal. By watching the measuring stick at each bent of piles after a lowering signal had been given, it could be seen that the line was being lowered to the same depth at all points, and no uneven strain put on any particular length of pipe. This operation was continued until the entire line was lowered to the depth required, when the ropes were lashed to the 6x6 and left this way until such time as filling could be dumped under the pipe where the dredging had been too deep. In this way it was possible to obtain a perfect fall.

Yerba Buena Power House: Wire Bridge from Wall of Building to Pole Line.

Nothing now remained to be done but to make land connections at the gas-works, on the east shore, and with the west side trunk line on the west shore. A piece of 12-inch pipe was used for a drip pot and a common brass cylinder, deep-well pump for the pump. The line was completed in July, 1902, and since that time no trouble has been experienced from the water, as the drips make approximately two gallons of water only per day, and the drip pot will hold about 50 gallons.

In 1903, it was decided that another river line was required as an emergency line, to be used in case of accident or during repairs on the old line. A 4-inch high pressure line was considered of ample capacity for the purpose. The point selected for the laying of this line was about 500 feet above the 12-inch line, a distance considered sufficiently safe to avoid any possible accident to the old line because of working on the new. Then it was deemed well to have the two lines so far apart that any accident happening to one might not affect the other. At this location a navigable cut had been made through the middle-ground by a lumber company, in days gone by, and by using it some money could be saved in dredging.

For this line extra heavy 4-inch line pipe, threaded, but without couplings, was used, and a style 3 Dresser river sleeve for the joints. This sleeve is designed for use on river lines, and experience with several styles of sleeves demonstrated that preference should be given it over the common, screw coupling with the split sleeve used for protection. It is made with the center of the sleeve reduced and threaded so that pipe can be screwed in.

A Rand Drill Company's 12x16x16-inch compressor with a 6-inch outlet was purchased and installed in the exhauster room at the gas-works. This was one of the first things done, for we desired to use the compressor in testing out the line as it was made up. A Johnson-Reynolds' regulating station was used to cut the pressure from 20 pounds—the pressure maintained at the gas-works—to 30-tenths inches water pressure on the west side.

In view of the fact that no decided grade or fall was necessary for this line, the only dredging to be done was across the ship channel where it was thought best to lay the line at a depth greater than any to which the channel might eventually be made, by dredging.

An entirely different method from that used in laying the low pressure, 12-inch line was decided upon in laying the new line. A float about 12x16 feet was made of timbers, and on this float the line was made up. After a length of pipe was screwed up and the joint tested, the float would be pulled ahead, allowing the line to settle in the water. This operation was continued throughout the laying of the line. While the pipe was found to bend easily, that is, 2 or 3 feet in 100, it was found necessary to bend some lengths at the blacksmith's to conform with any decided or sudden drop of the river bottom. Only three or four piles were required in laying this line to keep the pipe in the cut dredged for it. These piles with the aid of anchors also served to hold the raft in place while screwing up the pipe. No fittings of any kind other than the sleeves were used on the line, the pipe being bent in all cases where a bend was necessary. About six men were required to lay the line and one week's time was taken from the day when the work was started on the river until the line was completed. The connections on the west side were made by using a 12x6-inch split tee, the trunk line connected into being a 12-inch line and the outlet of the governor 6 inches.

The Key Route Electric Railway Power Plant, Oakland, Cal.

The location of steam engines and steam boilers under the same roof without a partition wall between is a conspicuous feature of the power plant that has been provided for the San Francisco, Oakland & San José Railway, in California. This is an interurban electric railway line, designed to bring Berkeley and Oakland, and later, San José, into close connection with San Francisco. These smaller cities are, of course, on the opposite side of San Francisco Bay from the city of San Francisco and a part of the development has included the institution of a fast ferry service and the construction of a pier 3 miles in length from the Oakland shore. By running the electric trains on the pier the time of total travel is shortened.

At present the railroad operates four six-car trains simultaneously at 20-minute intervals, though it is designed to handle eight-car trains, and it was decided that a present direct-current output of 1,450 rated kilowatts would suffice. The power house has been located at a central point on Yerba Buena Avenue, Oakland, and it has the advantage of steam railroad facilities and proximity to tide water for condensing purposes. As the line has not yet been extended to San José, direct-current was adopted as best serving the present conditions, for the extreme distances of travel either way from the power station are not very great. In planning the station the present building is designed to allow for additional machinery, and it is likely that the space remaining for the generating equipment will be given up to an alternating-current outfit.

The type of station is that in which the boiler and engine rooms are side by side, so that future extension is allowable at the end and the length of steam piping is otherwise reduced to a minimum, but the unusual arrangement exists of a main or central portion in which are disposed the generating machinery and of two side bays, in one of which are placed the steam boilers and in the other—this practically cut off from the generating room—a storage battery and in a separate room the repair shop. The plant is without a basement, and instead the condensing apparatus lies in a pit below the general floor of the engine room and the piping is generally carried in trenches about the floor. The chimney rises outside of the building, and an economizer, which has been provided, is also set outside of the building, together with a hot well, which is one of the interesting features of the work. The fact that a partition wall was unnecessary between the boiler installation and the operating room is owing to the fact that oil is used for a fuel and there is an absence of dust. An interesting point in connection with the erection of the plant is that the machinery, both generators and boilers, were erected before the building was itself, this being carried on during the summer time when the weather conditions in California are such that there is no danger from heavy rains. The machinery was erected without the use of a traveling crane, and it was thought not necessary to install one in the completed building.

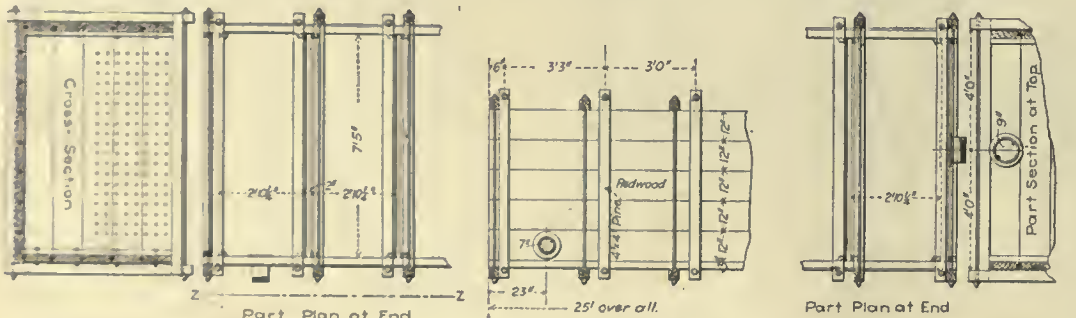
The power house has general ground dimensions of 153 feet 6 inches and 125 feet 4 inches. It is built of red brick, steel columns and steel roof trusses except over the battery bay where they are of timber, and the roof itself is of galvanized corrugated iron. The clear height of the engine room is 32 feet, that of the boiler room is 22 feet and that of the battery room, which has a wooden ceiling, is 14 feet. The engine room has a width of 45 feet 6 inches, and the boiler room 40 feet 5 inches, while the other wing is 35 feet in width and the two rooms are respectively 91 feet and 58 feet in length, the former being occupied by the storage battery. An accompanying photograph shows the interior of the operating room with the row of boilers separated merely by the interior row of columns. A plan is also given to show the arrangement of the generating plant; this does not include the wing containing the storage battery and repair shop.

The boiler plant consists of Cahall water-tube boilers set in batteries of two, eight boilers all told, with space for a fifth battery in the present building. Each boiler has 2,640 square feet of heating surface, presented mainly in fourteen sections of 4-inch tubes 18 feet long, nine tubes per section, and two 36-inch steam drums. On a basis of 10 square feet of heating surface per horse-power, it will be seen that the present boiler installation comprises 2,112 boiler horse-power. Their working pressure is 200 pounds per square inch. The oil used for combustion is known as asphaltum base crude oil, from the Bakersfield district of California, and it is discharged into the furnaces through Pfieffer burners. Storage capacity for the oil is provided as usual outside of the building, and for this purpose there are two 35,000-gallon tanks, 20 feet in diameter. As shown in the plan drawing, the boiler plant is arranged in two groups, and the space between them is utilized for the boiler-feed pumps and for the pumps employed in connection with the delivery of oil to the burners. The latter are Snow 6x4x6-inch duplex pumps, installed in duplicate.

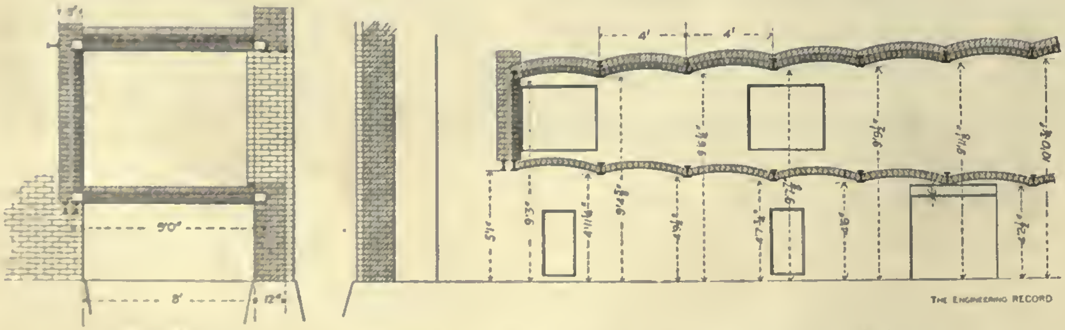
The products of combustion are conducted from the boilers in a brick duct supported overhead back of the settings, leaving space to get at the rear of the settings and at the blow-off connections. An accompanying drawing shows the general construction of the smoke ducts. They are built of brick arches sprung between I-beams, which span the space between the rear of the settings and the outside boiler house wall, and they have a constant width of 7 feet 8 inches and a height varying from 4 feet to 6½ feet. The lower bricks of the duct roof are of firebrick. Opposite the space reserved for the pumping equipment two openings in the outside wall of the smoke conduit lead, one to the chimney directly, and the other to the economizer setting outside the building. The economizer is supported above ground on a level with the breeching and is without by-pass connection, as this is provided by the two openings from the smoke duct ground on a level with the breeching, and it is the Green type, set some 15 feet from the wall of the building, in line with the center of the stack.

The chimney is a red brick structure, with two circular shafts its full height. It rests on 8-inch piles driven to hardpan on 30-inch centers. These piles are capped 2 feet by a concrete foundation of a total depth of 9 feet, about 23 feet square at the bottom and 21 feet square at the top. Embedded in the concrete are six layers of old rails, the rails in each layer laid alternately with respect to those in those adjacent. On the concrete, which is on the level of the station floor line, rises the brickwork, square for 14½ feet and circular above. The total height of the chimney proper is 121 feet 2 inches. The inner flue has a constant diameter of 8 feet, and its top is about 119 feet above the grate bars. It is designed to serve the boiler equipment yet to be installed, and is arranged to receive gases at two diametrically opposite points. This is indicated in the plan, the second opening being at present closed. As usual with stacks designed to receive the products of combustion from two points, a baffle wall has been built, but this extends transversely across the bottom of the flue and does not rise quite to the height of the top of the openings into the chimney. The inner shell is of ordinary brick as well as the outer shaft, but it is lined with firebrick for 14 feet above the intakes. The provision of clean-out openings in the bottom of the stack is indicated in an accompanying cross-section of the chimney. These are 2 feet high and 18 inches wide. A point to which attention may be called is the corbelling out of the brickwork at intervals to bring the outer close to the inner shell. The outside has a batter of 1 inch in 2 feet. The top of the outer shell is covered with a cast-iron cap, built in four sections bolted together and anchored into the brickwork, as indicated. The cast iron is ½ inch thick. A ladder has been built down the outside of the stack and this is fixed to the outer shell at points 7½ feet apart. The rounds are 15 inches apart and the parallel sides of the ladder are each ⅜x2½-inch metal.

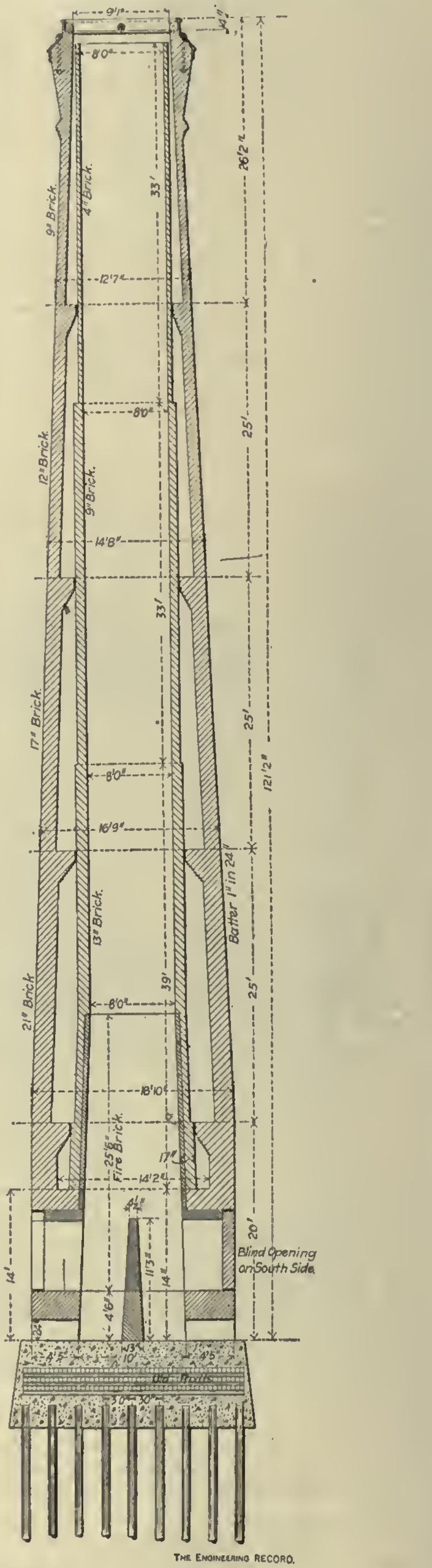
Steam is conducted from each boiler in an 8-inch extra-heavy pipe carried forward into a 12-inch extra-heavy header, which extends across the boilers overhead. At the entrance of the 8-inch supply pipe a gate valve is supplied in the branch. The header itself is without a valve. There are two generating units at present in place and the steam line to each of them drops from the bottom of the header to a floor trench and is then carried to the engine cylinder. A feature of the installation is the employment of electrically-driven pumps in connection with the condensing outfit, and no auxiliary steam line is necessary for this purpose. For the boiler feed and oil pumps, however, a 3-inch pipe is taken from the top of the header and carried to the pumps, as indicated in the drawings. The steam-pipe fit-



Part Plan at End. Part Longitudinal Elevation Z-Z. Part Plan at End



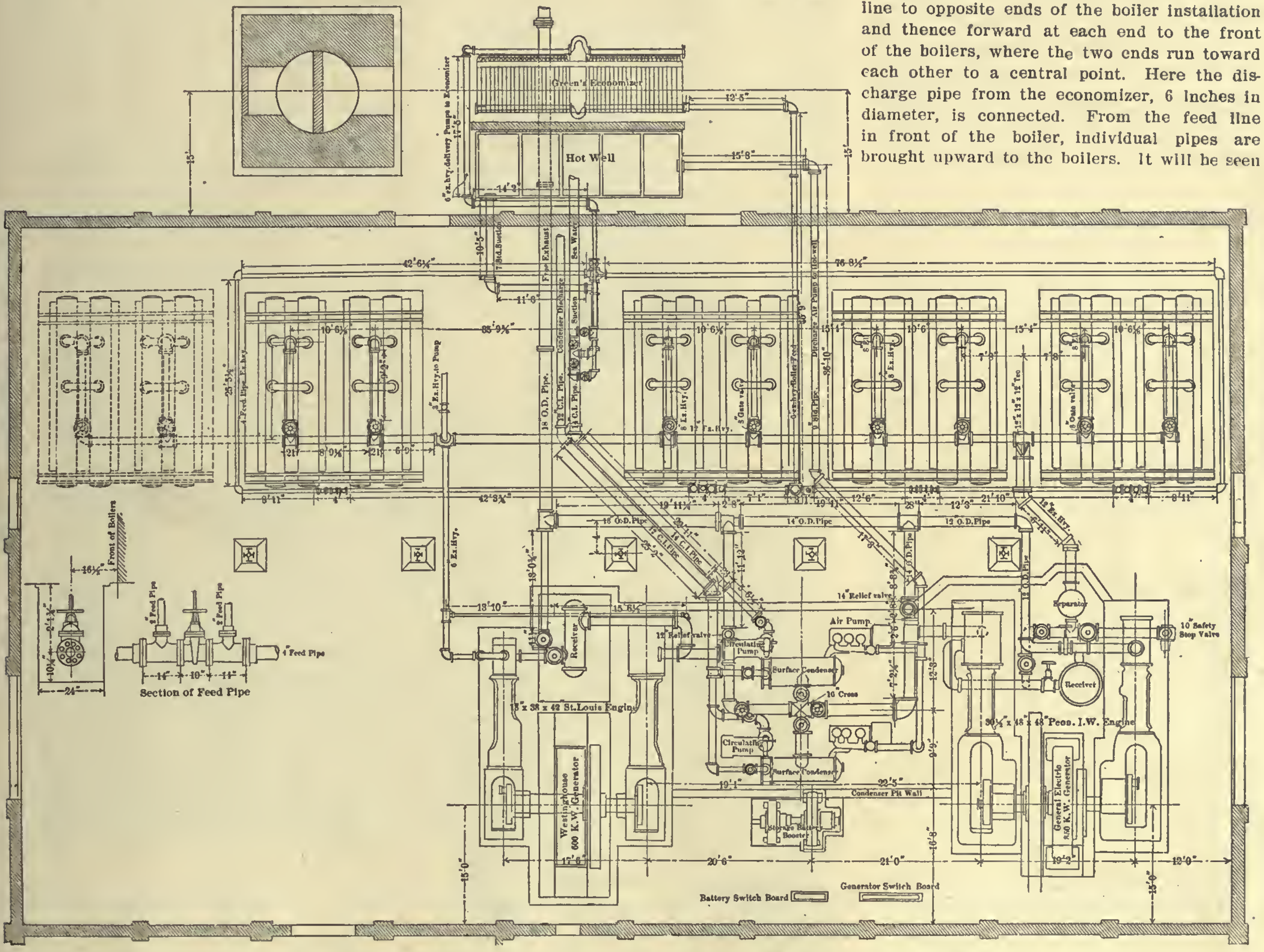
Cross-Section Longitudinal Section.



Yerba Buena Power House: Wooden Hot Well, Brick Smoke Ducts and Chimney Stack.

tings are of the Crane manufacture and the piping is encased in Johns-Manville 85 per cent. magnesia covering.

The generating machinery comprises an 850-kilowatt General Electric generator, driven by a cross-compound Pennsylvania Iron Works engine, and a 600-kilowatt Westinghouse generator driven by a cross-compound engine built by the St. Louis Iron & Machine Works. The large engine has cylinder dimensions of 30½ and 48x48 inches and runs at 80 revolutions per minute, and the small engine is 18 and 38x42 inches in size, operating at 100 revolutions per minute. The arrangement of piping allows, in a usual way, for supplying the low-pressure as well as the high-pressure cylinder with live steam in case it is necessary to cut out the high-pressure side, and the exhaust from the high-pressure cylinders may be discharged directly into the exhaust system. Normally, of course, the steam passes from the first stage into the second through the receiver and from the second into the condensers. The two connections into the exhaust system from the Pennsylvania engine are each equipped with a back-pressure or relief valve, while the connection to the exhaust system from the St. Louis engine at a point between the high-pressure cylinder and the receiver is controlled by a gate valve. The run of the exhaust piping is shown in the plan and is of standard wrought-iron piping.



Plan of Yerba Buena Power House of the San Francisco, Oakland & San José Railway.

For condensing, surface condensers of the Wheeler type are employed, and it will be noted that the steam from each engine is brought to both of them, so that when both engines are in operation both condensers are in commission. With one engine running, either condenser can be used. The circulating and discharge pipes, both of which are cast iron, pass through the building alongside of the outward exhaust, as shown. Each circulating pump is of double inlet centrifugal pattern with 9-inch suction pipe and 8-inch discharge. Each is directly driven by an 18-horse-power 500-volt Bullock motor.

The feed-water system for the boilers may be referred to in connection with the condensers, as the discharge of the air pumps is delivered to a hot well for purification and the water is used over and over again. Each condenser is provided with an independent air pump, which is an Edwards triplex type driven through gearing by an 18-horse-power Bullock motor, both motors controlled by Cutler-Hammer starting boxes. The two pumps discharge into 9-inch standard wrought-iron pipe which delivers the water into one end of the hot well. The general features of this are given in an accompanying illustration. It is a wooden tank, built of 3x12-inch redwood planks tied together, as indicated, by 4x4-inch pine bolsters and ½-inch wrought-iron tie rods. It is 25 feet in length, 7 feet 5 inches in inside width and 5 feet deep. At distances of about 3 feet throughout the length of the tank provision has been made for the insertion of removable partitions to serve as baffle plates or as screens for separating the oil from the water. The screens are perforated with 1-inch holes 4 inches apart in both directions, as indicated in the drawings, and the water from the air pumps is delivered into the top of a chamber at one end and it is drawn off at the bottom from the compartment at the other end. The planks are splined together by 1x2-inch strips and no metal is used in the construction of the tank except the tie rods, which are not exposed to the water, and the inlet and outlet connections, which are of brass. The suction from the hot well is led to the boiler-feed pumps, of which there are two, of the Snow center-packed plunger type, 8x5x10 inches in size. The delivery from the boiler-feed pumps is 6 inches in diameter and passes backward to the economizer. Before passing outside of the building, however, the water may be discharged in opposite directions through a 4-inch feed line carried at the floor line to opposite ends of the boiler installation and thence forward at each end to the front of the boilers, where the two ends run toward each other to a central point. Here the discharge pipe from the economizer, 6 inches in diameter, is connected. From the feed line in front of the boiler, individual pipes are brought upward to the boilers. It will be seen that the boiler main, which is of extra-heavy piping, forms a ring around the boilers and can be supplied either directly from the pumps or from the economizer.

The electric output of the station is, as already stated, direct current, and, of course, at the normal voltage of 525 to 575 volts for railway work. The storage battery, which consists of 264 cells, furnished by the Electric Storage Battery Company, is connected through a motor-driven booster to float on the system and carry the fluctuations of the loads. Its discharge capacity is 1,000 amperes per hour, but its ultimate capacity along the present lines will be 1,600 amperes per hour. It is designed for momentary fluctuations of 50 per cent. above this capacity. The booster is of the

Western Electric make and comprises a 69-kilowatt generator driven by a 108-horse-power motor. Six feeders are carried from the building, each of them of 1,000,000 circular mils cross section. A simple wire bridge has been built from the power house wall to the regular pole line and this is shown in an accompanying photograph. The supports of the feeders are cast-iron poles embedded several feet in the ground and these carry at their top two longitudinal pieces of 2x12-inch timber, to which are fixed in turn 4x6-inch cross-arms. Each of these has the six pins for the cables.

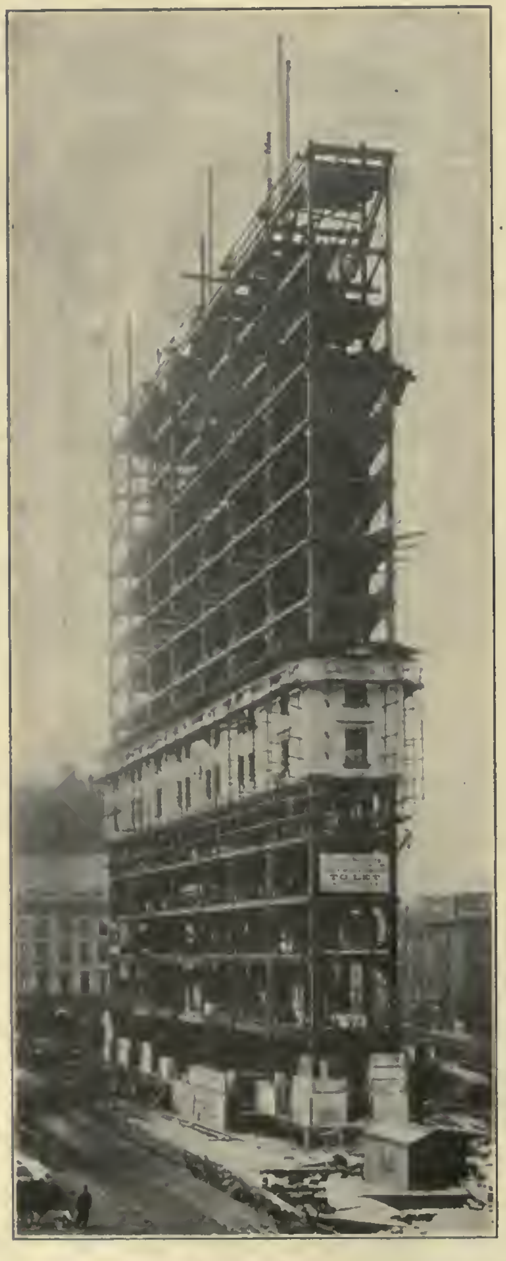
The engineering features of the system were developed under the direct supervision of Mr. J. Q. Brown, assistant general manager and engineer of the company. Mr. Edward M. Boggs, M. Am. Soc. C. E., of Oakland, was civil engineer and Mr. Howard C. Holmes, M. Am. Soc. C. E., of San Francisco, was consulting engineer in connection with the construction of the long pier mentioned. Mr. E. A. Heron is president of the company; Mr. W. H. Martin, vice-president, and Mr. W. F. Kelly, general manager. The chief engineer of the power station is Mr. F. W. Nelson.

The Construction of the Times Building, New York City.

Part II.—Erection of Framework and Walls, Special Derrick Fittings, Description of Subway Columns and Girders, Comparison with Hotel Belmont Methods.

The Rapid Transit subway passes through the northwest corner of the Times Building about 20 feet in the clear above the cellar floor and about 4 feet in the clear below street level. The sub-basement and cellar extend the full width across the subway, underneath it, and the latter is thus carried through the building, but is an entirely independent structure. It has a heavy platform of steel and concrete, supported on columns about 13½ feet high and forming a deck on which the standard steel column and steel beam roof construction of the four-track subway, as illustrated in previous descriptions in The Engineering Record, is seated. Holes through the roof and floor of the subway structure receive the columns of the Times' Building, which are located so as to clear the tracks and carry above the subway roof a number of heavy girders on which the upper story columns of the building are set as required by the architectural considerations. These upper columns are independent of the positions necessitated for the columns passing through the subway.

Inside the Times' Building the subway deck has three main transverse plate girders radial to the track alignment, and from 20½ to 32½ feet apart. The longer of them are made in sections, with their abutting ends meeting on the centers of the caps of H-shaped columns, made in one case with four 6x4x⅞-inch angles, one 8¾x13/16-inch web and four 13x⅞-inch cover plates. The column base is extended by gusset flange plates to a width of 40 inches to reach across the tops of the 15-inch, 60-pound I-beams forming its grillage, and embedded in cement mortar on the solid rock. One of the main girders, 15 feet long, weighs 7½ tons, and has a 66x11/16-inch web, four 8x8x13/16-inch flange angles, and two 17x⅞-inch cover plates. Another of about tho same length has a 48x⅝-inch web, 8x8-inch flange angles and 17-inch flange cover plates, and has the web reinforced by a pair of 28¾x¾-inch filler plates between the flange angles, and by two 45¼x5/16-inch plates riveted on outside the vertical legs of the flange angles. Web-connected to the transverse girders are lighter longitudinal plate girders, from 2½ to 5 feet apart, which support the floor of solid concrete slabs, as thick as the girders are deep, or of thick concrete arches.

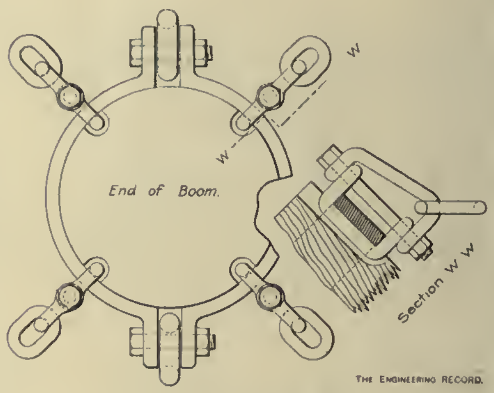


Times Building: Frame Erected to Main Roof.

The steel work for the building and for that part of the subway that is included in it was delivered as required by trucks, and was unloaded and erected by three boom derricks, which set it in place, usually without rehandling the heaviest pieces. Erection was commenced at the south end of the building, where a derrick was set on the roof girders of the finished adjacent section of the subway. This derrick, which had a 45-foot, 30-ton boom, a 55-foot boom, 16 to 18 inches in diameter, an 18x18-inch mast, 35 feet long, and two 12x12-inch stiff legs, set the steel for the subway and for the first two tiers of the building at the narrow end. Afterward two guyed derricks were set up over the wider part of the building and erected the remainder of the steel work, the stiff-leg derrick not being moved above the street level.

At the narrow end of the building the width of the steel framework was not sufficient to give satisfactory spread to the derrick guys, and a special arrangement was devised by Mr. Barras to give them additional stability. Where the outside wall columns were only about 35 feet apart a pair of 12x12-inch horizontal timbers were lapped past each other in the center of the bent and spliced to form a piece about 65 feet long, cantilevering past the columns in both walls equally. This timber was clamped firmly to the transverse floor girder and received the foot block of the derrick mast at its center point. At each end a vertical slot was cut in it to receive a sheave, beyond which there was a horizontal cross bolt to prevent the timber from splitting. The two side guys of 1-inch steel cable were led from the mast head around these sheaves and thence, with sleeve-nut adjustments, to the girder connecting one story lower to the feet of the columns, which supported the outrigger timber, and were secured there. This bracing proved efficient, and was easily moved from story to story. The derrick mast was 65 feet long, and the boom was 55 feet long and had a capacity of over 15 tons.

Each derrick had six 1-inch steel cable guys permanently attached to the top of the mast. The ends of the guys were looped and secured with four clamps. The lower loop engaged a rough cast-iron sheave 5 inches in diameter, the axle of which was the pin through the ends of a shackle that received the loop end of a screw rod. The latter had a sleeve-nut connection to the chain or clamp, by which the guy was secured to the column and girder anchorage. The open-sided sleeve-nut had about 2 feet adjustment, and the combination made a strong and efficient connection, which was quickly adjusted or released.

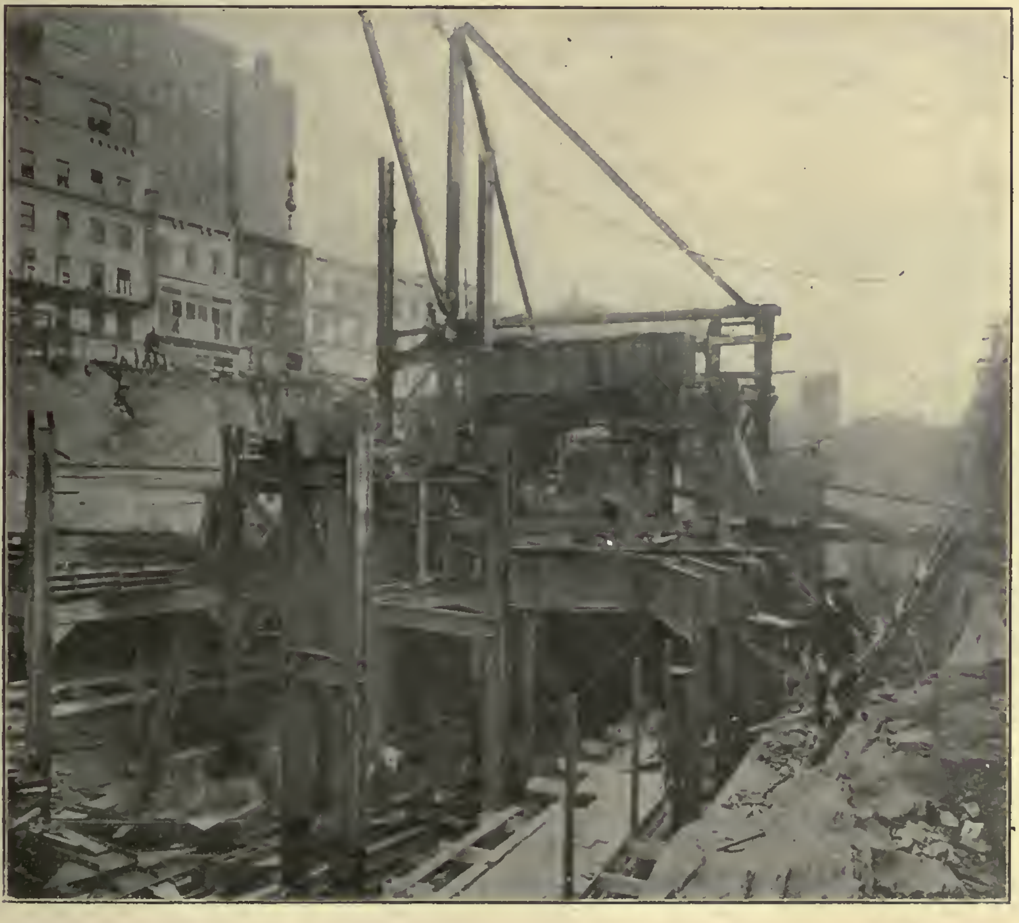


.Guy connections at Point of Boam.

Detail of Erection Derrick.

The derricks handled two tiers of beams at each setting, and were shifted from story to story by the usual method of unshipping the boom and using it as a gin-pole to hoist the mast, then lifting the boom from the mast. When the guys are temporarily lashed to the end of the boom for this purpose considerable time is lost in putting them on and removing them, and there is a large mass of hemp rope wound around the boom point. Under the load of the 8-ton mast and rigging this connection is apt to stretch enough to let the top of the gin-pole move perceptibly, and sometimes seriously menace its security when nearly all the stress may come on one guy. To avoid this Mr. Barras devised a special set of fittings for the boom point, as shown in the accompanying sketch. Four equidistant U-shaped double-eye forgings were set in notches in the timber and engaged the collar band which clamps the end of the boom and receives the hoist and topping lift tackles. These pieces had clearance to move freely and engaged the loop ends of half links, which were locked to them with vertical pins, and received the shackles, to which the ends of the guys were attached. Connection was thus afforded for four of the guys, and the other two were similarly attached to the regular welded single-piece links permanently connected between the halves of the collar to receive the operating tackles. By this means the guys could be attached and removed almost instantly by opening either the vertical bolts or the shackle bolts, and when not in use the attachment revolved up close to the boom out of the way and cleared the mast when it was topped up. Each derrick was out of service only about three hours on the average when shifted from one story to the second above it. In one case a derrick was shifted by ten men in 1 hour and 45 minutes, and in another instance, at the Bond Building, in 1 hour and 51 minutes, by the aid of this device.

The derricks and fittings were frequently inspected, and the men were so well trained and directed that the steel was erected without accident, although some very heavy pieces were hoisted on single booms, and the connections were difficult. The columns are in two story lengths and have a maximum weight of 38,000 pounds. The heaviest subway girder weighs 44,000 pounds, and the heaviest girder in the building proper weighs 60,000 pounds, but was received in three separate pieces, each a complete plate girder with shop riveted web and flanges. These were hoisted separately, assembled and field riveted together in place. The columns were received with one end of each splice-plate, the beam and girder connection angles and the sway brace gusset plates shop riveted to them, but there still remained 186 rivets to be field driven in each kneebrace connection. In all there were 80,000 field-driven rivets in the steel framework.



Times Building: Erecting Subway Columns and Girders, and First Floor Girders over Subway.

Very great pains were taken to fit the sway brace connections accurately and to keep the columns always exactly plumb, as eccentricities could not be corrected after once the riveting was done, and a little deviation in the lower stories would be greatly multiplied in the upper ones. The connections were very accurately punched and drilled at the shops, so that all of them matched excellently, and any carelessness which might have caused them to be misplaced at any point would have resulted in throwing out every connection in that line above. No such trouble, however, occurred. Near the narrow north end of the building one line and near the south end two lines, of intermediate columns were very carefully plumbed by a transit and thoroughly temporarily braced as soon as set so as to serve as guides to insure the verticality of all the rest of the columns, which were rigidly connected to them with accurately spaced horizontal members. This bracing and the permanent steel bracing of gusset plates and transverse vertical diagonals thoroughly secured the building against wind stresses, and the construction of the solid floors and partitions made the structure abundantly stiff, so that soon after the outer walls were built the structure could be subjected to full wind pressure. The temporary bracing consisted of four 4x12-inch diagonals, at right angles to each other, running transversely and longitudinally from the top of the column to the adjacent columns at the next lower floor beams. These braces were adjusted by pairs of wedges at the ends, and were provided in alternate stories only; but there was a set to each section of the column.

Some delay has been occasioned by waiting for steel, but the erection was practically completed up to and including the eighteenth tier at the top of the main building, about March 1, and preparations are now being made to erect the five story tower, reaching to a total height of over 300 feet from the ground. The hollow tile floors were laid about three stories behind the framework, and the outer walls are up about the thirteenth story. Many of the partitions are built, and three stories are ready for plastering. The outside walls are carried on special girders at every floor level, and bricklaying on them was commenced at the sixth story on January 5, 1904, the work being done both from cantilever and suspended outside platforms, as shown in the general view of the building from a photograph taken February 5. The walls are 2 feet thick at the top. As no bricklaying was permitted when the temperature was below 30 degrees Fahrenheit, considerable time was lost during the unusually cold winter months, and the work is now several weeks behind the contract time, four weeks having been lost by labor troubles. Bricks, mortar and other materials are hoisted by three fast-running hod elevators, with platforms to receive wheelbarrows. These have wooden frames or towers, two of which are located in the shaft containing the four permanent passenger elevators. The steel framework and guides for two of the permanent elevators will be erected in the shaft, and the hod platforms will be transferred to them and continue the rapid service, while their old wooden guides are removed and the other two steel frames are built and two of the passenger elevators installed there as soon as ready, so as to preserve the service uninterrupted and afford tennants an opportunity to inspect the building before it is quite completed.

The work has been carried on by an average force of about 300 men, most of whom worked a single eight-hour shift, derick men and some others working longer hours. The steel derricks were operated by two-drum Mundy hoisting engines and the four boom derricks used by the masons were operated by two Lidgerwood engines, and there were several small breast derricks operated by hand. Nearly all rivets were driven by twelve Boyer pneumatic hammers using compressed air from the mains of the subway contractor.

Mr. Cyrus L. W. Eidlitz is the architect and the George A. Fuller Company is the general contractor for the building. The structural steelwork was furnished by the Carnegie Steel Company, and the excavation was made by the Degnon Contracting Company, Mr. H. C. Sanford, chief engineer, Mr. E. A. Herrick, superintendent and Mr. W. C. Briggs, resident engineer in charge. Mr. L. R. Barras and Mr. George Moyer were the superintendents successively in charge of all the construction and erection.

An interesting comparison with the Times Building, both in the design of the steel framework and in the method of erecting it, is afforded in the construction of the Hotel Belmont, where an entirely different solution was made for the similar problem of constructing one corner of a tall steel building over the curved tracks of the Rapid Transit subway, where the excavation was carried to a great depth in solid rock. In the Hotel Belmont the subway tracks occupy a triangular portion of the first and second sub-basements, with right angled sides about 90 feet long in the planes of the outer walls of the building. Over this area the excavation was carried down only to the subgrade of the subway, while that for the remainder of the building was caried down nearly 20 feet lower. The subway thus virtually occupies a portion of the lower four of the five stories below street level, since there is no vacant space here under the subway floor as there is in the Times Building.

The subway floor is built on the solid rock bottom of the excavation, which here forms a bench adjacent to the lower stories of the hotel. The roof of the subway supports a portion of the hotel building twenty-three stories high and its columns are single short sections seated on the solid rock at sub-grade. This involves the use of exceedingly heavy girders in the subway roof, which are carried on special massive columns and support on their top flanges seventeen columns belong to the hotel framework. The columns have a length of about 13½ feet and are made with several different types of cross-section. One of them has three webs each made with two 16x⅞-inch plates riveted together and connected by eight 4x4x¾-inch flange angles to the two 27x¾-inch cover plate. This column has a 30x½x36¾-inch cap plate receiving the roof girders. Another type of column has three webs, of which the center one is composed of a pair of 15-inch 50-pound channels riveted together back to back, and each of the side webs is composed of a 15-inch 50-pound channel with a 14x⅝-inch web reinforcement plate. These webs are riveted to cover plates each composed of two or three thicknesses of 18x¾-inch plates. The columns weigh up to 5 tons each and are seated on distributing girders, some of which are 4 feet deep and 14 feet long, with triple webs, the center one being made with double and the side ones with single plates ½ inch thick. Each flange consists of four full-length 6x6x¾-inch angles and two 30x⅝-inch cover plates. This girder weighs about 8 tons, and is seated on a grillage of 24-inch I-beams.

The main transverse roof girders are of massive construction with multiple webs. One of them 66 inches deep and 23 feet 8 inches long has a center web ¾ inchea thick and two ½-inch side webs. Each flange is composed of four 6x6x¾-inch angles and two 20x¾-inch cover plates. The weights of these girders vary from about 24,000 to 53,000 pounds. One of them, 30½ feet long, is supported at both ends and carriea a twenty-three-story column about 10 feet from one end. Others carry two columns intermediate between their supports. Others are made in succesive lengths with their ends abutting on the column caps, and still others overhang their supports and carry the tall superstructure columns on their cantilever ends. These girders are connected by I-beams from 6 to 12 inches deep and about 5 feet apart which carry the concrete roof of the subway and a single floor of the hotel.

The very heavy girders were delivered promiscuously at the dock in New York City and some time afterwards the contractors for the erection of the subway secured for one day the services of a powerful floating derrick owned by the Merritt & Chapman Derrick and Wrecking Company. With it the girders were piled in tiers with their webs horizontal and so arranged that they were in proper sequence to be loaded on trucks as required for erection and with their ends pointing in the right direction to be hauled to position without turning. They were jacked up as required and skidded on horizontal rails and timber blocking to the tops of heavy trucks with capacities of 12, 18 and 30 tons each. The heaviest girders were drawn to the site of the building by sixteen horses. The girders were loaded on the trucks with their webs horizontal and both ends overhanging the trucks.

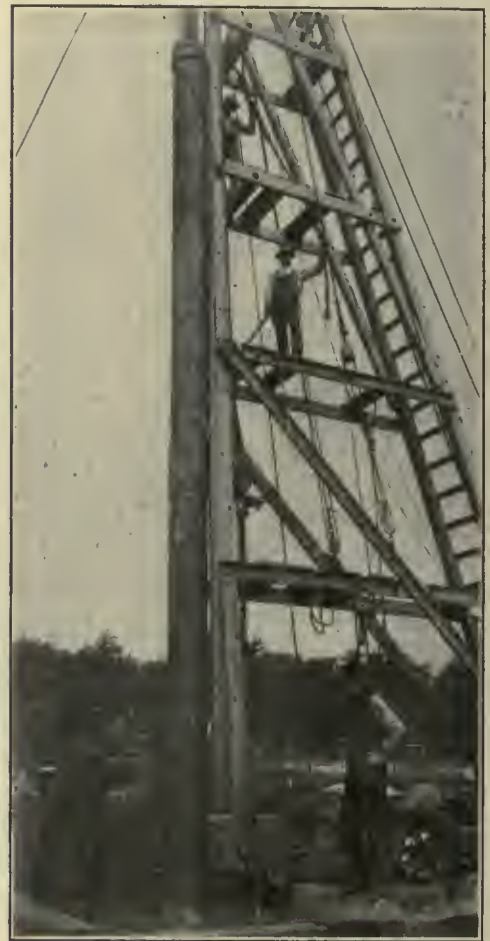
After the horses were unhitched, timber cribbing was built up under the girder just beyond the rear of the truck and two piles of cribbing were built just outside the forward end of the truck and supported heavy cross timbers under the overhanging end of the girder. The girder was then lifted free of the truck by two 20-ton Watson-Stillman hydraulic jacks, which were operated together at both ends successively. The truck was then removed and the girder was lowered to the ground by the ordinary operations of jacking and removing the crib-work. The girders were landed on the timber roadway platform which carried a portion of Forty-first Street over the hotel excavation.

Meantime timber trestles had been set between the subway column previously erected by small or house derricks. On the trestle caps 24-inch 80-pound I-beams 50 feet long were seated and covered with a deck or platform of lose 4-inch planks with their upper surface about 2 inches below the column tops. Other 24-inch I-beams 50 feet long were used as inclined skids reaching from the street platform to the subway deck at an inclination carefully calculated to slightly exceed the angle of stability of steel sliding on steel. These skids were shored at the intermediate points and had a total rise of about 13 feet. A six-part Manila tackle was attached to each end of the girder and anchored to the street above, the fall lines being operated by hand and snubbed around firm supports. In the center of the girder a four-part tackle was attached with the other end made fast to an anchorage in the excavation. Its lead line was taken to the hoisting engine and when all was in readiness, the engine was started and operated this tackle while the end tackles were slacked off, allowing the girder to be easily, safely and rapidly lowered to the subway deck. Here it was received on a number of rollers made from 5-inch steel pipe filled with concrete. It was easily moved to the required position, revolved 90 degrees to bring the web vertical and seated on the column caps by means of the hydraulic jacks and the hoisting engine. For the lighter girders, greased rails were used instead of the concrete-filled rollers.

Concrete Piles for Building Foundations.

One of the problems which frequently faces the mill architect as well as the designer of other large buildings is the economical construction of the foundations. It often happens that in order to support the building securely, it is necessary to put in a large amount of masonry in footings and base walls which is not called for except to develop the requisite bearing capacity from the soil. A year ago The Engineering Record described the manner in which the walls of some of the buildings of the Lackawanna Steel Company's plant at Buffalo were carried on independent piers. These piers were connected by arches which supported in turn the masonry of the walls above. Such a system of construction renders it unnecessary to build expensive trenches and furnishes all the support necessary for the building in case the piers are properly proportioned for the loads they have to carry. In addition, it saves the cost of the long masonry foundation walls.

Forty-Ton Load on Concrete Pile.



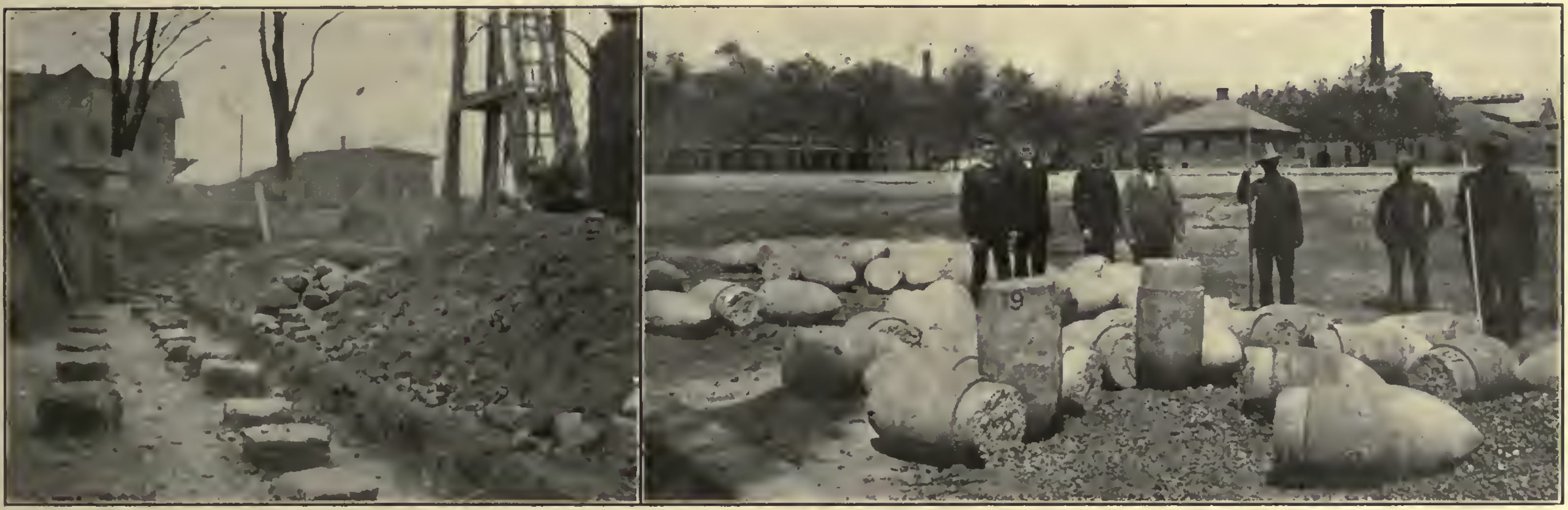
Rig for Driving Steel Pipe.

In the construction of the new post office at Lawrence, Mass., an interesting modification of the pier system of putting in foundations has been adopted. The earth support of this building is an excellent New England hard-pan, and it would not be necessary to go very deep into it in order to obtain all the bearing capacity needed for the building. Nevertheless, since a cellar under the whole of the building has not been needed, it has been found best to avoid all trenching whatever for the walls except what is necessary to strip off the surface soil. The foundations consist of 14-inch Simplex concrete piles driven about 13 feet. The supporting capacity of these piles is well indicated in one of the accompanying illustrations which shows one of them loaded with 40 tons of pig-iron. Under this load the pile sank about ⅜ inch, but after the removal of the iron, it came back ¼ inch, showing that the load was distributed by the pile through the soil in the vicinity and that the soil itself was depressed under the load.

This use of concrete piling is a comparatively new one and opens up a field in building construction which will be of particular interest to the designers of mills and factories, where cellars are rarely required and for this reason the depth of foundation trench is settled wholly by the necessity of securing ample bearing capacity and freedom from the lifting effect of frost. Previous uses of this system of piling show that in water-bearing earth it possesses distinct advantages over wood piles. It was first employed last year on a large scale at Washington Barracks, D. C., where two large barrack buildings and a number of officers quarters were provided with foundations in this manner. Washington Barracks is located on a tract of land where the ground water conditions are particularly destructive to wooden piling. The contractors for these foundations, the Cranford Paving Company of Washington, suggested that the objections to the wood piles could be overcome by using concrete, and they proposed a system of construction designed by Mr. Frank Shuman of Philadelphia. After a careful investigation by Captain J. S. Sewell, Corps of Engineers, U. S. A., who was in charge of this work the concrete piling was adopted.

In its most developed form the Simplex system employs a hollow pipe of the required length, diameter and thickness, with a detachable point of concrete or cast-iron and a driving head to protect the top from damage by the blows of the hammer. It is driven like an ordinary pile into the ground until it beds in hardpan or other suitable material. The tube is then raised slowly while concrete is rammed into it, the ramming forcing the material into any hollows in the sides of the hole and thus increasing the bearing capacity of the pile materially. The use of such piles for foundations, as a substitute for deep walls and footings, receives support from the often-observed compression of poor soil by piles. When these are driven close the soil is often rendered so firm as to be entirely satisfactory, and the concrete pile affords a means of accomplishing this result with indestructible material without the expense of digging, bracing and pumping large trenches.

In some cases, where there is a great deal of ground water to contend with, it is necessary to place over the main tube a thin shell which is driven with the pile to such a depth that it cuts through the stratum of the water-bearing material and forms a sort of cofferdam, within which it is safe to place the concrete. This shell can be left in place or withdrawn as desired.



Concrete Piling at Lawrence Post Office; Concrete Points for Use at Washington Barracks.

The Measurement of Temperature in Steam Pipes by a mercury steel pyrometer was described in a recent paper by Mr. R. K. Morcom, read before the Institution of Electrical Engineers, at Birmingham, England. The temperature is indicated by a pointer on a dial face, which has the appearance of an ordinary pressure gauge. The pointer is actuated by the expansion of mercury in a steel tube reacting on a spring. The instrument may be fixed in any position in the engine-room and connected by a fine steel tube containing any convenient medium to transmit the pressure to the spring. It is troublesome to calibrate and requires frequent correction. A platinum-wire pyrometer, he asserts, has frequently been broken by the rush of steam and is too delicate for the testing plant of an engine works. The present arrangement comprises a thin, steel tube, screwed well into the steam pipe through a stuffing box, so that an asbestos packing may insulate it from the steam pipe. Oil is used in the tube instead of mercury, as it is found slightly more accurate. The author also referred to the method of inserting a thermometer into a cup screwed into the pipe, the end of the thermometer being immersed in a bath of mercury.

Alcohol for Internal-Combustion Engines.

Alcohol as a fuel for internal-combustion engines has received a good deal of attention abroad of late years, especially on the continent. Many manufacturers have brought out engines adapted to the use of alcohol, but the general adoption of this type of prime motor has apparently not become very wide as yet, partly from the fact that in many quarters the production of alcohol is restricted by law and its price is proportionately high. The stimulus that the industry has had thus far is largely owing to the feeling that the cost of petroleum, only a small percentage of which is available for use in the internal-combustion engine, is threatened with an artificial advance, being controlled by centralized interests, if indeed the volume of the supply is not itself likely to fail increasing demands.

The characteristics of alcohol as a motive power are presented in a paper read about a month ago by a Dr. Ormandy before the Automobile Club of London. The following notes are taken from it: From the experiments of Professor Meyer of Charlottenburg, it is found that in some cases a compression up to 10¼ atmospheres was used and the greatest explosion pressure attained with alcohol was in a number of cases as high as 33 atmospheres. The possibility of using such high compression without preignition is due to the high specific heat of alcohol vapor and the fact that the spirit contains 10 per cent. of its volume of water. A study of Professor Meyer's work leads to the conclusion that the increased efficiency of the alcohol motor (30.9 to 32.7 per cent.) is entirely due to the increased compression employed, and the possibility of employing this compression is due, in the first place, to the low inflammability of alcohol air mixtures, but, in the second place, and in a higher degree, to the water contained in the alcohol.

The actual amount of heat which is necessary to evaporate a certain quantity of alcohol containing 10 per cent. of water, is only 5½ per cent. of the total heat of combustion of that same amount of alcohol. In calculating the heats of combustions, in all cases it must be understood that the heat which would be given out by the water vapor in the products of combustion condensing from the form of steam is not taken into consideration.

In order that the mixture of air, alcohol and water passing into the cylinder may be such that there is no necessity for any of the constituents to be in a state of suspension as liquids, it is necessary that a temperature of 374 degrees Fahrenheit shall be attained. This comparatively high temperature is only required when the mixture entering the cylinder is to contain the maximum amount of alcohol which the oxygen present is able to fully consume, and this is a state of affairs which it is not desirable to have. It is in all cases preferable to work with an excess of air, in order to make sure that combustion shall be as complete as possible. Of ten motors, Professor Meyer found that the one which worked on the poorest mixture with the most economical results would require the ingoing air to the carburetter to be heated to a temperature of 257 degrees in order to carry the alcohol and water in the form of vapor.

These calculations are carried out on the supposition that the air which is used to start with is saturated with water vapor at a temperature of 60 degrees. It is also easy to prove, in those cases where the air is not warmed prior to entering the carburetter, that it is only necessary to heat the mixture of air and alcohol spray to a final temperature of 86 degrees, in order to attain complete evaporation of the liquid; that is to say, contact of the sprayed mixture with a sufficiently large surface at or over 95 degrees to evaporate the liquid, and to give the mixed vapors a final temperature of 86 degrees is all that is necessary. The most economical results will be attained by a carburetter which delivers the mixed air and alcohol vapor at a temperature as little as possible above that necessary to retain the alcohol in the form of vapor, because by so doing we shall be enabled to work with safety at the highest possible degree of compression.

The amount of alcohol required in some cases to drive a motor on half load is 100 per cent. more when the water in the cooling jacket is kept at about 60 degrees than when the jacket is kept at 212 degrees. This is a subject of very great importance, and all tests of fuel consumption in alcohol motors which do not take this into account will be of little or no scientific value. The combustion of alcohol in the motor under full load is practically complete, and the products of combustion are odorless or nearly so. It has been stated that during the explosion of mixtures of alcohol and air acid substances might be formed which would have a deleterious effect upon the substances of the cylinder and the valves. The Experimental Fermentation Institute at Berlin have alcohol motors which have been running for years, and in no case have any signs of such action been observed.

A Variable-Speed Transmission.

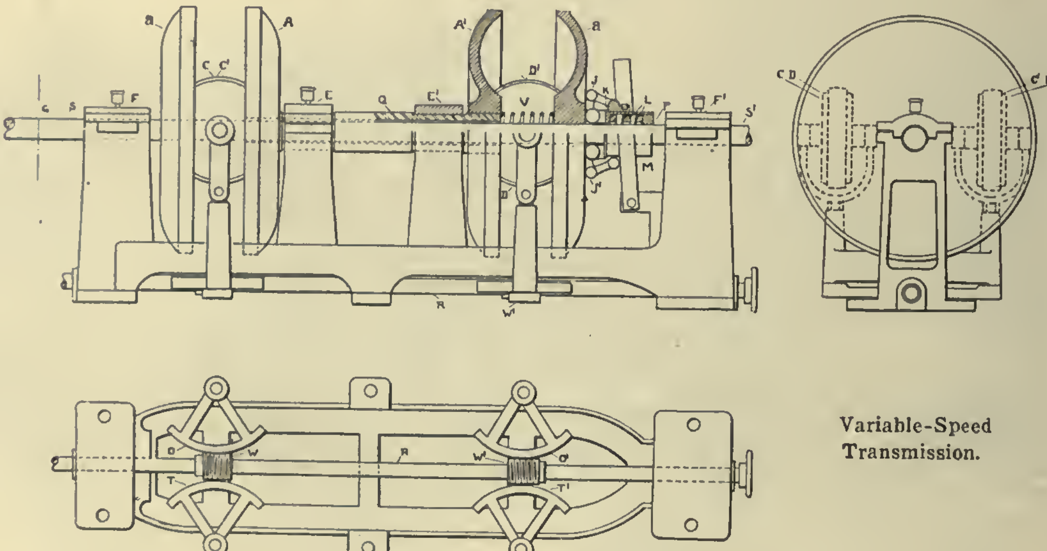
The variable speed transmission shown in the accompanying illustration is a recent modification of an apparatus that has been in use for a few years, mainly in New England mills and shops. The experience with these first machines has led to many changes in details and methods of construction which make the apparatus stronger than before while reducing its total weight. The machine as now built has practically all the non-movable parts in a single casting, which does away with bolted pieces liable to work loose. The engraving shows the general design for an apparatus made in sizes from 3 to 50 horse-power; the transmissions of smaller and larger capacity than these limits are somewhat modified from that illustrated, although the principal features of their construction remain unchanged.

The general scheme of the transmission is very simple. At each end of a quill a disk is mounted. A shaft passes through the quill and carries at each end a disk similar to those on the quill. This quill carries a pulley which drives the apparatus. Between the pairs of disks at each end of the machine is a pair of friction wheels through which the power transmitted to the quill is transmitted in turn to the disks on the shaft. The shaft which is driven in this manner can be connected in any suitable way with the mechanism to be operated. The friction wheels between the pairs of disks are so mounted that they can be adjusted to give a considerable variation in the speeds of the quill and the shaft.

This brief outline of the principle of the transmission will render the following description of its parts clear: A A′ and B B′ are the two pairs of disks, which have their opposed faces made with an annular groove. C C′ and D D′ are the friction wheels between the pairs of disks, their faces being curved to the radius of the grooves in the disks. The wheels are so mounted that they can be set to make any angle between the grooves; for this purpose their axes are turned simultaneously by the rod R, which moves the worm W W′ meshing into sectors O O′ and T T′ attached to the axes.

The disks A A′ are carried on the quill Q which runs in the bearings E E′. This sleeve also carries the pulley through which the power is applied, although this pulley is not shown in the engraving. The shaft S runs in the bearings F F′ on either end of the frame and carries the disks B B′. The disk B is keyed and pinned fast to the shaft while the disk B′ is splined to it. The clutch K is pinned to the shaft at P and turns with it. The driving pressure is obtained by throwing the clutch lever and causing the toggle joints J J′ to spring out. This action forces a collar back, compressing the spring L so that it exerts a pressure in both directions. This pressure pushes the disk B′ on its spline against the friction wheels D D′ and at the same time pulls the disk B against the wheels C C′. Both pairs of friction wheels are held in an upright position by their contact with the disks A A′. The spring V on the disk B′ is a releasing spring. When the clutch is thrown out and the spring L is exerting no pressure, the disk B′ is forced by V away from the wheels D D′, thus insuring the prompt stopping of the machine. The absence of any end thrust in the apparatus is a noticeable feature of its design.

The machine is made by the Power & Speed Controller Company, 147 Milk Street, Boston, Mass., who state that in some tests of an apparatus of 15 horse-power capacity the efficiency was a trifle over 80 per cent. with speeds ranging from 129 to 450 revolutions per minute. The average range of speed variations is 7½ to 1, between which limit and 1 to 1 all gradations in speed are possible with the machine.



Variable-Speed Transmission.

What Constitutes Reasonable Uniformity in Municipal Accounts and Reports?—I.

A paper read before the National Municipal League by Mr. F. A. Cleveland, of Haskins & Sells, New York.

The primary purpose of political organization is government, the establishment of social order. In democratic society this is accomplished through the creation of a public corporation. A corporate public agent being organized and equipped to maintain social order, its machinery is then utilized to render such other service as the members of the community, in their several private capacities, cannot with equal advantage perform for themselves.

Common Functions Undertaken by Municipalities.—The functions undertaken by municipal corporations are of three general classes, viz.: (1) those exercised in the interest of established order and social convenience; (2) those which pertain to social betterment or social elevation; and (3) those which have to do with social economy. Welfare, therefore, as comprehended within the meaning of modern municipal citizenship, and as conserved by municipal administration, must include all of these institutional purposes and activities.

A corporation is a lifeless, bloodless, legal fiction. It is a person of sovereign powers, without the ability, however, to exercise these powers except through living human agents. But these living corporate agents are impotent to exercise powers not granted; and again, they are unable to perform the functions granted or assigned to the corporation, except by means of the physical equipment suited to the accomplishment of the corporate ends.

It is in this situation that the advantage of corporate political organization lies. The political powers of government (those which pertain to the form of corporate organization, the election and appointment of living agents to direct the corporate activities, and the exercise of other electorial functions pertaining to changes in law or political policy) are retained within the direct or indirect control of the people whose welfare the corporation is to serve; the active administration of the affairs of the corporation is left to agents thus selected or appointed with authority to direct its functions and to enforce its rights.

Uniformity of Corporate Organization.—To become effective as a public corporation, the service of a municipality (i. e., the living agents into whose hands the corporate powers and physical equipment is placed) must be organized around the functions undertaken. And the community interests of one politically organized legal society being similar to the community interests of another, the functions to be performed by the corporation organized to serve these interests are similar. For the same reason the structural and legal form of municipal government bear a close resemblance.

The common provision for the exercise of political functions are found in constitutional and legal enactments for "the election and appointment of officers." Common provisions for the exercise of administrative functions in the interest of social order and convenience are found in the creation of departments and bureaus (a) for the "protection of life, health and property;" (b) for the maintenance of institutions of "public charities and corrections;" and (c) for the administration of "public highways and sewers." Common provisions for the exercise of functions pertaining to social elevation are found (a) in the organization of "public schools;" (b) in the maintenance of "libraries or galleries and museums;" and (c) in the support given to "public recreation." Common provisions for the exercise of administrative functions which have to do with social economy are found in departments and bureaus controlling (a) "municipal industries" and (b) "municipal investments."

Distributing the various bureaus and departments of corporate activity in such manner that they may be exhibited in relations to these common functions exercised an outline classification would appear as follows:

(1) GENERAL ORGANIZATION.

(1) *For Elections and Appointments.*
(2) *For General Officers and Offices.*

(1) Mayor.
(2) Council.
(3) Municipal Courts.
(4) Law Officers.
(5) Finance Officers.
(6) City Hall and General Officers.
(7) Department of Public Supplies.
(8) Public Printing.
(9) Miscellaneous.

(2) DEPARTMENTAL ORGANIZATION.

(1) FOR THE MAINTENANCE OF SOCIAL ORDER AND CONVENIENCE.

(1) *Protection of Life, Health and Property.*

(1) Police Department.
(2) Fire Department.
(3) Fire and Police Telegraph.
(4) Public Pounds.
(5) Health Department.
(6) Insane Hospital.
(7) Cemeteries and Crematories.
(8) Bureau of Inspection.
(9) Militia and Armories.
(10) Miscellaneous.

(2) *Public Charities and Corrections.*
(1) Homes for the Aged.
(2) Orphan Homes.
(3) Institutions for Defective Youths.
(4) Public Lodging Houses.
(5) Outdoor Relief.
(6) Prisons and Reformatories.
(7) Work Houses.
(8) Miscellaneous.

(3) *Public Highways and Sewers.*
(1) General Organization.
(2) Opening and Grading of Streets.
(3) Maintenance and Repairs of Streets.
(4) Maintenance and Repairs of Sidewalks.
(5) Street Lighting.
(6) Street Cleaning.
(7) Snow Removal.
(8) Street Sprinkling.
(9) Refuse Collection and Disposal.
(10) Sewers and Sewage Disposal.
(11) Miscellaneous.

(2) FOR SOCIAL BETTERMENT.
(1) *Public Education.*
(1) Elementary Schools.
  (a) Kindergartens.
  (b) Grade Schools.
  (c) Trade Schools.
  (d) Special Courses of Elementary Instruction.
(2) Schools of Higher Instruction.
  (a) High Schools.
  (b) Training Schools.
  (c) City Colleges.
(3) Miscellaneous.
  (a) Free Lectures.
  (b) Other Educational Services.

(2) *Public Libraries, Art Galleries and Museums.*
(1) Public Libraries.
(2) Public Art Galleries.
(3) Public Museums.
(4) Other.

(3) *Public Recreation.*
(1) Public Parks.
(2) Public Playgrounds and Gymnasiums.
(3) Public Baths.
(4) Public Celebrations.
(5) Miscellaneous.

(3) FOR SOCIAL ECONOMY.
(1) *Municipal Industries.*
(1) Water Works.
(2) Gas Works.
(3) Electric Light Plants.
(4) Municipal Heating.
(5) Street Railways.
(6) Municipal Subways.
(7) Municipal Conduits.
(8) Municipal Markets.
(9) Miscellaneous.

(2) *Municipal Investments.*
(1) Real Estate.
(2) Stocks and Bonds.
(3) Other Investments.

In none of the cities do we have all of the departments of service above shown; but in all of them in so far as the service is organized the relations indicated are present. From the point of view of functions undertaken and of organic provisions made to perform these functions, therefore, a common basis for classification is found with which all the data pertaining to either the political or administrative activities must be associated.

Uniformity of Classification Based on Organization and Service.—Municipal administration is largely a matter of business. In a free society the service employed by a public corporation must be voluntary, and therefore a subject or contract, i. e., one of offer and acceptance; in most of its aspects the exercise of administrative powers rests on bargain and sale; while, even in its political and governing functions, the corporation must have financial support. The character and efficiency of administration, therefore, must in large measure depend on the character of business judgment exercised by those in administrative control; and in an institution having such variety of transactions and such complexity of organization (one whose business in the aggregate amounts to many thousands or even millions of dollars), the exercise of sound official discretion depends on a system of financial account and statistical report, which will not only record each transaction in its proper administrative relation, but which will also reflect, in properly classified summaries, the net administrative results.

Municipal accounting has been defined as a method employed by a city for the purpose of recording its business transacted in the performance of its many functions, and for finally co-ordinating the data around problems of administration. A system of accounts employed by a city, therefore, being designed as an aid to administration, if true to this purpose, must, like the administrative service itself, take its form and character from the form and character of corporate functions exercised. The same is true of statistical reports. As a principle of uniform classification in municipal accounts and reports, this is not stated as a possibility, but as an administrative necessity. Such uniformity as is found in the functions undertaken by the various municipalities, and such as is reflected in common forms of organization, require that the general categories for the final summaries of account and statistical report in one city be similar to those of another. This is the assumption which lies at the foundation of the work of the Committee of Uniform Municipal Accounts and Statistics of the National Municipal League.

Schedules of the Committee on Uniformity of Municipal Accounts and Statistics.—Proceeding from this assumption, the Committee of the League on uniform municipal accounts and statistics has till recently turned its energies entirely toward the discovery of those functions and forms of organization that are common to municipalities. For guidance they have gone to the charters and organic laws; they have also availed themselves of the results of research of political scientists, and of the experience of professional accountants and officers of municipal control. Each result has thus been brought to a critical test and the schedules of the League have been found so well suited to the need that they have been adopted by a large number of cities as a basis for making their financial reports.

So useful were the schedules of classification thus formulated, that, from the date of their first publication, they have been utilized by cities attempting to restate their reports. In fact, the progress of the work of the Committee may be traced in the new classification from time to time adopted by municipalities. To-day there are no less than eighty cities whose financial statements bear the stamp of the work of the League; and the United States Census officers have made use of them in the collection and classification of municipal statistics. At the last conference of the League it was thought the success of this part of the work of the Committee warranted an enlargement of the scope of their labor. The Committee was therefore continued and instructed to report in outline a complete system of municipal accounts and reports.

It is to be held in mind that to this time no attempt had been made by the Committee to apply its classification to any part of the accounts of a city, nor to any part of a municipal report except to "Receipts" and "Disbursements." And the use that has been made of the schedules by the cities themselves has largely been of the same sort. Till the time of the last conference only three cities had adopted complete systems of accounts in which an attempt was made to apply the classification of the League, and two of these systems were in process of installation. The City of Chicago was the only city having such a system of accounts, that had made a report, and in this (the Comptroller's report for 1902) the application made of the schedules had been to Revenues and Expenses of the City, instead of the transactions of the Treasury (i. e., to Receipts and Disbursements). The larger work to be undertaken by the Committee, therefore, as before, was in the nature of pioneering.

The Larger Work of the Committee on Uniform Accounts and Reports.—To answer the specification of "completeness" the Committee must outline a plan by which all of the transactions pertaining to municipal activity may be classified, i. e., it must not only include the transactions of the Treasury and mark the flow of cash, but it must also take into account the transactions and the properties pertaining to every other department and municipal relation. The success of the committee in introducing a "uniform" system must depend on the adoption of a classification of detailed accounts from which the central controlling officers may bring the work of the bureaus and department into relation with the common problems of municipal administration, and which in turn might be used as a basis for a financial report. To accomplish such a task, to devise schedules which may be acceptable and serve as a basis for uniform accounting, will require years of continuous effort and must reflect the technical knowledge and experience of a large community in interest. The service which the Committee hopes to render is one of bringing this knowledge and experience together and of expressing it in intelligible form.

The initial work of the committee was to obtain a formulation which might be used as a working hypothesis for discussion, which might be used to draw out this experience in conference. The scope of the Committee's investigation was to include the physical and operative statistics of cities as well as their financial accounts and reports. At the first meeting held the first draft of that part of the programme which pertained to statistics was assigned to the chairman (Dr. Hartwell, head of the Statistical Department of the City of Boston), and the preliminary draft of the outline of Accounts and Financial Reports was assigned to the Secretary.

(To be continued.)

Letters to the Editor.

THE PRESSURE OF GRANULAR MATERIALS.

Sir: I have read with considerable pleasure your editorial comment on the subject of lateral pressures of granular materials in The Engineering Record of April 23, and wish to thank you for your kind reference to my experiments on grain pressures.

In connection with the subject of the lateral pressures of earth, I have read with a great deal of interest Mr. Goodrich's paper as presented before the American Society of Civil Engineers, and while there is considerable difference between earth pressures against a retaining wall and presures of grain in a deep bin, they are very closely allied to each other. There is, however, one important difference which I do not think is fully appreciated; in the case of a retaining wall, we have one wall only and have to deal only with the triangular shaped mass behind the wall, which is bounded by the wall, the angle of repose, or natural slope of the earth, and the top surface. In the case of a grain bin, we have the four walls which are compressible to a very much less extent than the grain itself and therefore the friction of the material against the walls causes the walls to act as columns to support the greater part of the load.

I regret that I cannot agree with you wherein you state: "The most valuable feature of the experiments of Mr. Goodrich are those which demonstrate beyond question that investigations of this nature to be of practical value must be on models of large size." So far as grain pressures are concerned, models of moderate size such as I used, are beyond question of equal value with very large models or even full-size bins, in fact are in some respects superior, inasmuch as they permit a greater variety of tests being made and more close observations. The same laws apply exactly in the models as in the full-size bins and my model bin tests check very accurately with the full-size bins. You will, I believe, agree with me when I say that when we once establish the laws governing the pressures, the problem is then practically solved, and calculations can be accurately made from the ascertained laws. In the case of sand or lose granular earths free from lumps or large stone, I believe equally valuable tests can be obtained from moderate size models as from very large ones. This, however, would not be the case in the event of using broken stone of large and variable size, bituminous coal, or other substances of that nature.

I appreciate most thoroughly the efforts of Mr. Goodrich to gain a more accurate knowledge of the pressures produced by earths and other granular substances, and regret very much that he was not more fortunate in the choice of his testing apparatus, and the manner of conducting the tests. His tests made in the bin are, in the writer's opinion, of very little practical value as applied to retaining walls for the following reasons: First, because he has the four walls which will support the greater part of the weight of the earth and therefore prevent the full pressure being attained at the bottom that would be attained if he had used only the one wall. Second, his system of weighted right angle levers is very defective in principle and the results obtained from them will depend largely on the personal equation of the operator. I know this to be true in the case of grain pressures and I am certain it is equally true under the conditions which Mr. Goodrich employed them, and I might say that I attribute whatever success I attained in my experiments to the use of the hydraulic diaphragm. The other tests of Mr. Goodrich made on a larger scale I believe to be of considerably more practical value than his bin tests, but they are also open to the somewhat serious objection that whenever considerable deflection takes place in his wall, the arching in the material behind the wall will prevent the proper pressures being ascertained.

To obtain accurately the pressures of any granular material, it is necessary that the pressure face of the testing appliance coming in contact with the material should not recede under the pressure more than an infinitesimal amount and should not in any way be dependent upon the personal equation of the operator, and I know of no appliance that will so well meet the conditions as the hydraulic diaphragm.

I regret very much that I was unable, owing to lack of the necessary time to carry out my experiments further, and more definitely ascertain the laws governing the pressures produced by coal, earth, etc. However the experiments that I did make with sand showed conclusively that the behaviour of other strictly granular materials is exactly similar to grain, so long as they are strictly dry, and the ratio of lateral to vertical pressure may be obtained from the angle of repose of the material. This angle of repose will, however, increase as the moisture, up to a certain limit and will then decrease with an excess of moisture and the lateral pressure will decrease and again increase in the same ratio until it may become equal to a maximum of hydraulic pressure; if, however, the drainage is such as to prevent an excess of water accumulating then it is believed that the maximum horizontal pressure will be that which is produced by the material when strictly dry. In the case of a deep retaining wall the pressure will also be considerably decreased, due to the friction between the material and the face of the wall; the coefficient would, however, decrease with an excess of water.

Based on my experiments and study of the grain pressure problem I believe that the problem of earth pressures is capable of comparatively simple solution and that accurate results may be obtained by the use of the hydraulic diaphragm and mercury column gauge, if used under the proper conditions. I have written you at some length, as I feel that since the question of pressure produced by granular materials is under discussion that an effort should be made to put it on a final and conclusive basis and I feel that it is more than probable that you will again be dealing with the subject.

Yours very truly, J. A. Jamieson.
Montreal, April 28.

Sir:—Please accept my hearty appreciation of your reference to my paper in your editorial comment on the subject of lateral pressures in granular materials, and of the opportunity afforded of reading Mr. Jamieson's letter of April 28. Through a report of it in one of the engineering magazines, his article presented before the Canadian Society of Civil Engineers, came to my attention but a few days before the publication of my own. I studied it with interest, referred to it at the presentation of my paper, have made some late experiments on wheat and other grains with my cylinder and shall refer to it and them more fully in the final discussion of my paper before the American Society of Civil Engineers.

As Mr. Jamieson says: "There is considerable difference (in detail) between earth pressures against a retaining wall and pressures of grain in a deep bin," but they are really, kindred phenomena. In one case the effect of arch action is predominant, in the other, it is less, but I believe never entirely wanting. While the triangular shaped mass behind a retaining wall, as described by Mr. Jamieson, is perhaps of major importance, still the manner of fill, kind of material, height of wall, etc., are very large factors, and when we come to bridge abutments and retaining walls with rear counterforts, the problem merges closely upon the one in deep bins.

I am still of the opinion that the pure retaining wall problem, i. e., the finding of the ratio between vertical and lateral pressures against extended surfaces is not to be solved by the use of small models. In absolutely dry granular masses of small sized particles, the experiments with large and small models are fairly concordant, but their practical value is nil, as such conditions are never met with in actual practice. In such materials the actual arch action is less and is fairly constant. I very much doubt, however, whether a test of dry sand in a 12-foot bin will agree at all with Mr. Jamieson's test on his 12-inch model, which I am very sorry was not carried further. This, I believe, is conclusively shown by plotting together Steel's experiments on dry sand and my own with the 3-foot model, as Mr. Jamieson has done for wheat in his 10-foot, 12-inch and 6-inch bins. The curves do not agree at all, and neither do they agree with those for wheat above-mentioned. While Mr. Jamieson's results are singularly concordant as to wheat, I feel that the general rule needs further demonstration before complete acceptance.

Mr. Jamieson's criticism of my bin tests are fully concurred in, and your editorial quotes my statement that they are of little value. What he says as to the defect in principle of right-angle levers, I fail to understand. There is a personal equation in all work where the results are not automatically registered, but in the case of my cylinder, the possible error was shown to be negligible by the exact uniformity of the many preliminary experiments tried in order to test the apparatus, and which, for want of other interest, were barely referred to in my paper.

Mr. Jamieson was especially fortunate in the design of his apparatus and his work escapes the criticisms which Wilson is open to, in the latter's application of the same general means. In the retaining wall experiments, only the final result, obtained after several months' waiting, is of value. The others are of hardly more than scientific interest, except as demonstrating the fact that high local pressures may be produced under certain circumstances. This fact was brought out more clearly in the presentation of my paper, than is done in the printed copy.

It would be of interest to calculate the actual amount of movement of the diaphragm used by Mr. Jamieson. Of course, it is infinitesimal and, doubtless, less than the one-thousandth of an inch which my apparatus gave. It is believed, however, that the latter amount is not sufficient to cause internal changes of any moment.

I believe that Mr. Jamieson has gone somewhat astray in not making more use of the angle of internal friction, which, in the case of wheat was found to vary as much as 20 per cent. from that of the surface slope, in some experiments which I have made with my cylinder since reading his article. While I am not certain of the fact, I believe that by using such a reduced coefficient, the 20 per cent. variation found in his 12-inch bin test from the 10-foot bin test may be accounted for. I believe further, that the relation between the ratio of pressures and the coefficient of friction cannot be given by a simple ratio, but is contained in Rankine's well known formula.

I know of but one mathematical investigator (of course, European, as you observed) who takes account of arch action in his retaining wall formula. I am of the opinion that a rigorous solution of the problem must take this into account, but further believe that when such a solution is finally worked out, it will be shown that more or less empirical rules are still the best for practical use. The present trouble is that there are too few of the latter. In order to have a firm foundation upon which to build them, numerous carefully conducted and fully discussed experiments are essential. It is to be hoped that many others will enter this field and that all those possessing relevant data will communicate it to the profession through your columns or in the discussions by the engineering societies.

Yours truly, E. P. Goodrich.
New York, May 4.

The Fenimore Sulphite Mill.

Sir: In the issue of your paper of the 30th ulto., you published a description of the Union Bag & Paper Company's plant near Sandy Hill, N. Y., under the heading The Fenimore Sulphite Mill. In this article it is stated that the steel work for the buildings was supplied by the Penn Bridge Company. This is not a correct statement of the fact, for in reality the steel work was supplied to the Grace & Hyde Company by the Fort Pitt Bridge Works, of Pittsburg, Pa. We trust you will kindly make a note of this correction in an early issue of The Engineering Record.

Yours truly, Fort Pitt Bridge Works.
New York, May 2.

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The Extent of the Electrically-Operated Section of the New York Central Railroad.

A good deal of surprise has been expressed from time to time concerning the extent of the lines which the New York Central & Hudson River Railroad Company proposes to equip electrically. The reason for this surprise is doubtless to be found in the lack of knowledge of the peculiar nature of the problem of handling the traffic centering at the Grand Central Station. An attempt to operate a portion of its trains by steam within the limits of Greater New York would unquestionably prove unsatisfactory to some of the patrons of the road and sooner or later result in legislation compelling the company to move all its trains electrically. Moreover, when the problem is carefully considered, it will be seen that there is really little difference between the operation of the suburban trains and the through trains by electric means, certainly not enough difference to warrant the company in making different terminals for these two classes of service.

The suburban service of the company is capable of enormous development. It is acknowledged by officials of the company that the drawbacks of travel immediately north of the Grand Central Station have retarded the growth of the Borough of the Bronx and the district beyond. Now that the company has been required by law to use electricity for suburban service south of the Harlem River, and very likely might be compelled to do so as far north as Yonkers and Mount Vernon, it is natural that the electric equipment should be extended so far as there is any likelihood of building up a good suburban business. It would not be good business to comply with the legal requirements and do nothing more. A study of the topography of this district will show there is little opportunity for obtaining adequate sites for electric and steam junction points south of Croton and North White Plains. A study of the suburban business of the company will show similarly that this traffic reaches practically to these two points. At the present time it is by no means so well developed as it should be, but with the smaller units, more frequent trains, greater speed and freedom from smoke and gases which electric apparatus will insure, there can be no question about the rapid development of this attractive territory immediately north of the city. It would be manifestly a short-sighted policy to stop the electric equipment of the lines south of Croton, and there are probably good reasons for extending it as far north as Peekskill. Croton being as far south as there is any reason for placing the limit of the suburban district, it naturally follows that from an operating point of view any attempt to change the method of hauling suburban trains south of Croton and North White Plains would be a mistake. To handle these trains partly by steam locomotives and partly by electricity would involve a change of cars or switching movements which would nullify to some extent the advantages of electric equipment. It would tend to check in particular the long-distance passenger and freight business which will be the most remunerative portion of the traffic inside the proposed electrical territory. From an operating point of view it is essential to give as good service as possible to the very limits of the suburban district, for the returns from this service are greater than those from the passengers and freight nearer the Grand Central Station. Moreover, the introduction of frequent, comfortable and rapid trains to the limits of the proposed territory will have a marked tendency in restricting competition from street railway companies.

The through-train service would naturally begin at the limits of the electric suburban district. As before mentioned, it is not good policy to run steam cars over electrically-equipped lines north of New York. Not only will the smoke and gases from the steam locomotives prove undesirable, but the cost of maintaining terminal stations for main-line trains south of Croton and North White Plains will become unavoidable with such an arrangement. The saving in the cost of these terminals will go some way toward offsetting the expense for electric locomotives for the long runs from Croton and North White Plains. Furthermore, the land for terminals farther south will be difficult to acquire, particularly in a shape well adapted for terminal purposes. The manufacturers of electrical locomotives give satisfactory assurance that their equipment can handle heavy loads at high speeds, so that the length of electric haul will have no effect on the schedule of through trains. In addition to these considerations, there is the manifest desirability of pleasing the public by dispensing entirely with the use of steam within the electric suburban district.

Increasing the Efficiency of the Rotary Kiln.

There have been a number of articles in this journal of late concerning the efficiency of the rotary kiln. It will be recalled by those who have kept in touch with cement burning in this country for the past ten or twelve years that this type of kiln was never seriously attacked by its opponents on the ground of impracticability, but it was often asserted that it was not a good apparatus to employ on account of its excessive demands on the coal pile. In the early days when oil was used as a fuel and certain features of the construction and use of the rotary type were not mastered there were some users of the dome kiln who were not disposed to acknowledge that the new type was even practicable, but it was mainly on the ground of its high fuel expense in operation that it was regarded with distrust. Even at the present time, when it has been settled that the rotary kiln really saves money to its users, it is still the weak feature of a cement plant, and it is not surprising that operators are endeavoring to secure a greater output from it for the same amount of fuel.

Elsewhere in this issue there is a very interesting paper by Mr. H. S. Spackman, giving an analysis of some investigations to ascertain the thermal efficiency of the rotary kiln. The value of these investigations lies in the suggestions they afford for an improvement in the process of burning as conducted at present. Mr. Spackman has done good work in showing how closely the experiments of Professors Richards and Carpenter and the theoretical analysis of Professor Newberry agree among themselves. It is most gratifying to observe that the data furnished by the work of these experts are so harmonious as to leave little doubt concerning the general distribution of losses of heat in burning.

It seems evident that the great source of loss is the excessive amount of air admitted to the kiln. The remedy for this which many managers have introduced is the lengthening of the kiln, so that the heated air and gases will give up more of their heat before they pass into the stack. The lengthening of the kiln results in the exposure to these gases of more raw materials and consequently gives them more work to do. There is little question but what it increases the output of clinker per pound of coal, and it is the direction in which most practical men have been working; in fact, so far as The Engineering Record is aware, it is the only direction in which any improvements have been suggested regarding the kiln itself. The utilization of the waste gases in the boiler plant of the works is a different proposition.

Mr. Spackman suggests that equally good results might be obtained by reducing the amount of air admitted to the kilns. He apparently does not consider that so much air must enter as most cement burners now admit. In other words, he suggests that the way to prevent the losses of heat due to an excess of air is to reduce the excess to the minimum needed to produce a good clinker. This is a proposition worthy of careful consideration by experienced manufacturers, because in the present condition of the industry, when it is absolutely necessary to reduce all the costs of making cement to the absolute minimum, it is the least expensive of the proposed remedies.

There is one feature of this suggestion, however, which renders it impracticable for application in the large number of wet mills in operation west of the Alleghenies. In the wet process, in which the kilns are charged with a slurry containing a large amount of water, it is absolutely essential to use an excess of air, because the only way to carry off the moisture in the kiln is to employ air in excess. In the studies of the heat losses in kilns up to the present time no attention has been paid, at least in the published records of such work, to these wet-process kilns which combine in one long cylinder the two-fold duty of dryer and clinker burner. Some very interesting experiments along this line have been made in Michigan mills, and it is to be hoped that eventually some account of them can be published. It is evident that in such plants the remedy suggested by Mr. Spackman cannot be employed because there it is necessary to employ a greater quantity of air than is customary in the Lehigh district.

In calling special attention to Mr. Spackman's work The Engineering Record would also suggest the advisability of some scientific work by the Association of Portland Cement Manufacturers along this line. Just at present a large number of kilns are idle or are kept running more in the hope of good things to come than any present indications on the order books of their owners of nice profits in the immediate future. The Association might well emulate the Society of German Portland Cement Manufacturers in its scientific work, and conduct a series of practical tests of the thermal efficiency of one of these kilns, distributing the results to its members when they are compiled. The expense of thoroughly good scientific work along this line would be considerable, but if it were divided among the members of the Association it would be quite small, probably less than fifty dollars apiece. It would be difficult to name any one feature of cement manufacture which could better occupy the Association just now. At the present time the investigation of steam boiler furnaces has reached a degree of accuracy surprising to those who have not kept in touch with the work that is being done, and the investigation of a rotary kiln can be carried out along just the same lines and with the same apparatus. The experiments ought to be made on both a dry kiln and one running on slurry, but if the expense of this would be too great at least a dry kiln should be carefully tested.

Two Chicago Engineering Problems.

Chicago now has under consideration two engineering problems of a high order. The first of these is the reconstruction of the street railway tunnels under the Chicago River, and the second is the construction of the drainage canal of the Calumet district. The lowering of the river tunnels is a problem which has been imminent for a number of years. It was strongly advocated by the city authorities before they had the municipal ownership bee in their bonnets, but since they obtained virtual control of the street railways, it is noticeable that their ardor in the matter of lowering the tunnels has materially abated. The Chicago River is one of the most important harbors of the United States. The water-born freight entering and leaving Chicago Harbor every year is something enormous. For a long time the annual reports of the United States engineer officer in charge of river and harbor works at Chicago have contained a statement that further improvements of the river for purposes of navigation were limited by the depth of water over the tunnels. At the present time there are many vessels engaged in the Great Lakes traffic which cannot use the river on account of their draft. From time to time, vessels ground on the roofs of the tunnels, and there can be no question but what their present location is a considerable restriction on navigation. The importance of increasing the depth of water has grown greater since the opening of the drainage canal, for the current passing through the river has been increased by the flow through that artificial waterway. The objections to the lowering of the tunnels are based wholly on the expense of such work and the temporary inconvenience to passengers in the cars running across the river. Any increase in the length of the approaches to the tunnels will be very expensive, for owners of adjoining property have been able in the past to collect large sums as damages for the construction of such approaches.

The manner in which the work will be carried out remains at the present time uncertain It will be a difficult problem in any case. Various methods have been suggested, such as the blowing up of the present tunnels and the construction of others at different streets, the construction of new tunnels below the old ones by using the latter as caissons in which to work, and the extension of the approaches and the use of regular caissons for the subaqueous work. The depth to which the tunnels are to be sunk must be such as to "render navigation free, easy and unobstructed." The work is to be done in a manner satisfactory to the Chief of Engineers of the Army, and Colonel O. H. Ernst is now investigating the subject. After his recommendations have been made and the Secretary of War has finally approved the depth to which the tunnels must be lowered, the work will have to be done within "a reasonable time" or the city must pay a fine of $10,000 for each month's delay. The difficulty of the work is enhanced by the fact that lowering the tunnels without changing the location of their portals will increase the grades in the approaches so greatly that heavily-loaded trolley cars will probably be unable to ascend them by their own power. While there are various devices for helping out cars on heavy grades they are all more or less clumsy in operation, and their use on roads subject to very heavy traffic is of problematical value.

The second undertaking is the construction of the drainage canal for the Calumet district, for which $12,000,0000 was authorized by the last legislature. Its purpose, like the main drainage canal, is to drain the sewage and flood waters away from Lake Michigan and thereby keep the lake free from pollution and available as a source of water supply. The work will be done by the Trustees of the Chicago Sanitary District, who have decided to obtain a strip of land 1,000 feet wide running almost due west from Blue Island to the Sag. Chief Engineer Randolph recommends a cross-section in earth of 70 feet on the bottom with side slopes of 5 on 3, and in rock a width of 90 feet with vertical sides. These cross-sections are believed to be ample for a flow of approximately 250,000 cubic feet of water per minute with a minimum depth of 22 feet. It is expected that the work will require about three years for completion.

This project indicates that the Trustees of the Sanitary District have little fear that the city of St. Louis will obtain an injunction forbidding the discharge of the sewage of Chicago into the Illinois River. It must be confessed, from the standpoint of an unprejudiced observer, that the decision to spend $12,000,000 on this new drainage canal before the St. Louis proceedings are completed seems decidedly bold. This is particularly so when it is considered that Chicago claims to be impoverished, to be so poor that certain branches of municipal work elsewhere considered necessary cannot be carried on. The lowering of the tunnels under the river, which Congress has ordered, will call for an expenditure of $2,000,000; the reconstruction of many of the Chicago pavements, which is seriously needed, will be very expensive; the improvements of the water supply and the construction of a high service fire-protection supply will require large sums. With all these works demanded by public necessity the lot of the men who have to provide finances for running the Chicago municipal government is certainly not to be envied. As engineering problems, however, the construction of the Calumet canal and the lowering of the river tunnels are decidedly interesting.

Steam Turbine Tests in Commercial Service.

Through the courtesy of Mr. C. F. Bancroft, superintendent of motive power and machinery of the Old Colony Street Railway Company, there have been made public the extracts printed on another page of this issue, from a report of investigations and tests of a two-stage 500-kilowatt Curtis steam turbine. This is running at the company's Newport power station, and was tested during January and February of this year. The report was written by Mr. George H. Barrus, who conducted the tests jointly for the railway company and for the General Electric Company. The Newport station is the first plant of the Old Colony Street Railway Company to be equipped with motive power of this character, and the leading object of the trials, it is understood, so far as the railway company was concerned, was to obtain through a disinterested expert, a diagnosis, so to speak, of the whole turbine subject. This, it was hoped, would guide the company in the selection and installation of engines for their remaining plants, over thirty in number, some of which were about to be renewed. The object noted is one which appeals to the entire electric power station interest, and it is believed the report is, for this reason, of the greatest value. One thing which makes the work of special interest and importance is that it was conducted on a turbine actually operating in station service, and some of the tests were made with variable commercial loads, showing not only the economy of the turbine in steam consumption, but also in coal consumption, the latter covering the coal required for all the auxiliaries in a complete working plant as well as by the turbine itself. One of the interesting features of the work was the investigation of the economy of the independent superheater with which the plant is fitted and the economy of the turbine using superheated steam referred back to the coal pile. These and the other questions were investigated by Mr. Barrus in the most thorough and comprehensive manner, and it is greatly to be regretted that the complete detail report covering all of them cannot be published.

The main feature of the report of interest to engineers and owners of power plants is the economy of the turbine compared with that of high class reciprocating engines, and the results obtained by Mr. Barrus furnish conclusive data regarding this most vital point. The best reciprocating engine plant of which we have data requires 1.2 pounds of coal per indicated horse-power per hour (it so happens that this was also one of Mr. Barrus's tests); this is the plant of the Grosvenor Dale Mills, where the steam consumption was, in round numbers, 12 pounds per indicated horse-power per hour. The steam here was slightly superheated, and it would be proper probably to place the consumption of dry saturated steam in such an engine at 12.5 pounds per indicated horse-power per hour. Reducing this to the equivalent for electrical horse-power in a direct-driven generator, in which 85 per cent. of the indicated horse-power delivered from the engine is delivered by the generator, we have 14.76 pounds per electrical horse-power per hour, or 19.84 pounds per kilowatt hour, as representing the best practice of the time for reciprocating engines. It will be seen that the turbine result, 19.78 pounds per kilowatt hour, using dry saturated steam, is fully its equal.

At half load the comparison is much more favorable to the turbine. There are not many data for such loads on reciprocating engines, but it is not far out of the way to take 14 pounds per indicated horse-power per hour as representing the best economy obtainable at half load in the type of engine referred to. In this case the efficiency of the generator drops to 70 per cent., for the friction losses remain constant, and we have 30 pounds per electrical horse-power per hour and 26.81 pounds per kilowatt hour. The turbine at half load gave 21.38 pounds per kilowatt hour. Under half loads, then, the turbine is 20.3 per cent. more economical than the reciprocating engine.

These comparisons refer to the two-stage type of turbine. It is understood that turbines with a greater number of stages of expansion are more economical than the two-stage machine, and, this being the case, there seems to be no doubt that the present status of the turbine for electric station work is at least abreast of the best reciprocating engine, if it is not already in the lead.

The Effect of Meters on the Consumption of Water.

In connection with the studies for supplying Pittsburg with filtered water the engineers of the project have pretty generally recognized that the enormous and wasteful consumption of water made it necessary to estimate on a much larger filtration plant than was required for the legitimate demands of a community of the size of the Smoky City. A larger plant, of course, means larger first cost and larger maintenance expenses, although perhaps not in direct proportion. Hence an important part of their task has been to find an acceptable way for reducing the consumption from the 253 gallons per capita per day rate, which obtained as the average during 1903 for the twenty-three wards of the city supplied by the municipal works, to a quantity which the experiences of other communities show to be more reasonable. That an effective way for accomplishing the desired result exists, has existed for years and has been repeatedly used with success is a matter of record. But to make the oft-tried remedy acceptable to the officials and voters of certain municipalities taxes the engineers' ingenuity and patience.

The campaign against wastefulness has been fought with much persistency in Pittsburg, and Mr. Morris Knowles, the chief engineer of the Bureau of Filtration, has been especially industrious in collecting from a great many places information relating to the results secured by the introduction of water meters. A portion of the great mass of data which he has reduced to diagrammatic form and readable statement is printed elsewhere in this paper. A detail study of the chart showing the effects of meters in various cities is interesting. It seems to contain some contradictions, although, to be sure, more information than can be plotted on such a diagram is needed for an intelligent understanding of the ups and downs of the lines of some communities.

The very evident effect of the placing of meters on any considerable percentage of the water service pipes of a city, especially if they be put on services discerningly selected, is clearly indicated by the general tendency of the majority of the lines. Although different men might plot the curve of general average tendency somewhat variously, it appears that Mr. Knowles' curve shows qualitatively, if not with absolute accuracy as to numerical values, the efficacy of meters in lowering the per capita consumption. It is interesting to observe how steep the first part of the curve is, indicating that a very large proportion of the saving, in the majority of cases, is effected by the meters installed upon the first 30 per cent. of the services.

There are a number of lines on the diagram, however, which show an increase—in some cases a great increase—in the per capita consumption of water with increases in the number of meters. More particular knowledge of personal local conditions would doubtless explain many of these apparent contradictions of the general experience. Mr. Knowles, in a statement to Director Bigelow, of the Department of Public Works, sets forth an explanation for this tendency to increase of consumption in spite of an increase in number of meters, in the desire of the inhabitants of some wealthy and prosperous cities to use water more freely even if it costs more. Attention is also drawn to the fact that in many places, after there has been a reduction in consumption due to the liberal introduction of meters, if the installing of meters has not been kept up the consumption goes back to the former rate or increases. This apparently leads to the conclusion that in order to continue the reduction of the per capita consumption, or even to keep it at a low figure once attained, it is necessary to keep on adding meters in greater and greater proportion.

Notes and Comments.

The Slip of Pumps at places like Harrisburg, where the water occasionally carries large quantities of sand, slack and culm, can hardly be appreciated. Mr. Charles A. Hague was recently retained to test a new pumping engine at that place and preparatory to the run took out of the valve chambers about two cartloads of such materials. After the test had been run for twenty-four hours he again examined the chambers and found one of the suction valves entirely adrift on account of the damage to its fastenings by the cutting action of the sand. The estimation of the consumption of water in such a place by means of the plunger displacement will manifestly yield results as accurate as the newspaper reports of the Russo-Japanese war.

The Demolition of Old Works often affords some excellent illustrations of the value of methods of construction, and sometimes shows that some features of old-time practice at which the younger generation is inclined to look askance are of unexpected worth. For example, it is often claimed that coal tar pitch is a poor material for waterproofing. To such a claim the condition of the waterproofing of the old Park Avenue tunnel north of the Grand Central Station in New York gives a pretty strong negative answer. This work consists of tarred felt and coal tar pitch, and was laid thirty-two years ago, when less material and skill were employed than at the present time. A portion of it has been recently torn out in the course of the improvements of the New York Central road and it was found to be unchanged in every way. This experience is in a line with that of some pavements which are mentioned in Mr. Tillson's well-known book on the subject. In fact The Engineering Record has been assured by contractors with a large experience in paving that coal tar, properly selected and treated, was a better material than asphalt for both pavements and roofing. As these contractors were in a position to use either asphalt or coal tar with equal facility and economy their statements made a considerable impression at the time, which is recalled by the condition of this old waterproofing on the tunnel mentioned.

The Water Meter has been attracting attention in the city council of Cleveland, which recently passed an ordinance making their use optional for domestic consumers. Mayor Johnson has vetoed this bill for this reason: "There is no way justly to determine what consumers should pay for water except by meters, and the change proposed by this ordinance abandons an attempt already carried to a very successful issue to establish justice in the payment of water rates. The records of the department to date show that 10 per cent. of the consumers, under the old flat rate, were paying a grossly inadequate amount, while 90 per cent. were bearing an unjustly high burden by paying for more water than they used. The policy of this ordinance is to allow the wasteful 10 per cent. of the consumers to return to the old flat rate, and pay less than their share." If the ordinance were to become a law, he predicts that it would soon become necessary to spend over two million dollars in extensions of the water-works plant and to put in service again an old pumping station drawing its supply from a dangerous source. His arguments are certainly sound, and even those people who do not sympathize with some of his financial doctrines must acknowledge that after the city has spent the money for meters for a very large proportion of the services in the city it is ridiculous to lose the benefit from their introduction.

The Sulphate of Copper Cure for excessive numbers of bacteria in a reservoir is recommended by Dr. George T. Moore, of the U. S. Department of Agriculture. For a number of years he has been investigating the growth of algæ in water and experimenting with different chemicals to discover some means of preventing the growth of this low form of plant life. Free chlorine, sulphur dioxide, silver salts, magnesium sulphate, various oxylates and other substances were tried, only to be abandoned for one cause or another. Finally copper sulphate was discovered to be best suited for the purpose, and it is claimed that by the use of 50 to 60 cents worth of this salt for every million gallons of water in a reservoir all known types of algæ can be killed without affecting the potability of the water. It is also claimed that the typhoid bacillus is very sensitive to this solution, and that a few parts of the sulphate in 100,000 parts of water will effectually free it from typhoid and cholera germs in three or four hours. Without in any way disparaging the value of these studies it may be safely asserted that until the proposed remedy has been tried a number of times on a large scale the managers of water-works will do well to place no reliance on its practical value. The condition of water in a deep reservoir makes it hardly possible to secure a uniform distribution of the sulphate through the contents of such a basin, even assuming that the chemical will have the effect on a large scale that the laboratory experiments indicate.

The Fifth Regiment Armory, Baltimore.

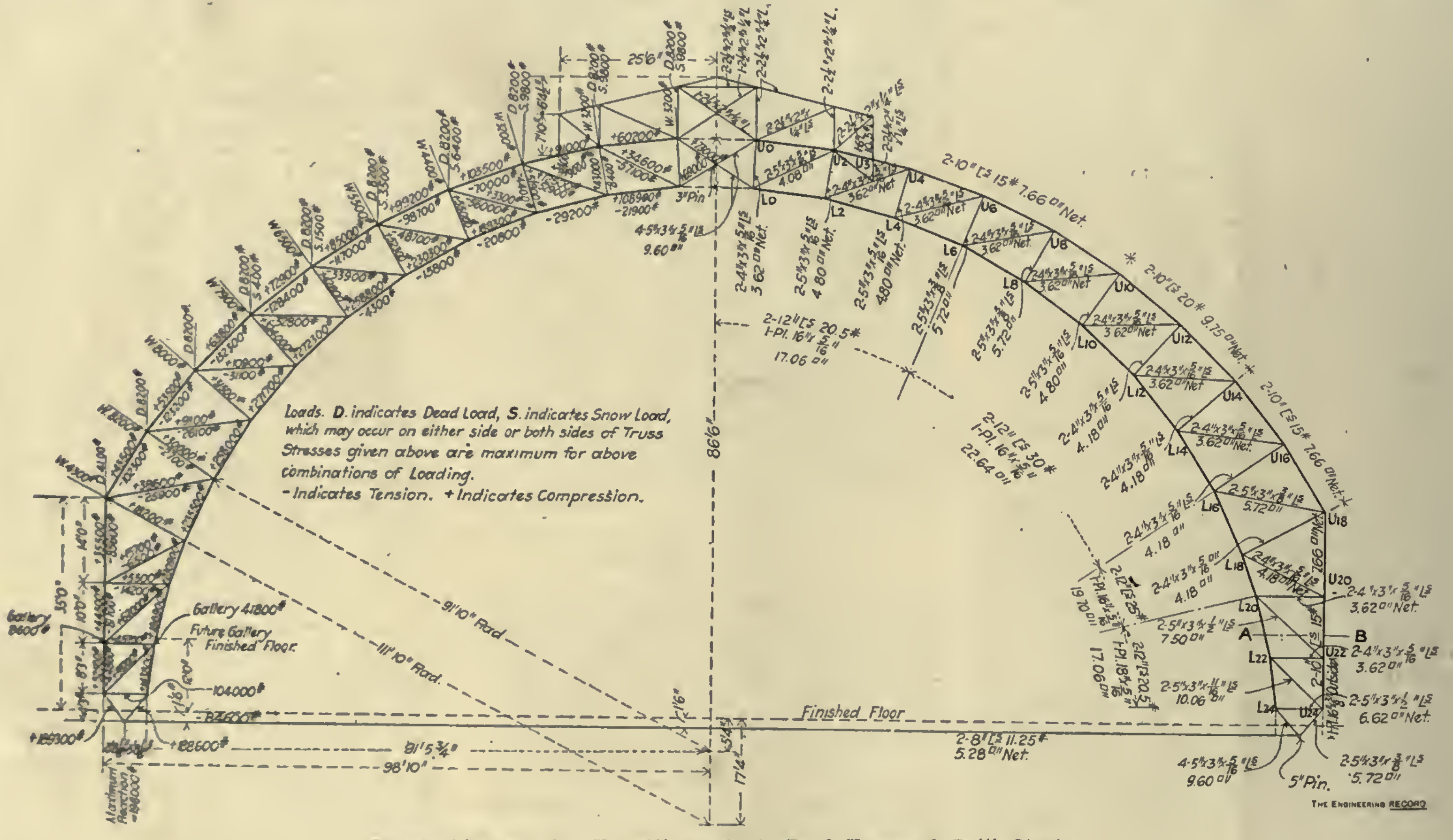
One of the largest buildings in Baltimore is the new brick and steel armory on Hoffman Street for the Fifth Regiment, Maryland National Guard. It occupies the whole of a 354-foot 3-inch by 284-foot 6-inch lot, and has recently been completed at a cost of about $425,000, inclusive of $125,000 for the lot. The structure forms a two-story hollow square with massive outer walls and a large drill hall with an arched roof occupying the whole of the center court. The space between the outer walls and those of the drill hall is about 40 feet wide on both sides of the building and 27 feet wide at the ends. It is partitioned into rooms from 20 to 50 feet wide—used for administration, reception, staff and board rooms, for officers and company rooms, corridors, toilet rooms and a large gymnasium. Underneath these rooms there are stables for the ambulance, storerooms, a reception room, a pistol range, a 300-foot rifle range and rooms for coal storage, heating plant and other purposes. The outer walls are of solid brick masonry with stone facing and trimmings, and are paneled with triangular buttresses about 25 feet apart which form bastions pierced with narrow slits for rifle men. The level top of the wall forms a parapet, between which and the walls of the drill shed there is a horizontal platform over the second-story roof which has sufficient area to parade the entire regiment.

The most interesting structural features of the armory are in the drill-hall roof which covers an unobstructed floor area about 199 feet wide and 293 feet 2 inches long in the clear. This space is spanned by ten three-hinge arch trusses, which divide the space into nine intermediate panels of 26 feet 9 inches, and two end panels of 26 feet 2½ inches. The chords of the trusses are arcs of eccentric circles, as shown in the strain-sheet diagram. The rise of the intrados is 88 feet and the total height from grade to the top of the steel work is about 105 feet 7 inches. The trusses are made with riveted connections and are braced together in pairs with longitudinal struts and diagonal members, as indicated in the general diagram. The drill room has an estimated seating capacity of 16,000 persons, exclusive of the proposed gallery 12 feet above the floor which will surround it on all sides and have a capacity of 4,000 people.

The framework is made entirely of medium steel except the lattice-bars, rivets and lateral rods, which are of soft steel, all conforming to the standard specifications of the American Association of Steel Manufacturers. The roof is proportioned for a live load of 30 pounds to the square foot of the vertical projection of its surface, due to wind pressure, and for a snow load of 2 to 30 pounds per square foot of horizontal projection of the upper six panels on each side of the roof, no floors or other weights being suspended from the trusses. Unit stresses were allowed as follows: In tension, plates and shapes 16,000 pounds per square inch, lateral rods 23,000 pounds per square inch; in compression, columns 13,750 pounds — $577\frac{L}{R}$, lateral struts 17,190 — $720\frac{L}{R}$, where L is the length in feet and R is the least radius of gyration in inches. Members subjected to longitudinal and transverse loading are proportioned to sustain the algebraic sum of the combined stresses. Shearing stresses allowed per square inch are: pins 11,000 pounds, rivets 10,000 pounds, web-plates 7,500 pounds; bearing stresses, pins 22,000 pounds, rivets 20,000 pounds, shapes 16,000 pounds. For lateral connections unit stresses are allowed to be 25 per cent. greater than the above. Bearing plates are proportioned to reduce the pressure on the masonry to 250 pounds per square inch. It was required that the second coat of paint should be applied not less than ten days and not more than thirty days after the first field coat. If an interval of more than sixty days elapsed between the encasing of the steel work and the second coat of paint, a third coat of paint was required. Cast-iron lintels with T-shaped cross-sections were required over all door and window openings, except where the latter were arched. In other respects the specifications corresponded in general to advanced standards for bridge and structural steel work.

The main trusses are wholly within the drill hall except the horizontal tie bars which connect their end hinges under the floor. The truss is divided into twenty-seven panels by radical members. Between them the top and bottom chords are chords of circular curves with radii of 111 feet 8 11/32 inches and 91 feet 10 inches, respectively. The centers of these arcs are respectively 17 feet 2 11/32 inches and 5 feet 4 inches below the floor level. The floor level is 1 foot 6 inches above the centers of the end pins. The angles included between the radial web members of the truss vary from 6 degrees 58 minutes and 50 seconds to 7 degrees 32 minutes and 49 seconds. The top top chord is intersected by verticals 98 feet 10 inches each side of the center at points 35 feet above floor level. The truss conforms to these lines and the end vertical posts thus provided are flush with the inner faces of the drill-hall walls. The chords are made with trough-shaped rectangular cross-sections built with pairs of 10 and 12-inch channels and 16 or 18-inch cover plates, and all web members are pairs of angles, as indicated in the strain sheet. All connections except the hinge joints are field-riveted, and each semi-truss was assembled at the shops in four sections, but the members were most of them shipped separately with the connection plates shop-riveted to the webs of the chord channels. The chords were spliced with pairs of web plates, which also serve for diagonal connections at every panel point, and the ends of their channels were mitered and planed to accurate bearing. Bent plates cover the outside flanges of the chord channels at every joint.

The inner flanges of both chords and the outer flanges of the top chords are latticed with flat bars riveted together at intersections.


Loads. D. indicates Dead Load, S. indicates Snow Load, which may occur on either side or both sides of Truss
Stresses given above are maximum for above combinations of Loading.
-Indicates Tension. +Indicates Compression.
Gallery 41800#
Future Gallery Finished Floor
Finished Floor
91'10" Rad.
111'10" Rad.
81'5¾"
98'10"
3"Pin
5"Pin
A
B
THE ENGINEERING RECORD

Stress Diagram for Two-Hinge Arch Roof Truss of Drill Shed.

All web members are made of pairs of angles spaced 9½ inches apart in the clear and latticed together. The ends form jaws engaging the connection plates at chord splices. The crown sections of the trusses were shop-riveted in 2½ panel lengths, as shown in the detail. The top and bottom chords are extended by inclined struts from Uo and Lo to the center point C, where the stresses converge to the crown hinge. This is made with a 3-inch pin having half holes in the reinforcement plates and full holes in jaw plates which project from both semi-trusses and lock them together.

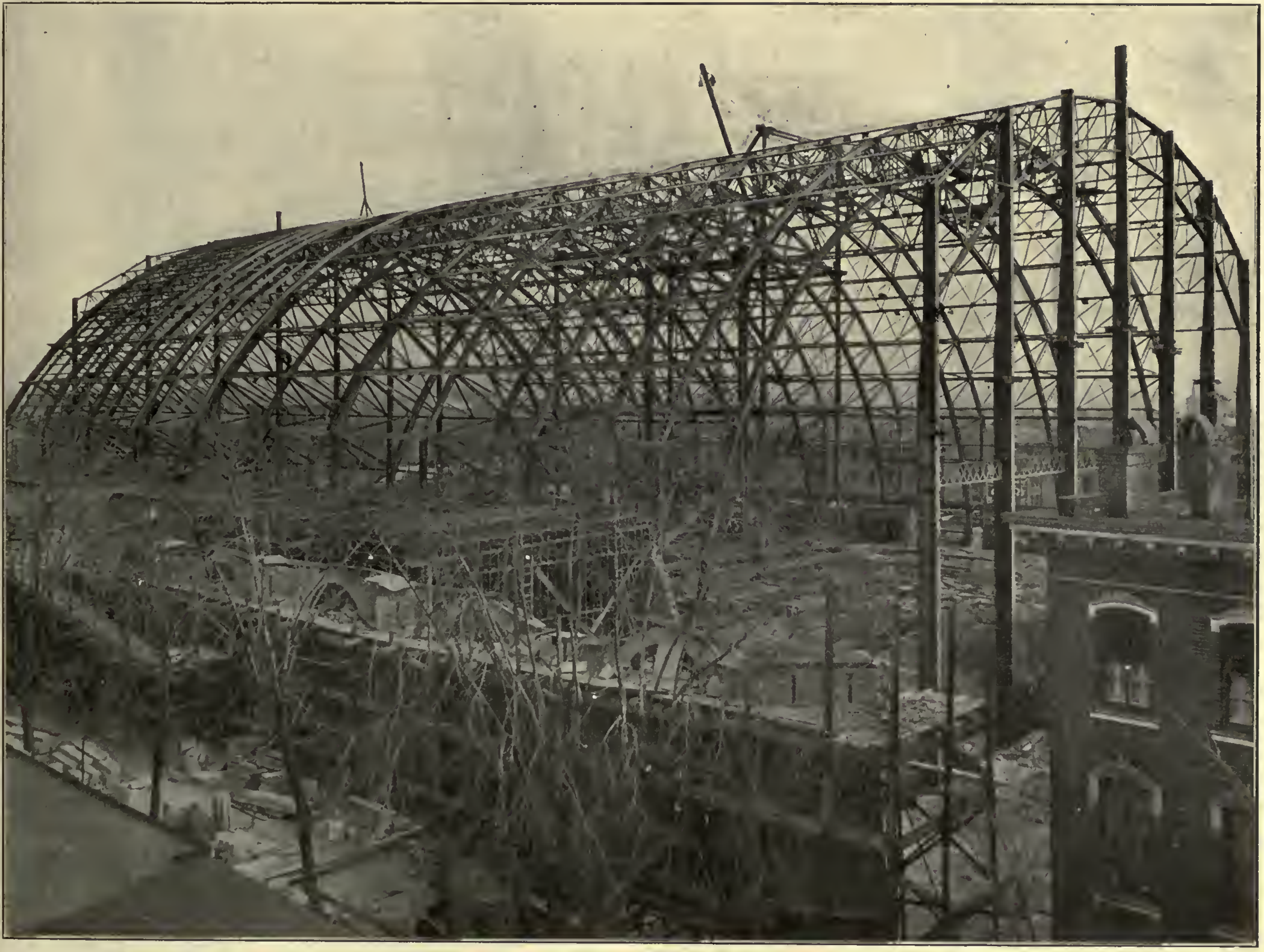
The lines of the top and bottom chords are continued across the center panel by false members which are connected to the trusses at Uo and Lo with bolts in slotted holes which allow them longitudinal motion due to the expansion and contraction, which produces a maximum rise and fall of about ½ inch in the crown pin. The top chord members UoC are X-braced together by pin-connected diagonal rods which continue the lateral bracing of the top chord panel from one semi-truss to the other. The lower ends of the trusses have rectangular closed box sections made with solid plates about 6 feet high and 8½ feet wide riveted to the webs of the chord channels. Between these plates the end sections of the chords, converge to the lower pins, which engage riveted shoes like those for ordinary bridge trusses. These shoes are fixed at one end, and at the other end are seated on ordinary expansion rollers with riveted bed plates having longitudinal bearing strips and guide ribs for the rollers. The shoe webs project beyond their reinforcement plates to make full pin holes locking them to the corresponding jaw plates of the trusses.

The pins engage the ends of the horizontal ties, which are made with pairs of 8-inch channels riveted together back to back. They are in sections about 32 feet long and are spliced with web and flange plates, as indicated in the detail. Each truss is surmounted by one bent of the ventilator framework 51 feet wide over all, which rises about 10 feet above the top chord. It is made with pairs of 2x2½-inch and 3x2½-inch angles riveted to gusset plates and flange-connected to the roof trusses. The trusses are braced together by wall struts and purlins in every longitudinal panel, as indicated by the diagram of the side elevation. Alternate panels have additional wall struts making the trusses form alternate towers and open panels.

The wall struts are lattice-girders from 2 to 3 feet deep, which are flange-connected to the webs of the vertical members of the trusses. In the lower panels the wall struts are replaced by longitudinal beams intended to carry the future gallery floor. The ends of these beams are kneebraced by pairs of 3x3-inch angles riveted together to make T-shaped cross-sections and having their ends bent to engage the flanges of the beams and the webs of the truss members. The intermediate purlins have clear spans of nearly 26 feet and are lattice-girders with their depths varied to correspond with the lengths of the radial members of the trusses to which they are connected. The ends of the top flanges have short vertical angles field-riveted to the webs of the top chords, and both top and bottom flanges have horizontal connection plates riveted to the flanges of the top and bottom chords.

The lateral rods in the planes of the top chords of the roof trusses cross two panels of the purlins. They are single sleeve-nut rods engaging pins through horizontal or inclined jaw plates riveted to the top chords of the trusses. Where they intersect the intermediate purlins they are discontinued and engage four pins in horizontal jaw plates riveted to vertical webs offsetting them about 12 inches below the top flanges at the center points, as shown in the detail. The purlins in the end panels of the roof are similar to the intermediate ones, except that they are somewhat shorter and have differences in their supports on the gable walls, where part of them are seated with riveted pedestals on the brickwork and others are riveted to the columns.

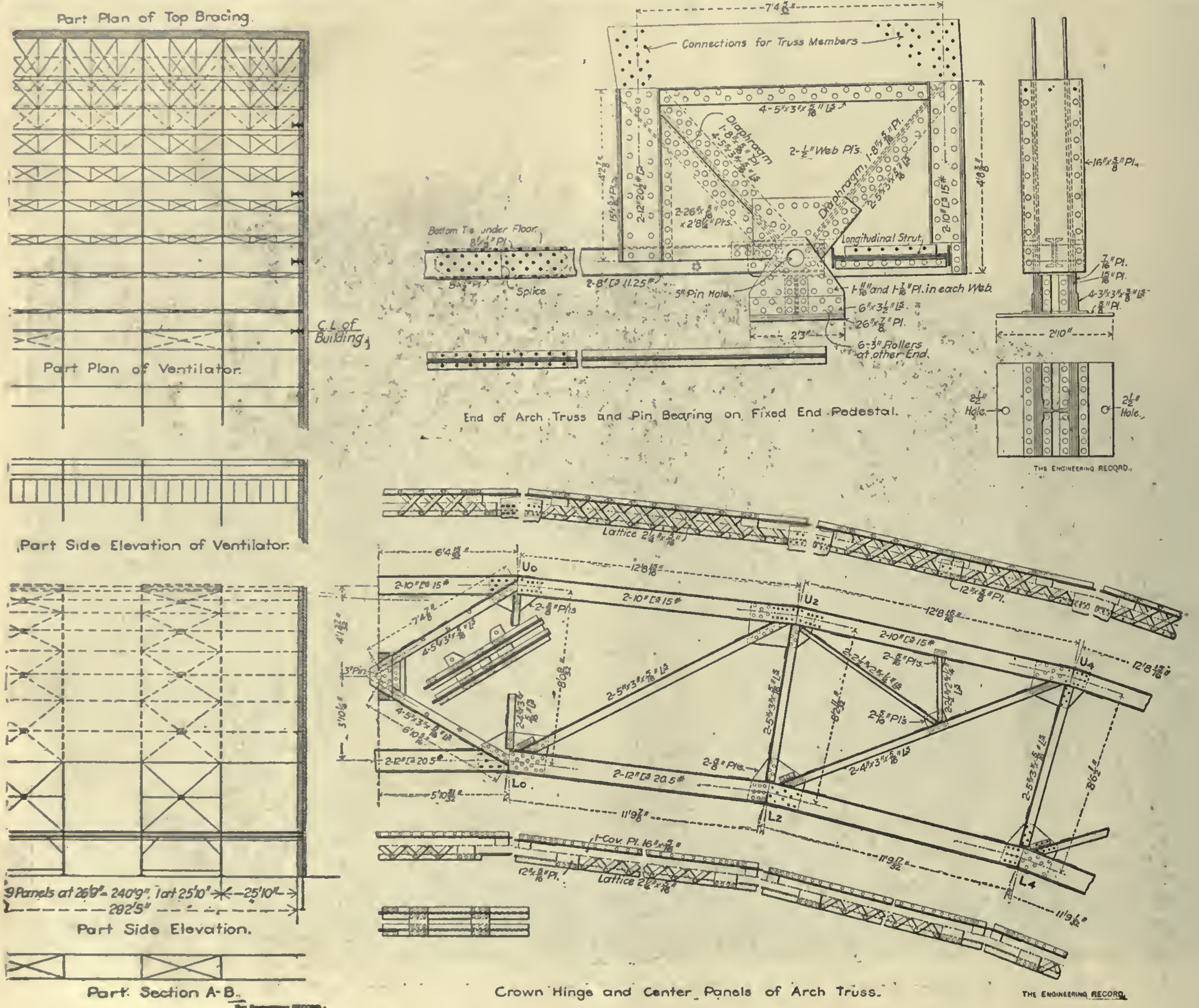
The gable walls are built of brick with a steel framework of columns and struts, as shown in the diagram. The columns have single wide webs and a pair of intermediate vertical angles, and were shipped in two sections each field-riveted with web splice-plates. Their upper ends are connected by deep inclined struts somewhat resembling the roof trusses in gen-



Baltimore Armory Drill Shed, Showing Roof Trusses and Main Columns in End Wall.

eral outline, but differing from them in their details. Their top flanges are made with a 15-inch I-beam having a pair of 3x3-inch angles riveted to the center of the web on one side, thus giving considerable stiffness against transverse flexure. The bottom flange is made similarly with a 15-inch channel and a pair of continuous angles. The angles in both flanges are separated sufficiently to receive, between the vertical legs, the connection plates for the web members, which consist of single and double 3x3-inch angles.

The columns are braced at about their middle points by light horizontal lattice-girders about 3 feet deep in the planes of the walls.



Baltimore Armory: Partial Plans and Elevations and Arch Trusses— Details of the Drill Shed.

The total weight of the structural steel in the armory is about 1,000 tons, and the weight of a single main truss, exclusive of the ventilator frame, is about 34 tons. The trusses were erected with two traveling cranes, each consisting of a tower about 30 feet square, with two booms. The gable columns were set first and secured with guy lines; then the truss next to gable was erected and braced to gable columns, the travelers moving backward and setting the next truss and panel, and so on to completion. The purlins, struts and braces between the trusses were handled by light boom derricks on top of the travelers, and one pair of trusses were erected complete by an average force of about thirty men in four days. The erectors were followed by several gangs which assembled the secondary members and drove the field rivets with pneumatic hammers. The erection of the drill-shed roof was accomplished in about forty working days by an average total force of fifty men.

In each panel the purlins support two intermediate lines of 6x10-inch rafters which are bolted to the top flanges. These carry 3x6-inch horizontal wooden sub-purlins 2 feet apart to which is nailed the sheeting of 1⅜-inch boards laid close, parallel to the roof trusses. Over the roof trusses there are pairs of 4x10-inch rafter beams which form projecting ribs and divide the convex surface into panels corresponding with the framework. The ribs are covered with galvanized iron and the sheeting between them is tinned and painted. The lantern roof is made with 1⅜-inch sheeting carried on 3x8-inch rafters about 2½ feet apart, which are supported at the eaves, ridge and at intermediate points by purlin I-beams. The sheeting is tinned and painted, and the glazed vertical sides of the lantern are nearly covered with fixed sash about 4 feet square. The flat roofs over the other portions of the building are sheathed and covered with felt and slag.

Messrs. Wyatt & Nölting, Baltimore, were the architects of the building, and Messrs. R. C. Sandlass and T. M. Kellogg, associated, were consulting engineers. Messrs. Adams & Schwab were the engineers for the electric and heating systems, and the American Bridge Company, Mr. Paul L. Wölfel, chief engineer, was the contractor for the structural steel work, which was built at the Edgemore plant.

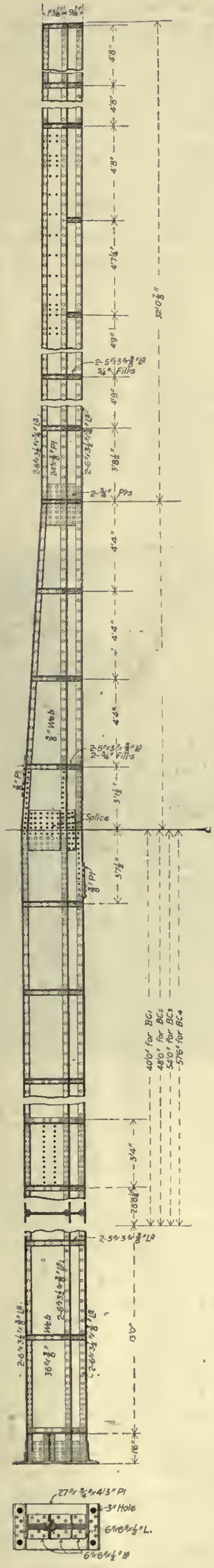
An English Scherzer Rolling-Lift Bridge.

A small highway bridge has recently been completed over Barking Creek, England, which has a center span of the Scherzer type of rolling bascule, said to be the first example in England. The bascule span has a clear opening of 45 feet and is made with two plate-girders 18 feet apart on centers, carrying a wagon road and street car tracks. At one end of each girder there is, tangent with the lower flange, a braced framework carrying about 270 degrees of a circular flange 20 feet in diameter, on which the girder is revolved vertically. The heel of this curve engages a track on the adjacent span, which has two plate girders 21 feet 4 inches apart affording clearance for the bascule girders between them. On the center of the 45-foot track-span there is an operating tower which contains a pair of electric motors geared to a horizontal transverse shaft over the roadway, to which are keyed a pair of grooved drums, one in the plane of each bascule girder.

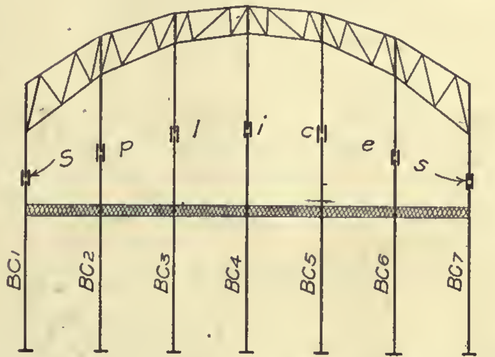
At the rear of the tower there is on each side, a very steep groved track curved to conform to the varying moments of the moving bascule so that the counterweight which it supports shall always approximately balance the weight of the bascule span. The counterweight consists of iron ballast in a rectangular horizontal transverse steel box with a large roller at each end engaging the curved track. A link on each roller axle receives both ends of a steel rope, the bight of which takes several turns around one of the drums, and then passes around a groove in the upper part of the circular frame at the heel of the bascule girder on the river side of which it engages a sheave adjustably connected by a vertical screw to the main girder. The heel of the bascule is anchored to the approach span with a number of steel cables, but no mention is made of rack teeth in the heel bearing or in the horizontal track, which is made with a pair of angles.

The bridge can be opened or closed in less than 2 minutes at a cost of $.02 for electric power, and hand gear is provided by which it may also be operated. The tower is about 33 feet high and 20 feet square, and is of riveted construction with members made of pairs of channels and T-bars. The 5-foot plate-girders are of the ordinary English construction with vertical web-stiffener angles bent at both ends to horizontally engage the flange plate. The lower flanges are reinforced by a pair of angles riveted together back to back with their horizontal legs engaging the flange cover plates and with vertical web plates riveted between their outstanding flanges and projecting below them to receive the field-riveted connections to the ends of the floorbeams, thus carrying all the floorbeam loads through the head of the rivets. The floorbeam connection is specially commended in the published description as "A sound method of suspending cross-girders." The two river piers and the abutments are made with cast-iron hollow piles filled with concrete. They are made in several sections joined together with hub and spigot joints filled with lead, but not calked.

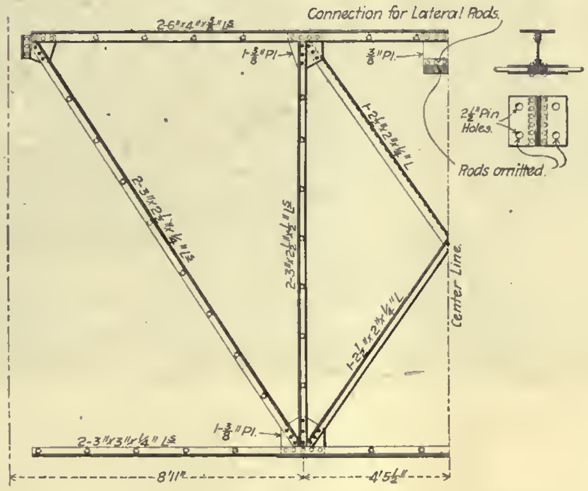
Mr. Gerald Baker was the engineer of the bridge, which was built for a contract price of about $66,000 and was described and fully illustrated in a recent issue of "Engineering."



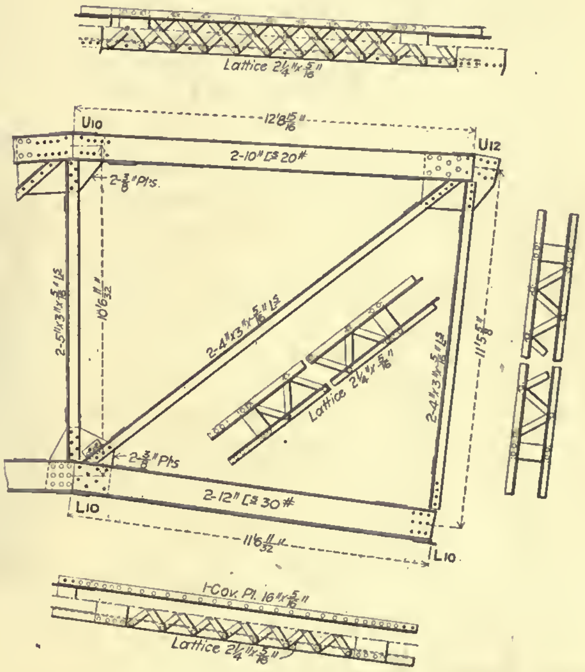
Main Column in End Wall



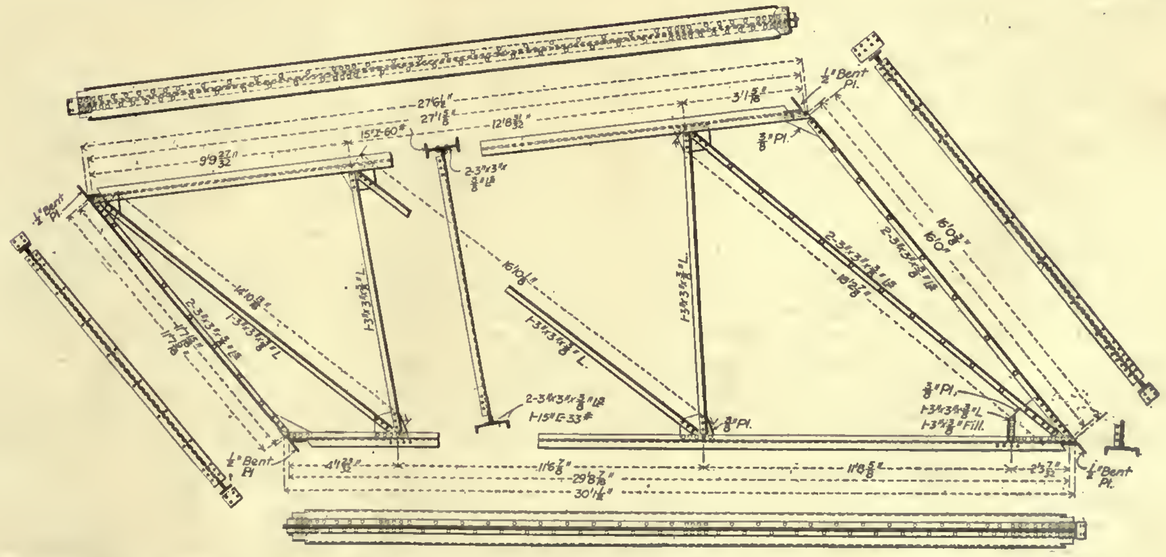
Columns, Struts and Braces in End Wall



Intermediate Purlin.



Typical Panel of Arch Roof Truss.



Strut between Wall Columns in Gable End.

BALTIMORE ARMORY: DETAILS OF THE STRUCTURAL STEEL IN THE DRILL SHED FRAMEWORK.

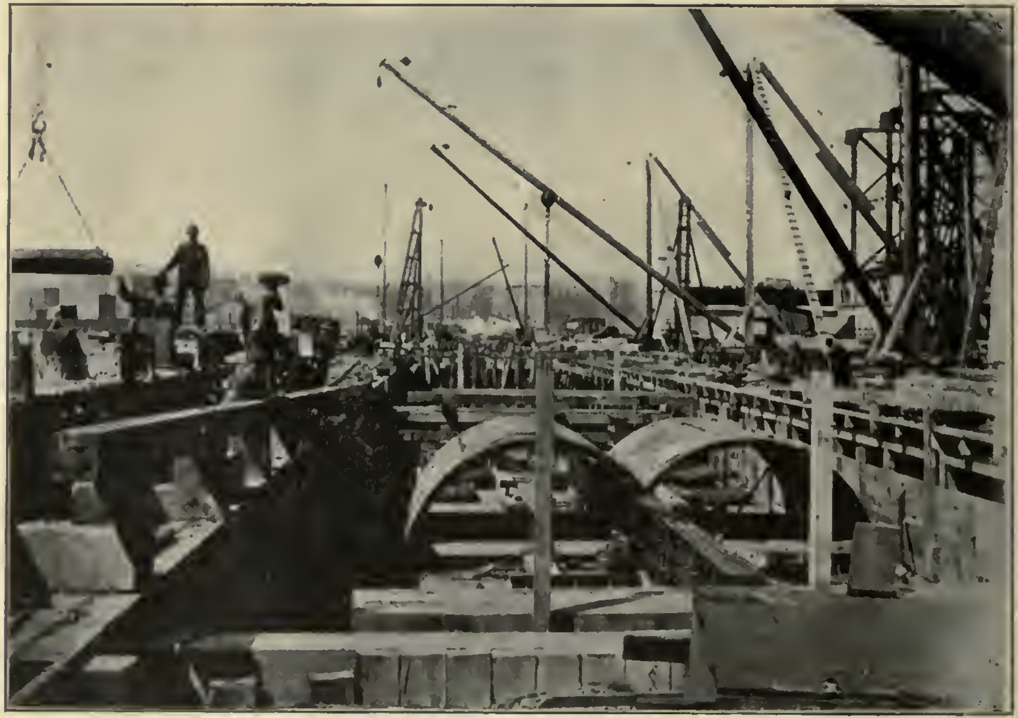
The Harlem River Tunnel of the New York Rapid Transit Railroad.

The double tracks of the east-side line of the New York Rapid Transit Railroad are carried under the Harlem River near Lenox Avenue in a twin-tube cast-iron tunnel about 640 feet long which has a maximum depth of about 48 feet from the bottom of the invert to mean high water level. It forms a part of section 9 of division 3 and is joined at both ends to a reinforced concrete construction with an ordinary horse-shoe-shape cross-section. The axis of the tunnel is a tangent in horizontal projection and consists of two 3 per cent. grades united by a vertical curve in the center. The roof of the tunnel is about at the original level of the river bottom at the deepest point. The soil is soft mud, underlaid by rock, the surface of which is close to the tunnel at the west end and dips to a great depth at the east end. The tide has an average rise and fall of about 6 feet and a maximum current sometimes as great as 4 miles an hour. The line of the tunnel intersects one of the pile rest piers of an adjacent swing bridge and it was prohibited to obstruct more than half of the river at once.

The special conditions and the very shallow depth at which the tunnel is located made its construction difficult, and special methods have been developed for it which are of unusual interest on account of the novel features involved and the success so far attained. These methods and the details of the tunnel construction have already been described and illustrated, as the work progressed, in The Engineering Record of August 22, September 5, December 19 and December 26, 1903. Since the appearance of the last article, considerable progress has been made in the construction of the second half of the tunnel by a special method therein described which at that time was only proposed, and the present article describes the continued development of the plant and the execution of the work. The completed tunnel is shown in cross-section in the issue of September 5, 1903, and consists of two intersecting cast-iron cylinders of 15 feet clear radius which are separated by a vertical diaphragm. They are made in rings 6 feet long composed of several segments bolted together through inside flanges and are imbedded in a rectangular mass of concrete with the upper corners cut off. The inside is also plastered with concrete finished flush with the inner edges of the flanges so as to make a smooth cylindrical surface.

The first half of the tunnel from the shore to the middle of the river was built under pneumatic pressure in a caisson formed in a dredged trench by driving and bracing heavy sheet pile walls and covering them with a solid timber deck or roof platform sunk to place on their upper edges. Underneath this roof the excavation was completed, the cast-iron shell was assembled and the concrete was placed. This method involved the use of sheet piling for the side and end walls which extended above the finished top of the tunnel. Mr. D. D. McBean, one of the contractors, designed and successfully conducted this novel method of construction with the approval of the chief engineer of the Rapid Transit Railroad Commissioners. It occurred to him, during the construction of this part of the tunnel, that a considerable economy might be effected if the upper ends of the sheet piles could be saved, and in studying the possibilities he devised a modification of the system which essentially consisted of the substitution of the upper half of the permanent iron and concrete tunnel structure for the temporary timber roof and side walls above the springing line. The revised method was simply to dredge the tunnel excavation nearly to sub-grade and to build in the trench permanent side walls of sheet piles extending up only to the springing line of the tunnel. On these walls and on temporary end walls or bulkheads the upper half of the tunnel structure is to be sunk to form the roof of a stationary pneumatic caisson, in the bottom of which the excavation will be completed between the sheet piling walls, the concrete will be laid and the cast-iron shell segments assembled to form the lower half of the tunnel joining the upper portion and completing the structure.

In accordance with this plan, a temporary pile dock was built from the shore to the end of the completed half of the tunnel, enclosing a space about 39 feet wide and 300 feet long, which is surrounded by a working platform or dock 20 feet wide on each side enclosing the site of the remaining portion of the tunnel from the end of the completed half to the end of the shore section of the subway. Rows of permanent foundation piles were driven here as required and supported horizontal submerged timber frames, which served as guides for the accurate alignment of the sheet piles in the side walls. The latter were of special construction, made of heavy 12x12-inch timbers 65 feet long bolted together in sets of three and driven by a special machine which traveled on rails laid on the working platform, as indicated in the general cross-section of the tunnel trench and dock.



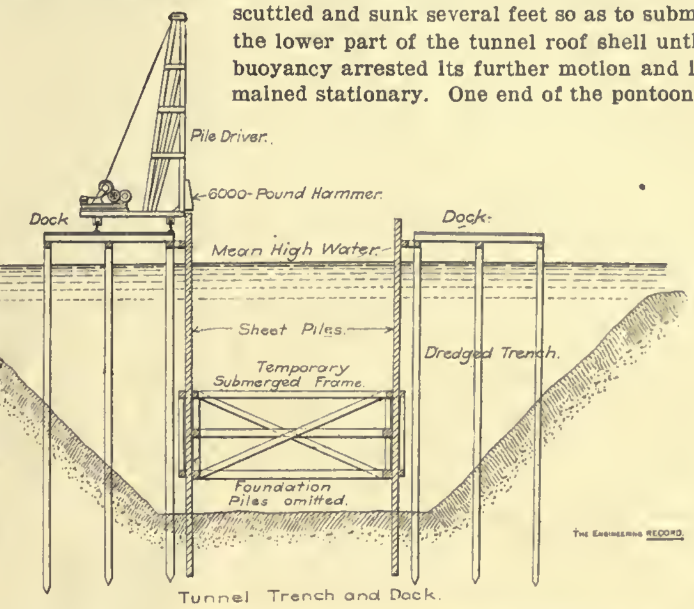
Assembling Upper Half of First Section of Tunnel Tubes in Pontoon.

In order to assure the accuracy of driving the sheet piles and to be able to remove boulders and other obstacles that might be encountered, a set of four steel pilot piles 60 feet long were first driven adjacent to the last wooden pile. Three of them were then withdrawn, leaving a space in which the wooden pile was placed and driven to a somewhat greater depth. The pilot piles were driven with the pile-driver ram aided by a 150-pound hydraulic jet carried down through the center of the pile. When any large boulder or other obstruction was encountered which the pilot pile could not displace, a hole was drilled in it and it was dynamited. The pilot piles were built as shown in the accompanying detail and were driven without the use of any follower, cushion or other protection to the head. After considerable service, a close inspection failed to reveal any battering of the heads or any injury or distortion to the cutting edge at the point. They were easily withdrawn by a six-part tackle operated by a hoisting engine. The wooden piles had an average penetration of about 18 feet on the east side of the river and were cut off about 40 feet below mean high water by an ordinary circular saw mounted on a vertical shaft. The piles covered a longitudinal distance of about 38¾ inches each. They were planed on all sides and were so accurately driven that in a length of about 300 feet there was an average clearance of only about 1/50 inch between the theoretical widths of the piles. They were driven by a 6,000-pound special hammer falling 6 feet, and in many cases the penetration for the last 10 feet averaged only ⅛ inch for each blow of the hammer.

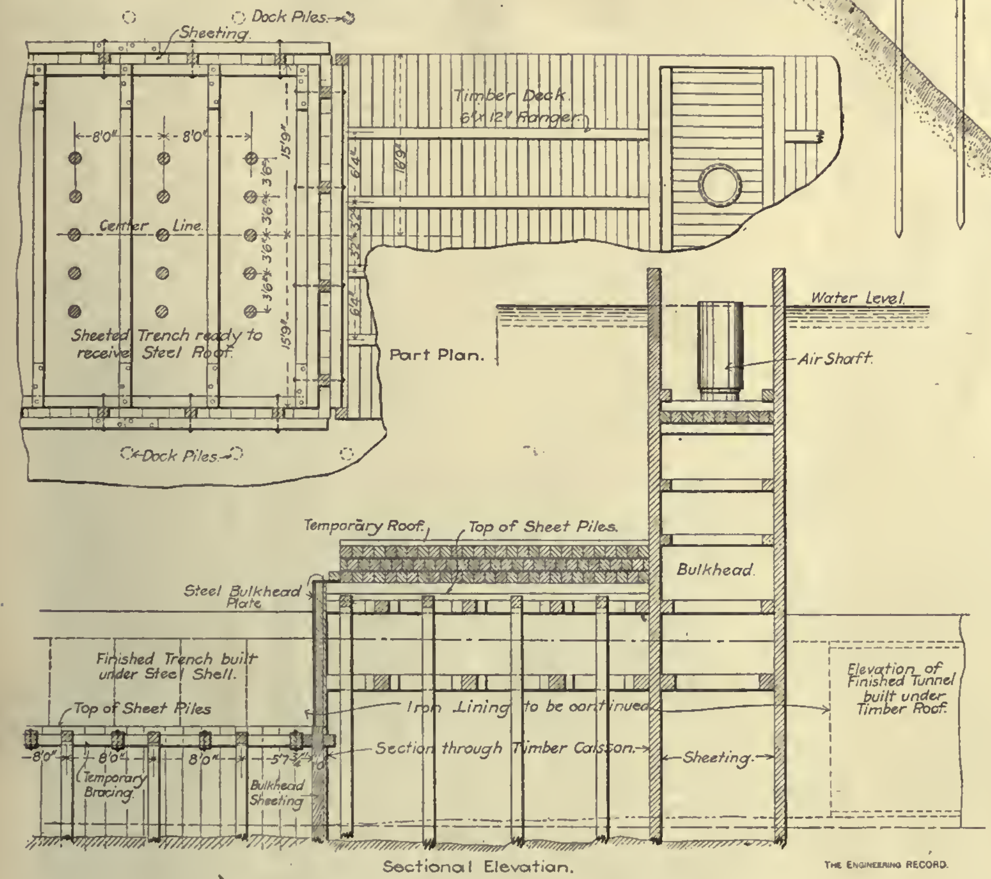
After the piles had been braced and cut off under water, a pontoon 35 feet wide, 106 feet long and 12 feet deep was built over the center line of the tunnel at the shore end between the construction docks. It was very simply constructed with 12x12-inch transverse timbers 4 feet apart on centers to which were spiked the 3x12-inch longitudinal bottom planks and the 4x6-inch vertical side timbers. The sides were sheathed with 3-inch planks, which, with the bottom planks, were calked. On the 12x12-inch transverse timbers, three rows of 4x12-inch longitudinal timbers were spiked. On the floor of this pontoon were laid 16x16-inch transverse timbers 8 feet apart on centers; on them along the center line were laid a row of longitudinal 10x16-inch timbers, and two rows of 16x16-inch timbers 6 feet 3 inches from the center line. Between these longitudinal timbers the 2-inch plank flooring is spiked to the 16x16-inch underlying transverse timbers, as indicated by the general cross-section.

The center diaphragm and skewback pieces of the cast-iron tunnel lining were first set and then the other segments were bolted on to complete the arches, ring after ring being added until the shore end section 84 feet long was completely assembled. The rods and braces shown in the cross-section were added to secure the temporary floor, brace it against upward pressure and tie the arch segments firmly together. On account of the grade and the vertical curve, the tunnel shell is to be constructed in three sections about 84 feet, 90 feet and 90 feet in length and sunk separately, although the contractor would have prepared to build it all in a single section if the axis had been horizontal. The skewback sections of the shell are made of special design with a wide horizontal flange stiffened by vertical transverse webs. To the under side of this flange is bolted a steel plate 38 inches wide with a vertical flange on the outer edge. After the shell was thus completely assembled, both ends of the semi-tubes were closed by vertical transverse diaphragm plates ¼ inch thick bolted with tar paper between the flanges of the segments of the last two rings.

Access was provided to the interior by arranging segments of the shell plates so that they could be unbolted and removed. The exterior concrete was then filled over the shell, as indicated in the cross-section, virtually completing the upper half of the tunnel. The pontoon was loaded with timber which helped to ballast and trim it, but floated off and obviated the necessity of handling it when the pontoon was scuttled and sunk several feet so as to submerge the lower part of the tunnel roof shell until its buoyancy arrested its further motion and it remained stationary. One end of the pontoon was



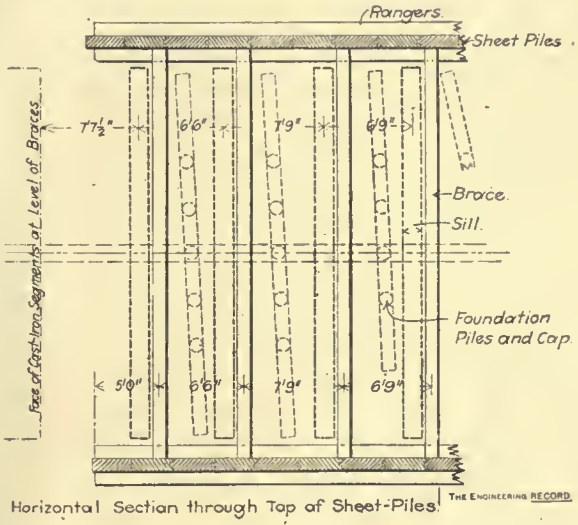
Tunnel Trench and Dock.



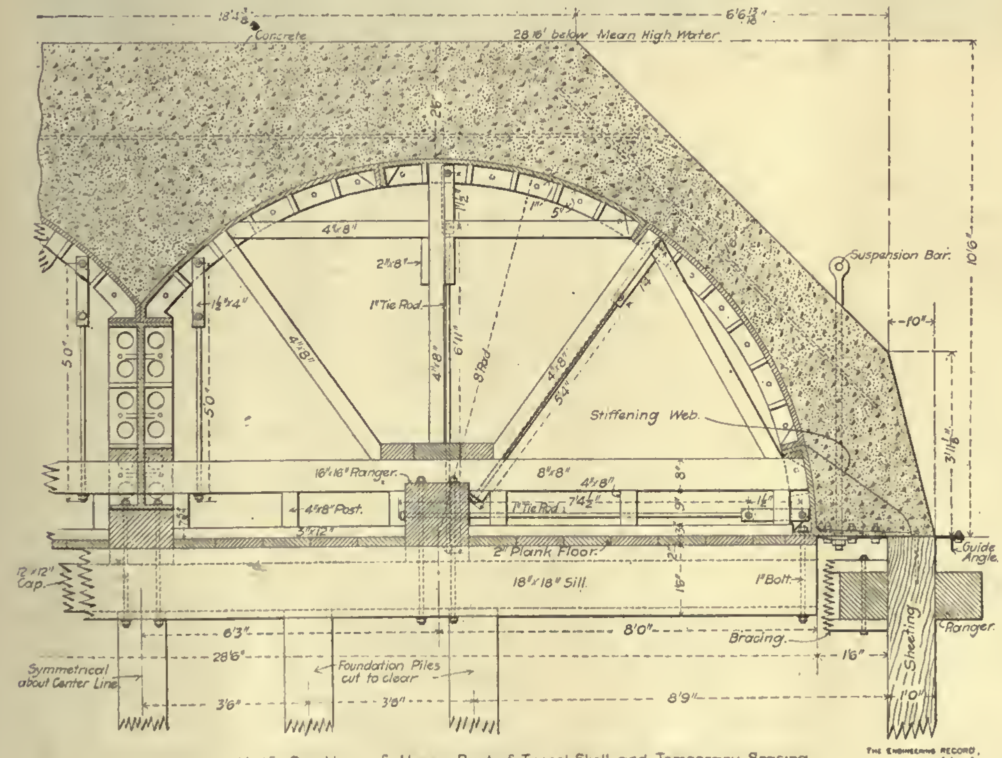
Part Plan.

Sectional Elevation.

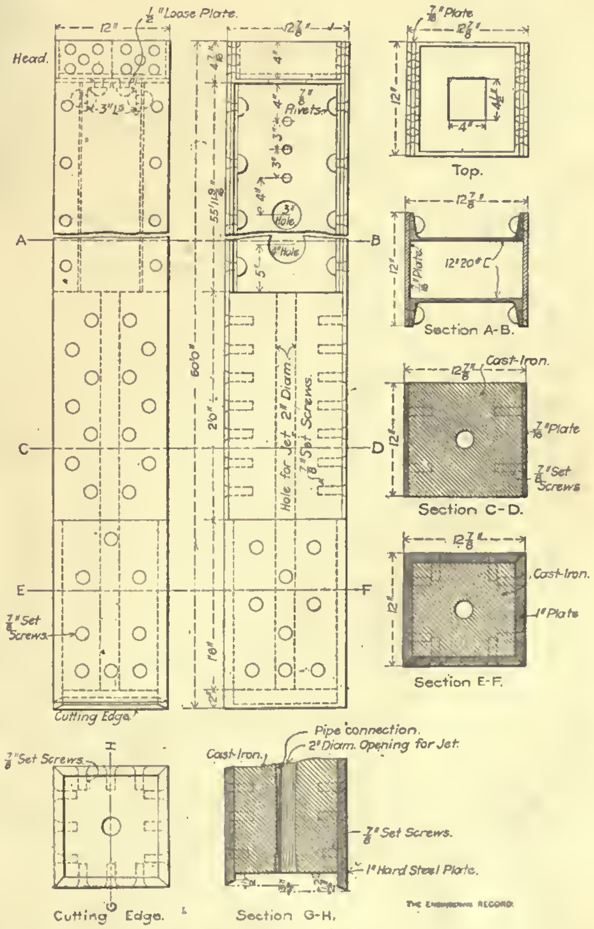
Bulkhead and Caisson connecting East and West Halves of Tunnel.



Horizontal Section through Top of Sheet-Piles.



Half Section of Upper Part of Tunnel Shell and Temporary Bracing.



Cutting Edge.

Section G-H, Steel Pilot Pile

HARLEM RIVER TUNNEL: WOOD AND STEEL CAISSONS, BRACING AND PILOT PILE.

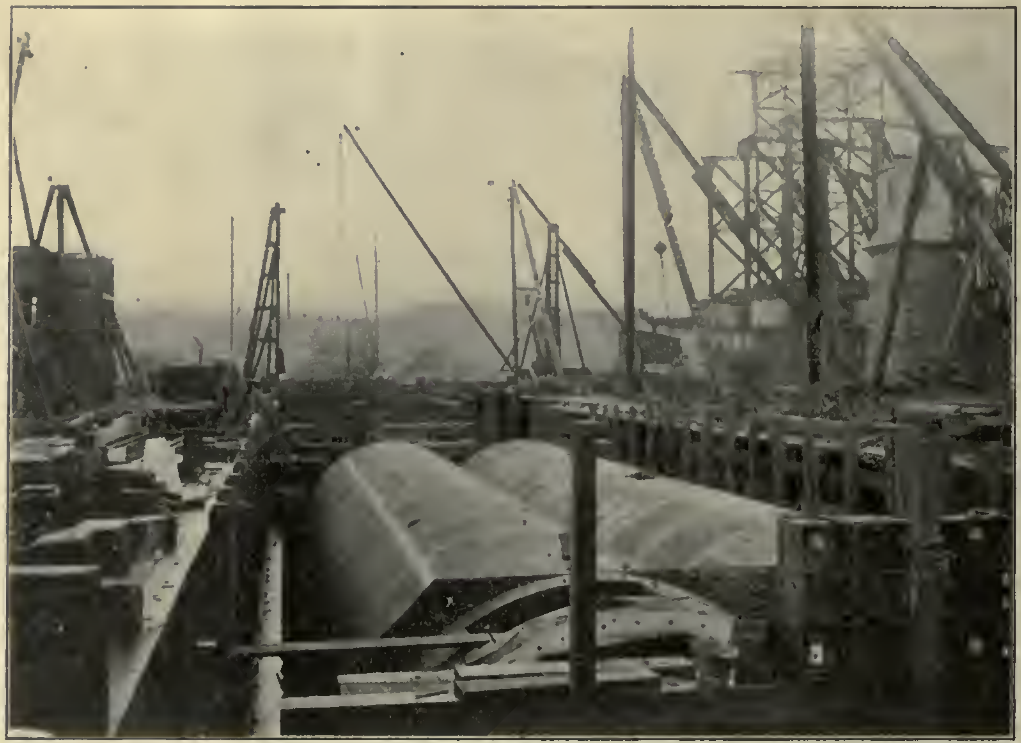
then removed and the latter was drawn out from under the tunnel so as to be ready for the construction of the next section. Each 6-foot ring of the tunnel roof shell weighs about 41,000 pounds and is covered with about 618 cubic feet of concrete. The calculated weight of the steel, concrete and timber comprising the total structure handled was about 50 pounds per linear foot less than its total displacement. The estimated buoyancy was overcome by loading loose stone on top of the concrete so as to give it a sinking weight and enable it to be positively controlled by suspending tackles. These were attached to the vertical eye-bolts shown in the cross-section and to transverse beams supported on the tops of the dock piles.

On May 5 the tunnel was lowered in about an hour, to within about 2 inches of the required position, while air was gradually pumped into it to decrease possible leakage through the false floor and to equalize the pressure on the latter. Fine vertical wires were carefully adjusted on the center line of the tunnel at each end and were aligned by a transit. Longitudinal and transverse tag lines were attached to the tunnel and a diver was sent down at the shore end in the space beyond the bulkhead diaphragm under the loose ring of shell segments. All being in readiness, the tunnel was pulled longitudinally until it was in contact with the shore section and was moved transversely until the instrumental alignment was perfect, when additional weight was placed on the roof and it was lowered to final position by 16 men slacking off on the 16 tackles. The unbalanced weight was so small that one tackle would have been strong enough to suspend it. The guide angles on the wide horizontal flange plates engaged the edges of the sheeting, on which the roof came to bearing in exact position. The diver bolted the end flanges of the tunnel shell to the corresponding ones of the shore tunnel and the hole through which he emerged was closed by the shell segment. The condition is therefore such that air pressure can be put on and the water expelled to allow men to enter and cut away the diaphragm plate close to the shell.

At the time this description was written the work had not progressed beyond this point. It was intended to drive drift-bolts through holes in the horizontal skewback plates and into the tops of the sheet piles by means of long rods passing through vertical pipes left in the concrete for the purpose. After the three sections of tube tops, aggregating 264 feet, are sunk to position, the bottom of the dredged trench, which is now 4 or 5 feet below the temporary floor, will be excavated as in an ordinary pneumatic caisson. The lower part of the shell and concrete will then be built up to complete the tunnel, and the bracing and foundation piles will be cut away to clear the interior as the work progresses. The upper halves of the 90-foot adjacent sections of the tunnel will be built in the pontoon, sunk, connected in about ten days each and the river end of the third section will be joined to the bulkhead in the middle of the river which closes the half of the tunnel which was built by the original process.

The 1 : 2 : 5 concrete used on this work is made with Giant Portland cement and screened gravel from ½ inch to 2 inches in diameter. It is mixed by a 2½-yard Carlin cubical mixer which is located on a scow alongside the dock and delivers to a 2½-yard steel bucket. The mixer is served by two stiff-leg derricks which deliver the sand, gravel and cement from attendant barges. The concrete bucket is passed along the dock and dumped wherever required in the pontoon by several stiff-leg derricks with 75 and 80-foot booms, which are seated at intervals on the working platform of the dock. These derricks handle all of the shell segments and other materials; they laid the 300 cubic yards of concrete on top of the first section of the shell in about 8 hours.

In the middle of the river where the third section of this half of the tunnel will join the tunnel from the opposite shore, there will be a space about 25 feet long between the last ring of that half of the tunnel and the end of the section now to be built. This space is partly occupied by the bulkhead closing the end of the tunnel and is provided with sheet pile walls, bracing and a timber deck like that used on the west side of the river. The ¼-inch transverse diaphragm plate which will close the west end of the last section of this tunnel, will project about 5 feet above the roof of the tunnel so that when the latter is sunk to position, it will lie in the plane of the outer face of the existing timber bulkhead and will form a facing for it. A diver will secure it to the bulkhead with three rows of horizontal spikes and with bolts through a horizontal flange on the upper edge which engages a plate in the timber deck. This plate will form a permanent connection between this section of the tunnel and the connecting portion which will afterwards be built under the timber deck, in the place where the bulkhead now stands. The diaphragm will be stiffened by a 4x4-inch flange angle around each end, and will be spiked to the sheet piles on both sides. It will be made in several pieces spliced with double cover plates and will have a rectangular opening into each tube of the tunnel. The position of the 16x16-inch needle-beams under the tunnel roof has been very carefully located to clear the caps of the foundation piles and the transverse braces of the sheet piling.


Harlem River Tunnel: Upper Half of Shell with Ends Closed; Crown Section Open for Diver.

Mr. William Barclay Parsons is the chief engineer of the Rapid Transit Railroad Commissioners, and Messrs. McMullen & McBean are the contractors for the work here described. Mr. Robert Melvin is the superintendent in charge, and Mr. E. B. Maylor is the resident engineer for the contractors.

Direct Telephone Communication between Liverpool and Paris was established for the first time April 10, it is stated by a European contemporary.

The Troitsky Bridge, St. Petersburg.

In 1891 the municipality of St. Petersburg decided to build an important highway bridge across the Neva, and designs were invited from all engineers regardless of their nationalities. In October, 1892, sixteen plans were received from Russian, French, German, Belgian and Swedish engineers. No action was then taken on them, but in June, 1894, the Committee of Awards announced that the design submitted by the Societe de Construction des Batignolles was the most satisfactory, and recommended the city to award them the contract. The committee wished to adopt a Russian design, and one was presented by Mr. Sangourski, which was rejected in 1896, and a new commission appointed who finally adopted the Batignolles design.

The Troitsky bridge, as the structure is called, crosses the Neva at Souvaroff Place near Fort Peter and Paul and the Troitsky Church. The total length is 1,575 feet and the width over all is about 79 feet. It has two 10-foot sidewalks and a 59-foot roadway with two street car tracks in the center. At one end there is a swing bridge turned by an electric motor operating a sprocket chain coiled around the roller track. It has a center pier 69 feet in diameter and two openings of 84 feet in the clear. Adjacent to it there are five fixed spans with center lengths of 189.7, 269.7, 341.2, 269 and 284 feet, respectively, with a masonry arch approach at the end opposite the swing span. The corresponding clear openings for the different spans are 170.6, 249.3, 282.2, 249.3 and 170.6 feet. Five of the river piers have caisson foundations, and the abutments and the other river piers are built on piles.

The superstructure has eight lines of riveted deck trusses. The top chords are horizontal except for a slight inclination to secure the grade or camber, which is continuous and forms a circular arc of large radius intercepted between the abutments. The bottom chords of all of the fixed spans are arcs of circles. The center span is a three-hinged spandrel-braced arch with the trusses made continuous over the piers and projecting as counterbalancing cantilever arms to support the ends of short suspended trusses in the intermediate spans. The end spans are also three-hinged spandrel-braced arches, each of which transmits its thrusts to the abutment masonry at one end and at the other end is made continuous over the pier and projects beyond it with cantilever extensions like those of the main span to carry the other ends of the suspended trusses of the intermediate spans. This combination of arches and cantilevers is designed to reduce as much as possible the horizontal thrust at the skewbacks of the center piers. It was used by the Batignolles Company for the Viaur bridge and has been patented by them.

The top and bottom chords of all spans have rectangular trough-shaped cross-sections built up of plates and angles with curved gusset plates riveted to the webs to receive the verticals and single diagonals. The lower chords of the arch spans are curved over the tops of the piers, where they are tangent to the segmental curves on each side. They are seated on cast-steel shoes engaging the ends of the cover-plates. The shoe has a convex bearing in a cast-steel seat which rests on two cast-iron bolsters, with horizontal and inclined bases set in pockets below the coping of the pier. The thrust bearing of the truss in the shoe and the bearings of the pedestal on the bolster are made adjustable with pairs of steel wedges. The end spans have at both extremities cast-steel shoes riveted to the under sides of the lower chords with half-hole bearings on horizontal transverse pins seated in corresponding pedestals. At the abutment ends the pedestals are movable on rollers with bed plates which are adjustable vertically by pairs of steel wedges. At the river ends the pedestals are fixed horizontally, but have similar vertical adjustments.

Harlem River Tunnel: Dock and Derricks; Completed Section of Tubes in Pontoon.

The crown hinges are made with pins having bearings of about 140 degrees in each of two steel castings with vertical webs bolted to the ends of the trusses. As the pin does not engage any full holes, the joint cannot transmit longitudinal tension, and there would be nothing to prevent the separation of the pin bearings were it not for a pair of small eye-bars pin-connected to the opposite trusses on the center line of the hinge pin, so as to hold them together, and at the same time enclose the ends of the main pin and prevent its motion transversely to the bridge axis. The adjacent ends of the suspended center span and of its supporting cantilever arms have vertical posts in the same transverse planes and the center span is supported by pins through slotted holes in the feet of its vertical end posts which engage the top chord end pins of the cantilever arms.

The trusses are connected by shallow plate-girder floorbeams 3 feet apart which are web-connected to the top chords by light lattice struts in the same planes which connect the bottom chords and by sway-brace diagonals of single angles in the transverse planes of the vertical post. The lower lateral system consists of X-brace angles and the top lateral stresses are taken up in the solid buckle-plate floor, which is made with single longitudinal panels spanning the full width from truss to truss. The plates are leveled up with concrete covered with asphalt on which double thicknesses of planks are laid to receive the wood-block pavement. The sidewalk floorbeams are supported at the center on the outer lines of trusses, their inner ends are flange-riveted to the main floorbeams and their outer ends form cantilevers connected at the extremities by fascia girders. They are paved with flagstones set in concrete filling over the buckle plates.

The decorative features of the bridge were designed with great care and submitted for the approval of a commission of the Academy des Beaux Arts. The principal embellishment consists of obelisks at the ends of the bridge, sculptured panels on the pier faces, ornate metal hand rails and cornices and large electric candelabra between the spans.

The spans were all erected on shore near the bridge site and were successively loaded on pairs of pontoons and floated to position on their piers. The two semi-spans of the central arch, together with their cantilever projections, were first erected and put in position, the long arms resting on a temporary pile pier in the center of the channel, which supported them until the crown hinge joint was made and their adjustment completed. The end spans were then erected and set on their piers and finally the suspended trusses of the intermediate spans were erected.

The foundation caissons and superstructure are of steel and weigh, respectively, 2,220,000 pounds and 13,320,000 pounds. The substructure contains 39,240 cubic yards of concrete and 4,447 cubic yards of cut stone. The total cost of the bridge was about $2,800,000; work upon it was commenced in April, 1898, and finished in November, 1902. The bridge was illustrated and described in "Le Génie Civil" January 23, 1904.

Condensation in an Underground Steam Pipe Line.

Some remarkable figures for the amount of condensation occurring in an underground steam pipe line were obtained this spring by Mr. William Wallace Christie, of Paterson, N. J., on a length of 300 feet of 4-inch pipe at the works of the Passaic Metal Ware Company, Passaic, N. J. In connection with some improvements recently made under his direction at that plant, it became necessary to provide means for conducting steam some 350 feet from a detached boiler plant and it was decided to run the steam line underground. To learn afterward the efficiency of the method of insulation adopted, four 4-hour tests were made on different days, these consisting merely of collecting and weighing the condensation formed in the pipe line during the periods in question.

The pipe is inclined upward from the boiler house, so that its far end is 4 feet above the initial point, or, in other words, the pipe is sloped upward at the rate of 16 inches in 100 feet. The pipe is enclosed within a box of 1¼-inch planks, 10 inches square inside, with the top readily removable. The whole, of course, rests in a trench excavated to receive it. The pipe is carried centrally within the boxing by means of light sheet-iron supports, cut with a semi-circular notch for the pipe and fastened at each side to the planking. The lumber was painted with creosote oil before nailing and mineral wool packed in the space between pipe and planking. The sheet-iron supports are spaced 6 feet apart and expansion is provided for by a slip joint and by bends at the ends. At the upper end the boxing is about 1 foot below ground, and it is stated that the snow over it is never melted during winter weather.

At the boiler-house end of the pipe, the condensation is ordinarily delivered into the boilers by a system of return traps. For the purposes of measurement, the traps were temporarily bypassed, so that it would be weighed directly. On March 15, with the outside temperature at 41 degrees Fahr., Mr. Christie says that 22 pounds of steam were condensed from 1 to 5 o'clock in the afternoon; on March 17, with the outside temperature 31 degrees, 23.25 pounds were condensed from 8 to 12 in the morning. On April 8, with the outside temperature at 62 degrees, 18.75 pounds were condensed and on April 9, with the outside temperature at 51 degrees, 22.75 pounds. During all these tests the boiler pressure averaged 80 pounds by gauge and it was estimated that about 25 boiler horse-power of steam were transmitted.

The foregoing figures show an average condensation in the 300 feet of pipe of 5.42 pounds, or 0.0153 pound per square foot of the pipe surface per hour. This is roughly equivalent to 0.255 British thermal unit per square foot of the pipe surface per minute. For the maximum condensation noted, this figure is 0.275.

The New York Times Building.

Part I.—General Design, Arrangement, Walls and Floors, Fireproofing and Equipment.

The ceremonial laying of the corner stone of the Times Building January 18, 1904, was an intermediate step in the construction of the latest and one of the most interesting of the New York skyscrapers. The actual construction may be considered to have commenced in January, 1903, when the excavation was begun for the great rock pit, rising from which there has been built a steel framework about 490 feet in height. This skeleton is being clothed with the walls and floors of the structure, and the building will soon be in readiness to receive its hundreds of tenants and to afford shelter for a great mechanical and editorial organization. The building occupies a long and narrow site enclosed between the intersection of four streets, three of which are important thoroughfares with heavy traffic. In plan it resembles a right-angle triangle with the vertex cut off to make a 20-foot side parallel with the 58-foot base. The longest side is about 143 feet long and the extreme height of the building above the curb is 380 feet.

The great prominence of the building, the fact that it occupies an entire block with unobstructed street fronts on all sides and its great height made the question of appearance and the character of the exterior an important problem. This was greatly complicated by the unusual proportions of the dimensions, the peculiar shape of the lot and the fact that the substructure is intersected by the subway tracks of the Rapid Transit Railroad Company, which seriously limited the arrangement of the foundations and the locations of the main columns, which carry thousands of tons of superstructure and heavy stresses due to wind pressure. The interesting features of the excavation, foundations and substructure were described in articles printed April 30 and May 7.

It was required to cover the entire lot with a building of the greatest altitude consistent with these conditions, constructed in the stiffest, strongest and most durable manner, completely equipped with sanitary and mechanical installations and presenting a handsome and imposing exterior. The purposes of the building required special quarters for the newspaper staff, numerous offices for public tenants and provision for a powerful and extensive mechanical plant. To meet these conditions it was determined to construct a main building about 225 feet high with a massive tower reaching 150 feet above its roof. To design this so as to secure a symmetrical and harmonious exterior was found to be very difficult and repeated efforts were made to find a motive adaptable to each of the four sides with their different angles and great variation of dimensions. Many complete elevations were made of the building and the tower in order to enable the design of each side to be adapted to the requirements of the other sides and to make the tower distinct from the lower portion of the building, while yet having it evidently integral with it. The first three stories above the ground level are treated as a base and are finished with Indiana limestone. The remainder of the building is faced with Perth Amboy glazed brick and terracotta trimmings with a sand-blast finish to produce a dull matched surface. The third to the thirteenth stories form a shaft, above which the remaining stories of the main building are treated as the base of the tower. The exterior here is very much enriched and terminates with an elaborate and ornate cornice.

The general character of the architecture is perpendicular Gothic, chosen partly on account of the equal subdivisions of the superstructure and more especially because it was better adapted to the varying dimensions of the long sides of the building and the four sides of the tower. The next consideration was to harmonize the tapering outline of the lot and to secure unity between the tall tower and the mass of the lower building, which was accomplished by the treatment of the openings and the arrangement of buttresses and cornices. The steel construction is emphasized by the panels between the long vertical pilasters in which the main wall columns are enclosed.

Arrangement.—The tower will be chiefly devoted to the editorial and news departments of "The New York Times"; the upper story of the main building will afford a large space for the compositors and will be abundantly lighted by a clere-story rising above the main roof. There will be fourteen office floors each designed for twelve rooms or for any other subdivision that the tenants may require. Below the street level it was necessary to excavate to a depth of about 25 feet below the curb to provide for the Rapid Transit subway, which occupies a space about 20 feet deep with a horizontal area equivalent to about one-third of the area of the main floors of the building. In order to provide for the heavy printing presses and other machinery where they would be entirely separate from the subway and have solid supports independent of the steel framework, the excavation was carried to a depth of about 30 feet below the subway, and required the removal of approximately 25,000 cubic yards of rock.

The position of the building bounded on all sides by public streets secured the privilege of sidewalk vaults outside the building lines and enabled it to occupy a very much larger area below curb level than above. It therefore has dimensions of about 178, 108, 168 and 60 feet for the sides of the three subterranean stories, thus giving each of them a floor area of about 16,000 square feet, while the upper stories have areas of 5,400 square feet. The space occupied by the subway structure with its deep floor and roof is included between the basement ceiling and the sub-basement floor and cuts off one end and part of one side of those two stories. The second sub-basement is carried down to give it a clear height of about 20 feet below the subway floor girders, and it extends over the entire area included by the vault walls, and is obstructed only by columns.

The large presses and other heavy machinery are seated on the solid rock entirely separate from the superstructure. Above the pressroom there is a platform leading to the subway station and a tunnel to an entrance on the opposite side of Broadway. The basement contains rooms intended to be used for stores and shops adjacent to the subway station; the sub-basement will be used for storage and the installation of some of the mechanical equipment for the building, and the first story will be devoted to the public entrance shops, and the publishing department of "The New York Times."

In the sub-basement the elevator machinery is enclosed near the center of the building and the remainder of the floor space, excepting the boiler-room, forms one large hall. In the second sub-basement there are permanent enclosures around a stair-well and two elevator shafts and around four light wells, the remainder of the space outside of the subway structure being undivided. The basement has several stair and elevator light-well enclosures, besides a transverse hall across the full width of the south end of the building. The remainder of the space will be divided to suit future requirements.

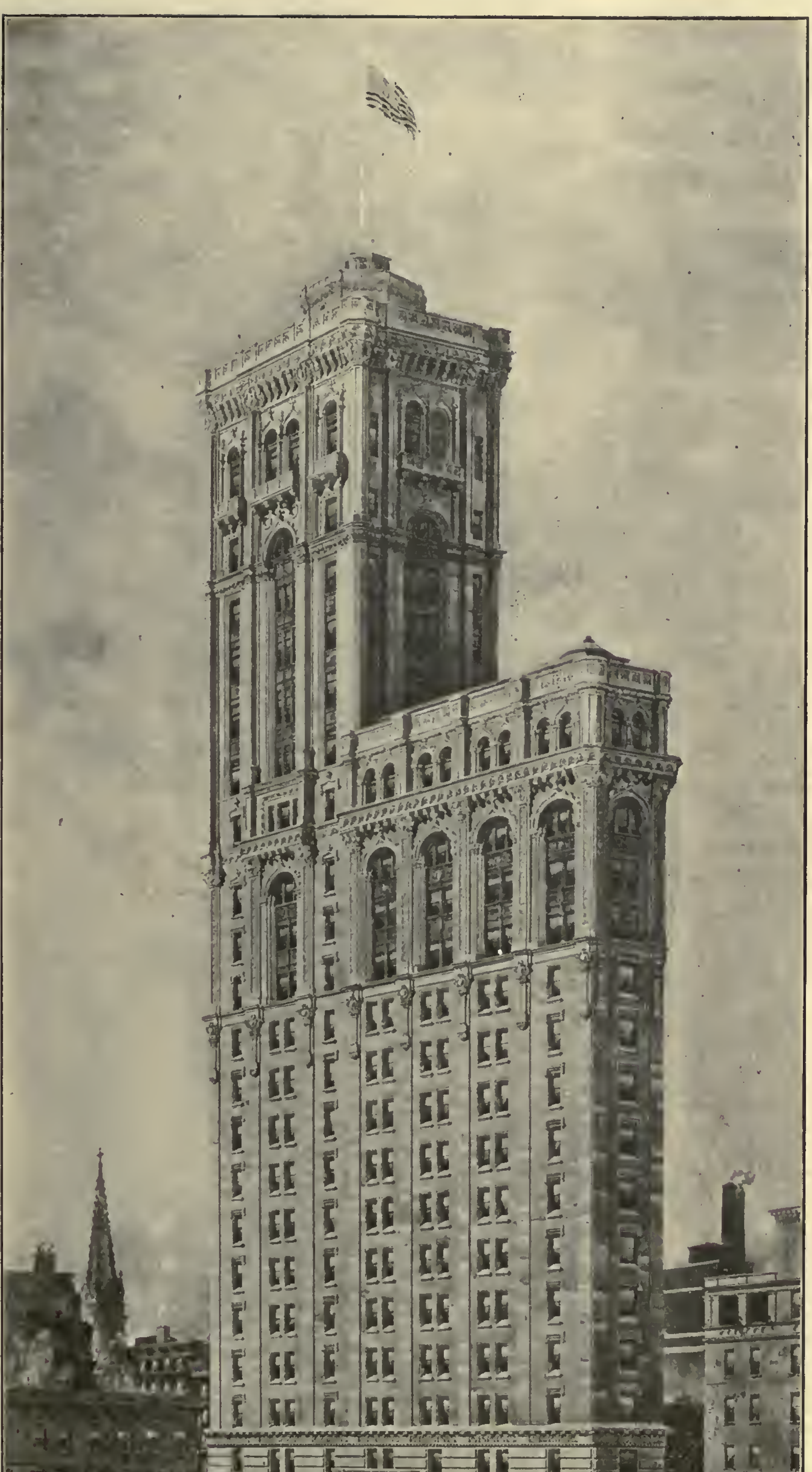
The first floor has two principal partitions dividing it into large end rooms and a central entrance and elevator hall about 40 feet wide and long. The fourteen typical office floors are planned for division into twelve separate offices when not otherwise arranged to suit the special requirements of tenants. The four elevators, stairs and the public toilet room, chimney and pipe shaft occupy a rectangular hall about 40 feet long and 25 feet wide in the middle of the west side of the building. A central corridor about 6 feet wide extends from end to end of each typical story of the building and the spaces on both sides of it can be divided by transverse partitions into twelve office rooms, about 18 to 21 feet long, extending from the outer wall to the corridor. A single room 20 feet long occupies the entire narrow end of the building, and the broad end is occupied by two large corner rooms and one small middle room.

The sixteenth story is an undivided hall for the use of the compositors and composing machinery and is lighted by windows in the wall and in the clere-story of a monitor about 50 feet long and 25 feet wide, which is located at the narrow end of the building and has its walls parallel with the outer walls. The seventeenth to the twenty-third stories inclusive each occupy the entire area of the tower and have extreme dimensions of 61 feet 8 inches by 58 feet 4 inches on the building line. They are served by a single elevator starting at the sixteenth story and located in a stair shaft which, with the smokestack and a small room, occupy a permanent enclosure about 18 feet wide and 27 feet long. The two inner walls of this partition contain one of the four interior columns which are the only obstructions to the floor space in the tower.

Walls, Partitions and Floors.—The vault walls are solid red brick masonry 32 inches thick at the base and about 55 feet high up to the sidewalk level. They are self-supporting and carry three tiers of floorbeams. The ends of all but the upper tiers have wide vertical transverse flanges to give them bearing against the brickwork and enable them to receive horizontal thrust and transmit it to the interior framework. These walls are waterproofed with several layers of felt and asphalt and are backed with rubble masonry laid in cement mortar, filling all the space between the walls and the rock excavation. On the east side of the building, where the rock slopes upwards away from the wall, the wall is reinforced by vertical 24-inch I-beams 30 feet long built into the brickwork with their upper ends riveted to a horizontal beam and their lower ends bedded in the concrete footing, which is extended vertically and horizontally to give ample resistance for any external pressure.

The framework of the building is of steel-cage construction practically conforming to the standards for modern railroad bridge work. Above the street the walls are of brick 30 inches thick at the base and 20 inches thick at the top with stone facing and terra cotta cornice and trim, thoroughly anchored to the steel framework. They are supported at every story by special girders bracketed out from the columns to carry the brickwork without any load from the floors. The partitions are built of 4-inch terra cotta hollow blocks laid in cement, set in concrete on the floor arches and plastered both sides with ¾-inch of cement mortar.

The pressroom floor is composed of cinder concrete from 1 to 6 feet deep leveled over the rock bottom of the excavation, enclosing the column footings and pedestals and finished with a granolithic wearing surface. All other floors are made with terra cotta flat arches 10 inches thick up to spans of 5½ feet, above which they are 12 inches thick. They are filled leveled over the top flanges of the floorbeams with cinder concrete and covered with yellow pine



View of "The New York Times" Building Looking Southwest.

flooring. The roof construction is similar to that of the floors with 10-inch terra cotta flat arches filled and graded with cinder concrete from 3 to 15 inches thick waterproofed with five-ply tar paper laid in flat asphalt and covered with Ohio tiles 1 inch thick laid in Portland cement mortar. All flashing is done with 20-ounce copper carried 16 inches above the surface of the roof.

Preservation and Fireproofing.—Special pains have been taken to protect the framework of the building from corrosion or other deterioration and to insure the preservation and durability of all parts of the structure. The minimum amount of combustible material has been used, and it is believed that the construction will not afford material for a serious conflagration, nor allow it to spread through different stories of the building. All steel-work is thoroughly painted with at least three coats of red lead and linseed oil and is insulated by solid non-combustible covering. The beams and girders in the upper stories are entirely enclosed by the floor construction, the exterior columns are built solidly into the walls and the interior columns are enclosed with solid fireproof insulation.

On account of the great depth to which the structural steel-work is carried below the street surface and the intimate connection between it and the subway where there is a possibility of exposure to the accumulation of gases, additional precautions have been taken to guard against corrosion. All of the steel-work here is plastered to a thickness of 1 inch with Atlas or Vulcanite Portland cement mortar laid as the brickwork was built up to enclose it. The same protection was extended to the deep girders over the subway roof. The interiors of the box girders were filled with grout which required as much as 50 barrels of cement for the protection of the three largest girders.

Up to 10 feet above the pressroom floor the interiors of all columns are filled solid with 1: 2: 3 concrete made with Atlas Portland cement and ¾-inch broken stone. Below the basement floor the interior columns are encased with solid red brick walls, between which and the steel-work the spaces are filled with concrete. Above the basement floor the interior columns are enclosed with 2-inch hollow tiles, between which and the steel the spaces are filled with cement mortar. The outer surfaces of the tiles are finished with plaster 1 inch thick.

The wall columns are enclosed with red brickwork, which is bonded to the main wall and forms solid buttresses in its face. The spaces between the columns and the brickwork are filled solid with Portland cement. All other metal work is thoroughly enclosed with some form of hard-burned fire clay enclosing insulating air spaces.

All doors and other trim are of red oak treated by the Fireproofine process and having the sectional area diminished as much as possible so that in case of fire and the possibility of imperfect fireproofing there would be a minimum of combustible material. All window frames and sash and all doors in the basement, subbasement and pressroom and in the elevator shaft are made of white pine covered with Kalamein. The elevator doors are glazed with wire glass and wooden or glazed partitions are not used in the building.

Fire protection is afforded by a 6-inch vertical stand-pipe reaching to the roof and connected to two automatic electric pumps each with a capacity of 250 gallons per minute. The building is also equipped with a complete automatic fire alarm system. The mechanical installation of the building is operated throughout entirely by electric power, which will be derived from mains from three different power houses. A 300-horse-power battery of Babcock & Wilcox boilers is so arranged that it can hereafter be modified for the development of steam power if necessary. Pneumatic pressure will be provided to operate a tube service and for other purposes and there will be a Kenny vacuum system for cleaning. Water supply and drainage pipes are carried in spaces alongside the columns furred out beyond the surface of the solid walls. Electric conduits are accessibly run in a special isolated shaft adjacent to the smoke-stack. The total cost of the building is estimated at about $1,200,000 exclusive of the mechanical equipment and the site.

Messrs. Cyrus L. W. Eidlitz and Andrew C. McKenzie are the architects of the Times Building, Messrs. Purdy & Henderson are the consulting engineers, the George A. Fuller Company is the general contractor, the Degnon Contracting Company made the excavation and the Carnegie Steel Company furnished the structural steel.

(To be continued.)

The Mile Rock Steel and Concrete Light-House, California.

The Mile Rock light-house and fog-signal station at the entrance to San Francisco Harbor, Cal., is a steel and concrete structure about 90 feet in extreme height above mean high water. It is designed for a lantern apparatus of the third order and a 10-inch fog whistle, with the necessary operating machinery, and has accommodations for three men.

The light-house is seated on top of a sharp rock known as Mile Rock, which originally projected to a height of about 20 feet above mean low water, with an irregular contour somewhat resembling a heart-shape cross-section at the low water line. This rock is situated in the Golden Gate channel three-eighths of a mile from the south shore, and rose almost vertically from water 40 or 50 feet deep, its high-water area being about 1,000 square feet. It is exposed to waves which, even in fair summer weather, interfered with operations on it until the construction had been carried up 5 or 6 feet above high-water level. The tide here has a mean range of about 6 feet and a very swift current, the duration of slack water being short.

The isolation and exposure of the light-house made its construction somewhat difficult and required that all work and materials should be of the best class and that it should be designed to afford the greatest strength and solidity. It is therefore made with a massive monolithic concrete base 34 feet high above low water and a steel shaft above it. The top of the rock was leveled at a height of about 10 feet above high water and about 3 feet of the sides were stepped off regularly, as indicated in the cross-section. This work was done principally by gadding and by the use of very small charges of powder where there was no danger of shattering the permanent rock. The excavation for this trimming and for a portion of the entrance and stair-well amounted to approximately 70 cubic yards. The concrete base rests on and encloses the dressed upper surface of the rock so as to practically form a ring around the top, beyond which it is a solid mass 16 feet high pierced only by the entrance, stair-well and fresh-water well. This construction virtually dowels the rock into the light-house and affords a rigid base, to which the riveted steel columns of the superstructure are thoroughly anchored, thus securing a structure which opposes both weight and shearing and bending strength to displacement by wind and waves.

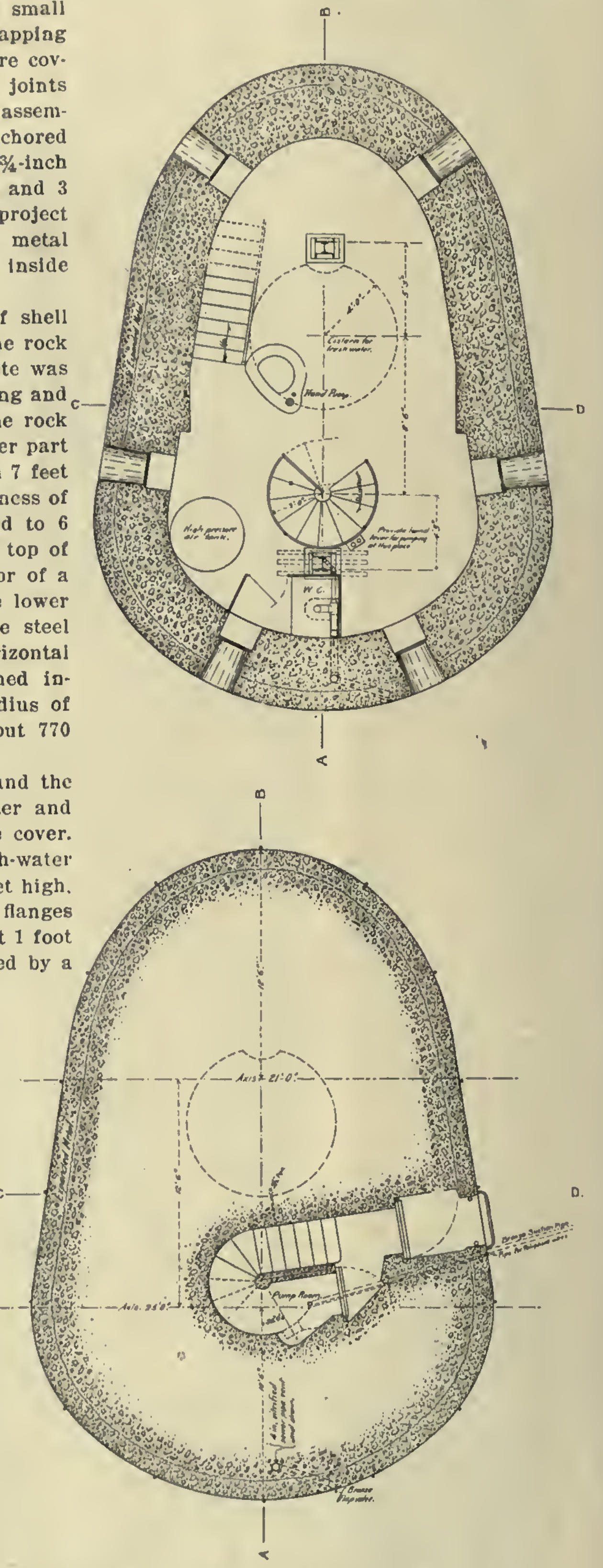
The outline of the horizontal section of the concrete base is formed by two segments of equal ellipses joined by tangent lines 12½ feet long. The major and minor axes of both ellipses are 25 and 21 feet long respectively. The 1: 2: 4 concrete is made with cement furnished by the United States Government, and was rammed in 4-inch layers, the top of each layer being specially roughened to make a perfect bond. The concrete was laid in a permanent steel mould formed of 3-foot courses of steel plates ⅜ inch thick and about 8 feet long. The courses are made in alternate large and small rings with telescopic horizontal joints lapping 2 inches. The vertical joints abut and are covered with 3-inch inside splice plates; all joints are riveted. Each course of plates was assembled as the concrete was laid, and is anchored to the concrete by two courses of ¾-inch crooked horizontal bolts 12 inches long and 3 feet apart. The inner ends of the bolts project through a continuous sheet of expanded metal parallel to the shell plates and 12 inches inside it.

The lower edge of the first course of shell plates rests directly on the surface of the rock and was kept in place, before the concrete was laid, by 1-inch vertical bolts 18 inches long and 3 feet apart, which were drilled into the rock on alternate sides of the plate. The upper part of the concrete base contains a storeroom 7 feet high, with walls 4 feet thick. The thickness of the upper part of the walls is increased to 6 feet to make a curved moulding at the top of the concrete structure and form the floor of a gallery about 3 feet wide enclosing the lower story of the steel superstructure. The steel shell terminates at this point with a horizontal 3½-inch angle, having its flanges turned inwards, and the corner rounded to a radius of ¾ inch. The substructure contains about 770 cubic yards of concrete.

The stair-well is 6 feet in diameter and the fresh-water cistern is 8 feet in diameter and 10 feet high, with a reinforced concrete cover. The entrance passage, 4 feet above high-water level, is about 3½ feet wide and 6½ feet high, the walls being protected with curved flanges of the shell plates for a distance of about 1 foot at the outer end. The entrance is closed by a very heavy door made with two thicknesses of crossed 2-inch oak plank. It has a heavy bull's-eye window in a bronze frame and has bronze bolts, hinges, locks and other trimmings and a bronze frame bolted to the concrete. The storeroom in the upper part of the substructure has six windows 20 inches in diameter with 1-inch glass set in heavy bronze frames fitted watertight.

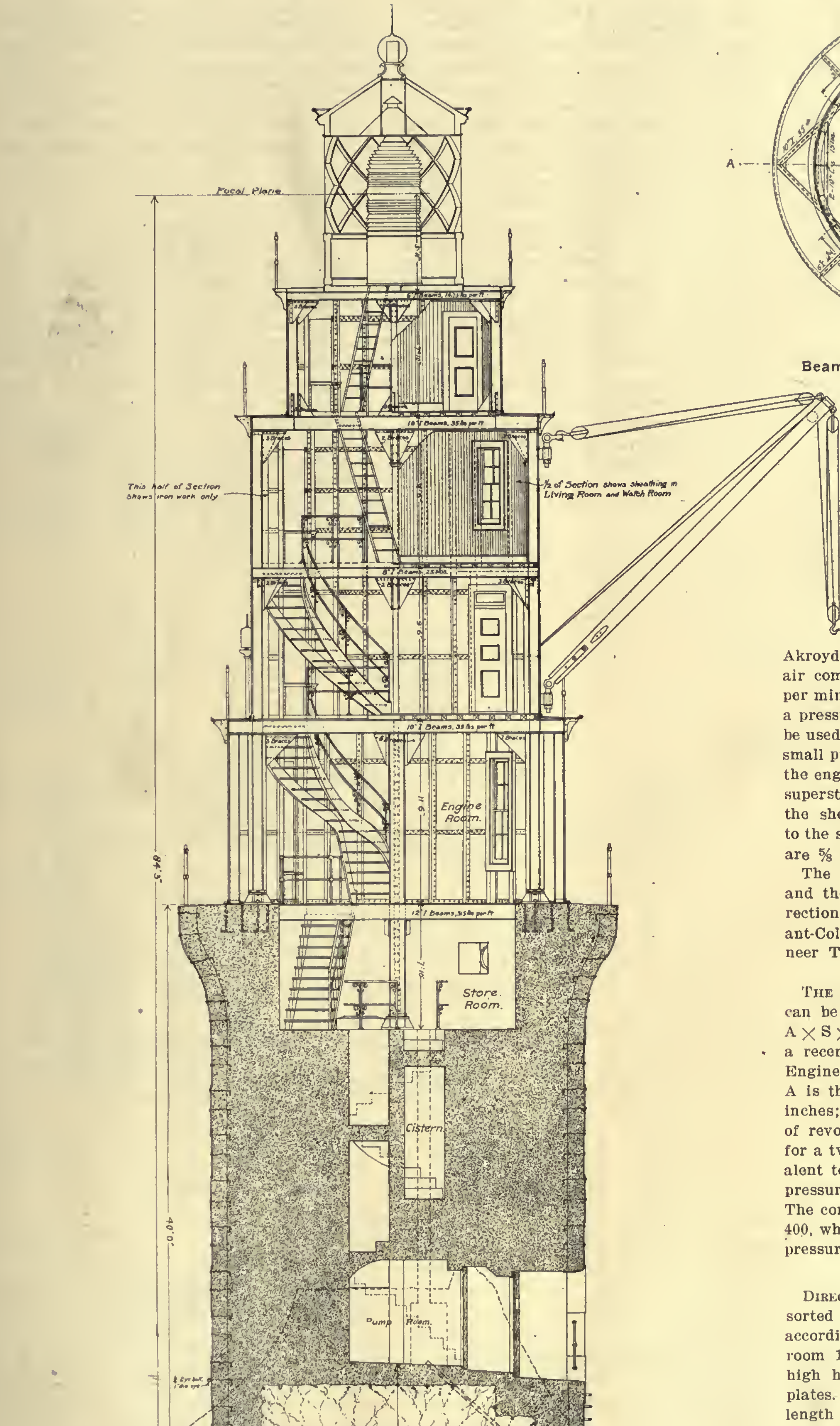
The lower story of the steel tower has an outline parallel to and 1 foot inside that of the concrete substructure and is 11½ feet high, with a horizontal roof, or deck, which forms an outer gallery around the base of the second and third stories 18 feet in diameter with a combined height of 19 feet. The fourth story, 13 feet 4 inches in diameter, is concentric with the third story and is about 8 feet high. The lantern is about 8 feet 9 inches in diameter and 11 feet high to the eaves of the conical roof. The superstructure is made entirely of structural steel and is especially designed to be easily accessible for inspection, sand-blast cleaning and painting. The medium steel conforms to the standard specifications of the Association of American Steel Manufacturers, and the mill certificate of tests was accepted by the Government.

The principal framework consists of four main vertical columns, auxiliary posts, angle studding in the walls, floorbeams and kneebraces. The columns consist of 8-inch 25½-pound continuous I-beams reinforced in the lower portion by pairs of 12-inch channels riveted to their flanges to make H-shaped cross-sections. They are seated on cast-iron pedestals, anchor-bolted to the concrete. The floors of the lower stories are made with 10 and 12-inch transverse I-beam girders connected by 6-inch I-beam floorbeams, angles and T-bars. The upper floors are made with transverse longitudinal and diagonal I-beams framed together with their flanges flush. The ends of the beams and girders are kneebraced to the vertical I-beams in the walls and to the main columns with ⅜-inch solid plates, giving great rigidity against wind stresses.

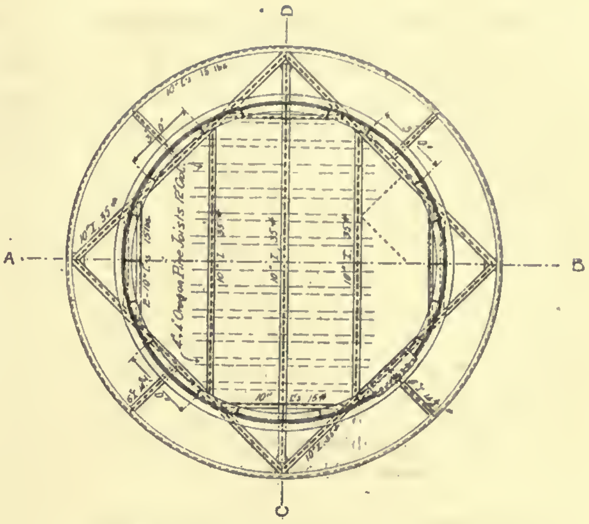


Sections through Foundation and Store Room.

The engine room walls have 8-inch 25½-pound I-beam posts, and the upper walls have 4x4-inch vertical angle studs crimped at the ends over horizontal circular girth angles. The exterior of the superstructure is entirely cov-


Focal Plane
This half of Section shows iron work only
½ of Section shows sheathing in Living Room and Watch Room
10" I Beams, 35 lbs per ft
8" I Beams, 25 lbs
10" I Beams, 35 lbs per ft
12" I Beams, 35 lbs per ft
Engine Room.
Store. Room.
Cistern
Pump Room.
84'5"
40'0"
6'0"
M.H.W.
M.L.W.

Mile Rock Lighthouse: Sectional Elevation of Tower and Foundation.



Beam Plan of Watch-Room Floor.

ered, except at the windows, by a cylindrical steel shell made with plates ⅝-inch thick, with planed edges riveted together with cover straps. The engine-room floor, boat deck and watch-room deck are covered with ½-inch steel plates with butt joints and cover plates riveted watertight and calked. The other floors are of wood. The light-house is equipped with a 25-foot wooden derrick boom, tackle and hoisting engine for handling the boat and supplies, and there are two Hornsby-Akroyd 20-horse-power oil engines, each with an air compressor of a capacity of 110 cubic feet per minute to operate the 10-inch fog whistle at a pressure of 70 pounds. The air pressure will be used for operating the hoisting engine, and a small pump which supplies sea water for cooling the engines and for flushing purposes. The steel superstructure was completely assembled at the shops and match-marked before shipment to the site. Most of the rivets used in the work are ⅝ inch in diameter.

The plans and specifications were prepared and the construction supervised under the direction of Mr. Thomas H. Handbury, Lieutenant-Colonel, Corps of Engineers, U. S. A., Engineer Twelfth Light-house District.

The Brake Horse-Power of a Gas Engine can be conveniently obtained by the formula: A × S × N ÷ 600, according to a Mr. Sumner at a recent meeting of the Institution of Marine Engineers of Great Britain, in which formula A is the area of piston, presumably in square inches; S is the stroke in feet; N, the number of revolutions per minute, and 600, a constant for a two-cycle engine. This is evidently equivalent to an engine developing a mean effective pressure of 55 pounds at every working stroke. The constant for a four-cycle engine is given as 400, which would correspond to a mean effective pressure of 165 pounds per square inch.

Direct Steam Radiation for heating was resorted to by James Watt about 1784 or 1785, according to "The Architect" of London. In a room 18 feet long, 14 feet wide and 8½ feet high he set up a box formed with two side plates. This box, placed on edge near the floor, length by 2½ feet wide, kept apart by means of stays and joined around the edges by other tin plates of bright iron tin, about 3½ feet in was supplied with a single steam pipe, serving both to supply the steam and drain the water. It is stated that the effect was not satisfactory, and this is explained as largely due to the comparatively poor radiating qualities which polished, smooth surfaces have been found to possess.

The Fraser River Bridge, British Columbia.

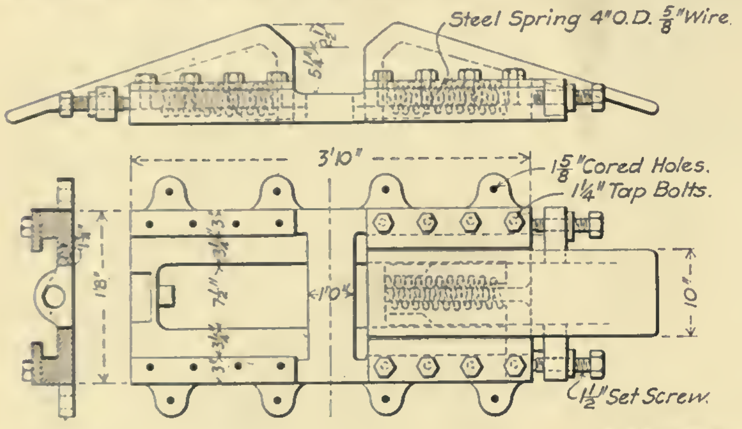
Part III.—The Swing Span.

The 380-foot swing span has pin-connected Pratt trusses 50 feet deep on centers, which correspond substantially with those of the long fixed spans, except that the bottom chords are composed of built members throughout and that the center panel is only 19 feet long so as to bring the bearings at the extremities of transverse girders tangent to the drum. The top chord of the center panel is composed of four 8x1 9/16-inch eye-bars. The top and bottom laterals, portals and the highway and railroad floorbeams correspond to those in the fixed span, except that the end floorbeams are carried directly by vertical connection plates flange-riveted to the cover plates of the end posts.

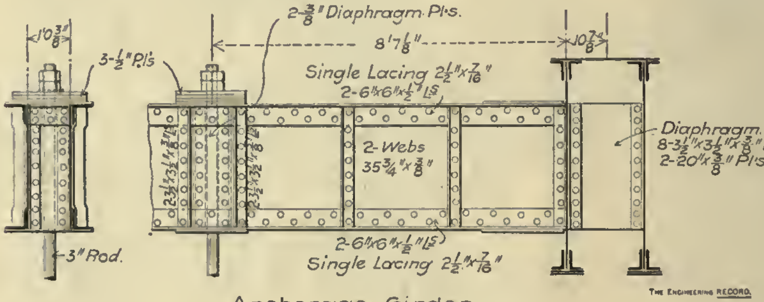
The turntable framing is very simple, and consists of two double longitudinal plate-girders web-connected in the same plane so as to make a rectangular frame, which is seated on the upper flange of the drum. This is a single web circular plate-girder 48 inches deep and 20 feet 6¾ inches in diameter on the center line. It has a ⅝-inch web and pairs of 6x6x¾-inch flange angles, and is reinforced by 5x3½-inch vertical web stiffener angles nearly 3 feet apart. The centers of the transverse girders are web-connected to a longitudinal anchorage girder 36 inches deep with double solid webs about 12 inches apart. These webs are connected at the center by a pair of vertical diaphragms 12 inches apart, and between them there is a vertical 3-inch bolt 30 feet long with the nut on the upper end bearing on the cover-plate of the girder. This rod passes through the center of the pivot casting and its lower end engages a reaction platform built into the pier masonry. The drum is centered on the pivot casting by eight radial struts which are light plate-girders flush with its lower flange and kneebraced to its upper flange. The inner ends are engaged between pairs of horizontal collar plates fitted to finished shoulders on the pivot casting. The upper plate is locked in place by a circular cap tap-bolted over it. The drum is supported on forty cast-steel conical rollers with their axles bolted to an angle-iron ring on a horizontal plate centered on the pivot casting. The rollers are journaled in inner and outer rings, which are respectively made of a 7x3½-inch angle and a 9-inch channel, both being spliced together in four sections. The circular rack which engages the operating pinion of the turntable is made in sixteen cast-steel segments with vertical webs bolted to radial cast-steel diaphragms or bracket pieces which connect it with the radial webs of the track segments.

The ends of the bridge are lifted by cast-steel wedges driven by shafting from the center of the bridge. The links and cranks by which they are operated are, in most cases, made of cast-steel with heavy reinforcing webs. The latch is made with a heavy horizontal bolt which drops into a socket between two spring buffers. These are arranged with sloping surfaces so as to engage the bolt and are adjustable so as to oppose a variable resistance to it when they gradually absorb the inertia of the moving structure. Each buffer is a heavy steel casting with horizontal flanges engaging a bed plate which contains stiff spiral springs and is bolted to the pier masonry.

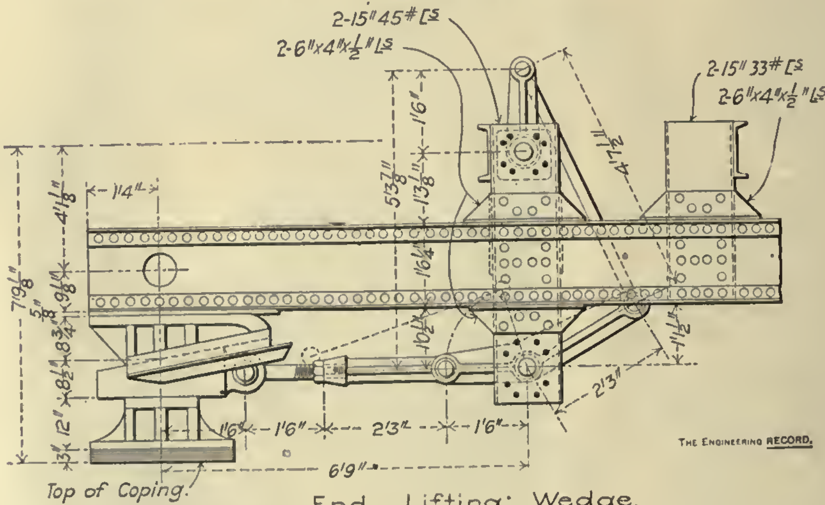
The machinery will be provided with hand gear for emergency, but will ordinarily be operated by an electric motor located above



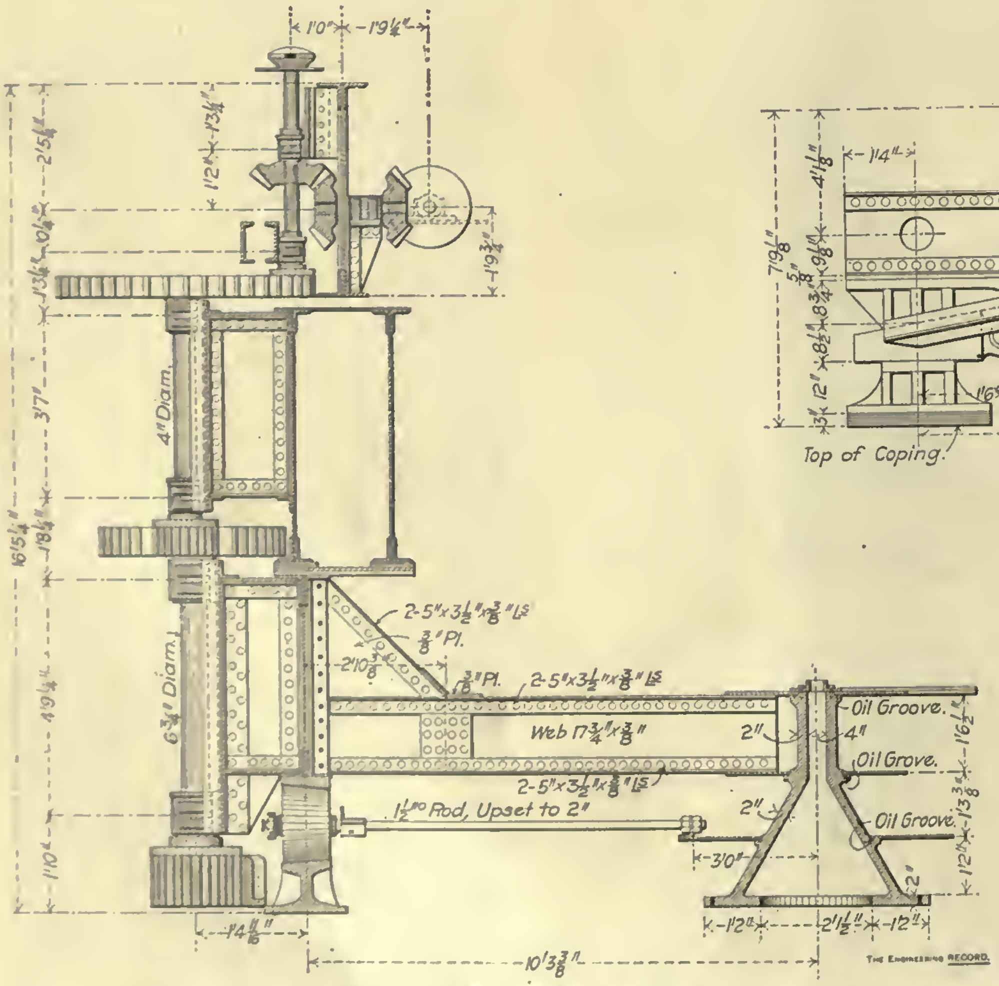
Detail of Latch Catch.



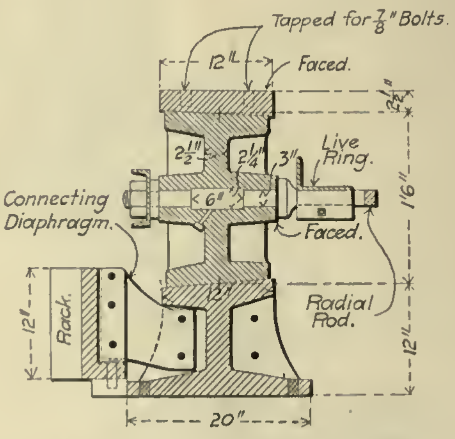
Anchorage Girder.



End Lifting Wedge.



Turntable Mechanism.

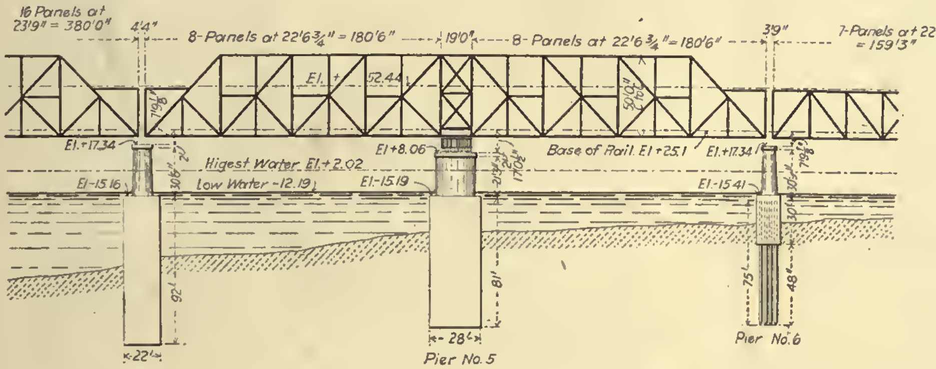


Section through Track and Roller.

FRASER RIVER BRIDGE: DETAILS OF OPERATING MECHANISM AND ANCHORAGE GIRDER FOR SWING SPAN.

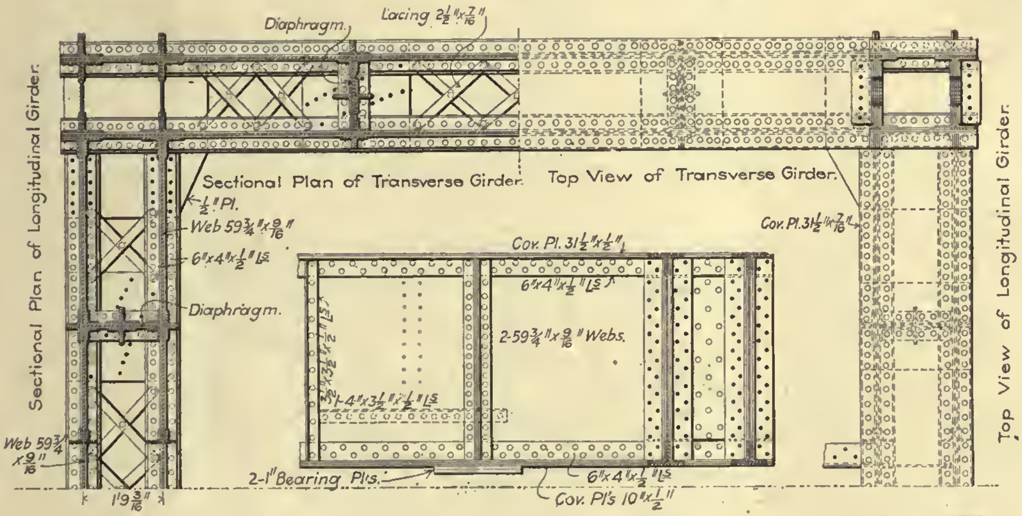
the top chords. The interlocking apparatus will be located on top of the 225-foot span at a point where the operator can see all river, bridge and land traffic. The estimated weight of structural steel in this span is 1,300,000 pounds besides 151,000 pounds in the drum and operating machinery. The total weight of structural steel in the bridge is estimated at 7,128,000 pounds, exclusive of that in the timber trestle. The 159-foot spans weigh 344,000 pounds each, the 380-foot fixed span weighs 1,577,000 pounds and the 225-foot span weighs 1,470,000 pounds, leaving 910,000 pounds for the plate-girder spans and steel bents.

The bridge was designed by Messrs. Waddell & Hedrick, consulting engineers, Kansas City, Mo., who inspected its manufacture and supervised its erection. The Dominion Bridge Company, Montreal, Mr. Phelps Johnson, manager, built and erected the superstructure, and Messrs. Armstrong, Morrison & Balfour, of Vancouver, were the contractors for the substructure.



THE ENGINEERING RECORD

380 Foot Draw Span.



The Engineering Record.

Part Elevation of Transverse Girder.

Half Plan of Bearing Girders supporting Trusses on Drum.

Fraser River Bridge: Elevation of Swing Span and Details of Bearing Girders.

The Oiling of the Road Bed of the San Francisco, Oakland & San Jose electric railway, to lay the dust, prevent the growth of vegetation and to serve as a means for uniting the rock ballast into a firmer mass, is accomplished by means of an ordinary tank car fitted with a special device. Two 3-inch pipes, hung by swivel joints, so that they may be lifted to clear obstructions, are connected to the tank to supply oil both in the center of the track and beyond the rails. Each of these pipes is drilled with 5/16-inch holes on ⅝-inch centers for the discharge of the oil, except for a distance of 6 inches over each rail, in order that oil may not come in contact with the rail itself. The arrangement gives a 12-foot stream of oil, and three oilings are sufficient for a year.

Water Consumption at Pittsburg and the Probable Effect of Metering.

Much information regarding the consumption of water in various cities of the United States has been collected in connection with the recent estimates for a filtration plant for the city of Pittsburg, Pa., and special interest attaches to this information on acount of its being compiled with the view of showing as well as might be the relation between the per capita consumption of water and the installation of meters. In connection with a presentation of this information, advantage may also be taken of the opportunity to present a statement of the conditions affecting the per capita consumption of water in Pittsburgh. Although these conditions differ considerably from those of most cities, it is believed that the compilation of statistics presented herewith can be relied on to show at least the general tendency of the influence of meters on consumption, as well as to emphasize certain characteristic features which often attend the installation of meters. The information from which the following notes have been taken was prepared during the past nine months, by Mr. Morris Knowles, chief engineer of the Bureau of Filtration, in connection with estimates for filtration projects reported to Mr. E. M. Bigelow, director of the Department of Public Works.

In determining the present and probable future per capita consumption at Pittsburg, the population has been estimated by taking as a basis the figures given in the 1890 and 1900 census reports. The population for 1903 has been estimated both from the increase in population from 1897 (date of police census) to 1900, and also from an investigation of the increase in the school census and of the building permits. The population of wards 1 to 23 (that portion of the city except ward 37, lying between the Allegheny and Monongahela Rivers) has increased at the rate of 4.9 per cent. per year from 1900 to 1903, and starting with the population of 1900 an increase of 40 per cent. in ten years has been used to obtain the estimates for this portion of the city alone up to 1930, as shown on one of the accompanying diagrams.

The population of wards 24 to 36 and 38, known as the South Side, has not been increasing as rapidly as the rest of the city, especially as the East End district; so that taking the entire city into consideration, the increase in population has been going on at the rate of 40 per cent. in ten years since 1900. The ratio adopted by Mr. Knowles for the purposes of the estimate is 35 per cent. for each ten years up to 1930, starting as before with 1900 as a basis. The population of wards 1 to 23 and 37 was given in the 1900 census report as 241,569, and that of the South Side as 80,047, making a total population for 1900 of 321,616. For 1930 the estimated population of wards 1 to 23 and 37 is 685,000, and for wards 24 to 36 and 38, 125,000, making a total of 810,000.

It may be stated here that the commission composed of Messrs. A. M. Miller, John W. Hill and Rudolph Hering, in their report to the Finance Committee of the City Council, dated February 27, 1904, has assumed a much lower rate of increase in population than that just given, its estimate of the least and greatest population being as follows:

Year.	Wards 1—23 and 37.	Wards 24—36 and 38.
1900 (census).	241,569	80,047
1910	318,000 to 327,491	92,072 to 98,000
1920	392,000 to 432,905	105,900 to 116,000
1930	474,000 to 557,956	121,814 to 132,500
1940	560,000 to 701,132	140,113 to 150,000
1950	645,000 to 858,815	161,239 to 168,000

The total quantity of water delivered to that portion of the city north of the Monongahela River (except ward 37) has been derived from the records of the Brilliant pumping station.

The machinery at this station is all modern, of the crank and fly wheel type and in good condition, so that it is doubtful if much of the large per capita consumption can be charged to inaccuracy of measurement due to slip of the pumps, etc. The average daily consumption for 1903 was 67,374,635 gallons and the maximum 72,764,020 gallons, an increase of 8 per cent. over the average. The ratio of increase of maximum pumpage over the average at Brilliant station has varied during 1896 to 1903 from 28 to 8 per cent. This ratio has been low in recent years, due, evidently, to lack of sufficient pumping machinery; for during January of the present year, when a new pumping engine was installed, it increased to about 25 per cent. The ratio of increase for the pumpage into the Bedford Basin from 1899 to 1902 has varied from 24 to 13 per cent., averaging 20 per cent. After a careful study of these data and those of many other cities in this respect, the ratio of 25 per cent. was adopted by Mr. Knowles for the purpose of estimates for the future.

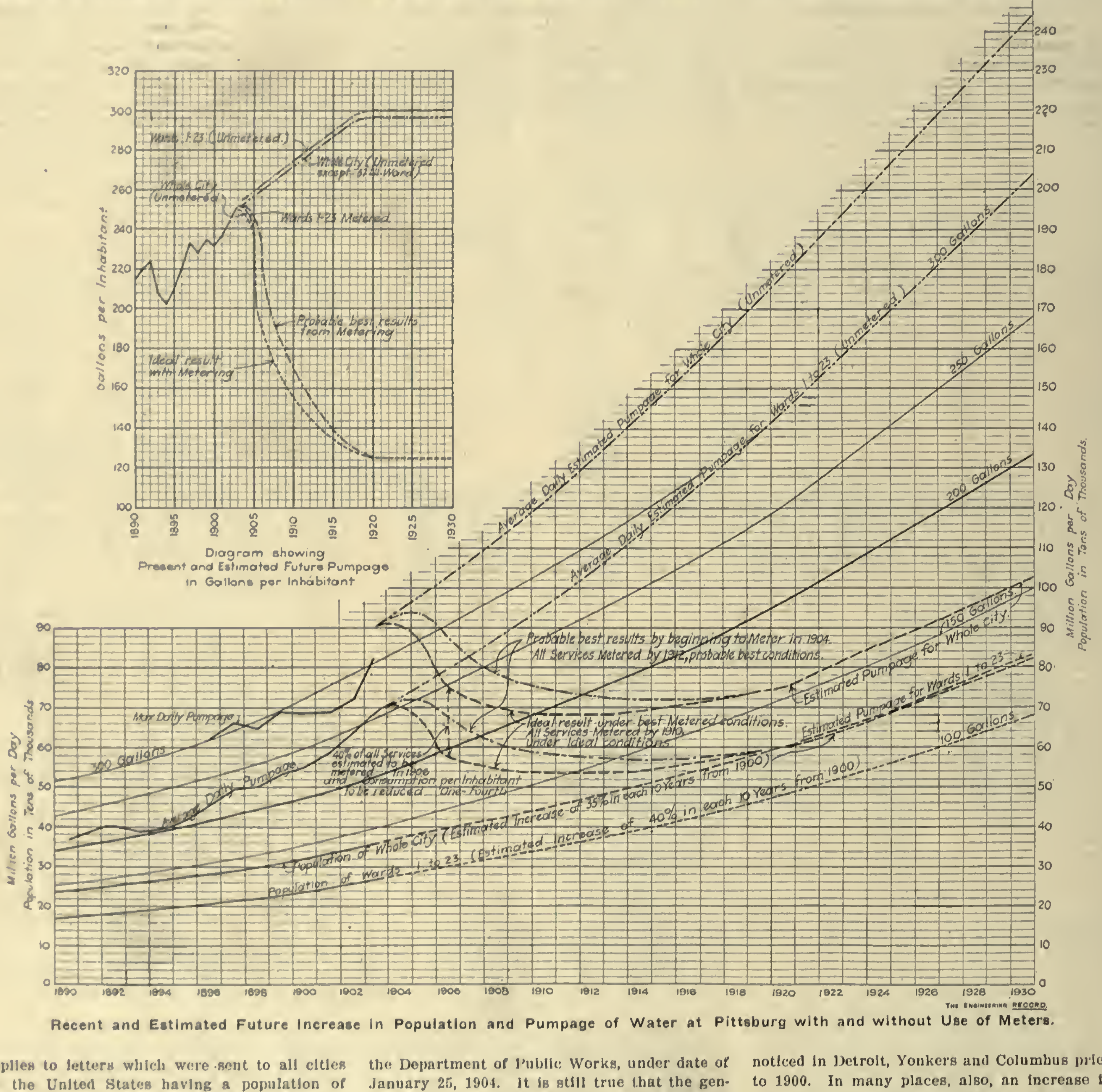
Accurate data upon the total consumption of water for the South Side (supplied by a private company) have not been obtainable, but it is thought to be about 17,000,000 gallons per day, or a little more than 200 gallons per capita. The consumption in the 37th ward, which is not at present supplied from the city works, has been estimated at less than the rest of the city because meters are generally used there. The total consumption for the whole city, as determined by these various factors, averages at present somewhat over 90,000,000 gallons per day. The per capita consumption for 1903 for the present municipal water district (wards 1 to 23) is 253 gallons per day. On one of the accompanying diagrams are shown graphically the past and future population and consumption of water as estimated by Mr. Knowles for various conditions. This diagram was dated September 11, 1903, and the curves for the probable results of metering were prepared on the assumption that metering would be begun in 1904 and that 40 per cent. of all services would be metered in 1906, and all services metered by 1910.

The other diagram, showing the effect of meters on the use of water, which was dated January 25, 1904, was prepared by Mr. Knowles and Mr. A. B. Shepherd, from data received in replies to letters which were sent to all cities in the United States having a population of 25,000 or more. Answers were received from 107 places, and the results for 74 of these were plotted on the original diagram. It was found impossible to plot them all, because of the confused appearance that would result, and as many places remained stationary either in the number of services metered or in the consumption per inhabitant, only a few of these latter were shown. The number of places has been still further curtailed in the accompanying diagram because of the necessary reduction in size (the original was 26x39 inches) for publication. The line A B C is simply an average line showing the general tendency. The line J N O shows the predicted results for Pittsburgh starting with the present quantity of 253 gallons per inhabitant and continuing under the best possible metered conditions and good restrictive and inspection methods. The line J K L shows the predicted results for Pittsburgh under probable attainable conditions, with an increase in the use of meters of about 13 per cent. per year.

The following extracts relating to this diagram have been taken from a statement prepared by Mr. Knowles for Director Bigelow of the Department of Public Works, under date of January 25, 1904. It is still true that the general tendency is downward, with an increase in the use of meters, i. e., the use of water is less. There are, however, some notable exceptions, especially among the wealthy and prosperous cities. The first ten per cent. of services metered shows a greater reduction than when any subsequent number is introduced to the same proportion. This is probably due in part to education and discussion, and also to the probability that the first meters were placed upon the worst wasters of water. However, after the first ten per cent. has been metered, it may be taken as a general conclusion that in order to keep the consumption down to the point thus obtained, it will be necessary to keep on adding meters in greater and greater proportion. This is seen upon the diagram by the lines representing Hartford, Dayton, Lawrence and Sioux City.

In many places it will be seen that after there has been a reduction in consumption due to the liberal introduction of meters, if this has not been kept up, the consumption goes back to former figures or even increases to greater quantities than previously obtained. This is noticed in Detroit, Yonkers and Columbus prior to 1900. In many places, also, an increase in the use of meters does not seem to be sufficient to offset the increased demand for water, as may be seen in Washington, Sandusky and Pawtucket.

Of all the cities on the diagram, those the most nearly comparable to Pittsburgh are Columbus and Cleveland, since 1901. The former has increased during that time its per cent. of services metered from 33.3 to 63.4, and the latter from 6 to 41.2 per cent., or an average increase of 33 per cent. The reduction per in-



Recent and Estimated Future Increase in Population and Pumpage of Water at Pittsburg with and without Use of Meters.

habitant in the former case is from 155 to 142 gallons per day, and in the latter case from 168 to 147. The reduction in each case being about in the same proportion, the slope of the two lines on the diagram does not differ materially.

The line JKL on the diagram shows the probable result for Pittsburgh with an introduction of meters fully as rapid as has been accomplished in Columbus and Cleveland. It will be seen that the slope of this line is fully as great as either the line for Columbus or for Cleveland, and the upper part of the Pittsburgh line is even steeper. While it does not reach to so low a figure in the same number of years as at either Cleveland or Columbus, it must be remembered that the starting point is very much higher and among the highest figures in the world. It may also be noticed that at certain points the Pittsburgh line is not higher than the corresponding point for Birmingham and Sandusky. It does not appear, therefore, that the rate predicted for Pittsburgh, when plotted upon this diagram, in its relation to other places in the country, is too conservative for it at least provides for more water than it is reasonable to expect will be called for. This point is important, as some of the daily press think provisions for one-half or one-third of the present purpose will be sufficient within a few months after beginning to install meters.

Regarding the reduction of water waste by the introduction of meters, Messrs. Miller, Hill and Hering state: "A material percentage of the large per capital consumption of water at the present time in Pittsburgh may doubtless be charged to leaks in the older lines of water pipes, a loss which will not be changed at all by the introduction of water meters, and can only be corrected from time to time as the leaks are discovered, upon tapping the mains for new service pipes, and then only in degree. This loss can only be remedied by laying bare the old pipes and going over the joints, a proposition which could not be seriously considered.

"In making our estimate on the probable reduced consumption of water, by reason of the general introduction of water meters, we do not believe it safe to assume the per capita consumption of water at less than 200 gallons per day for Pittsburg, and 160 gallons per day for the South Side. Upon this basis the works recommended at the present time would be sufficient until 1918, i. e., no additions will be required for the works before that date, provided the introduction of meters is carried out as recommended in the report of the Filtration Commission of January, 1899, which recommendation we cordially approve."

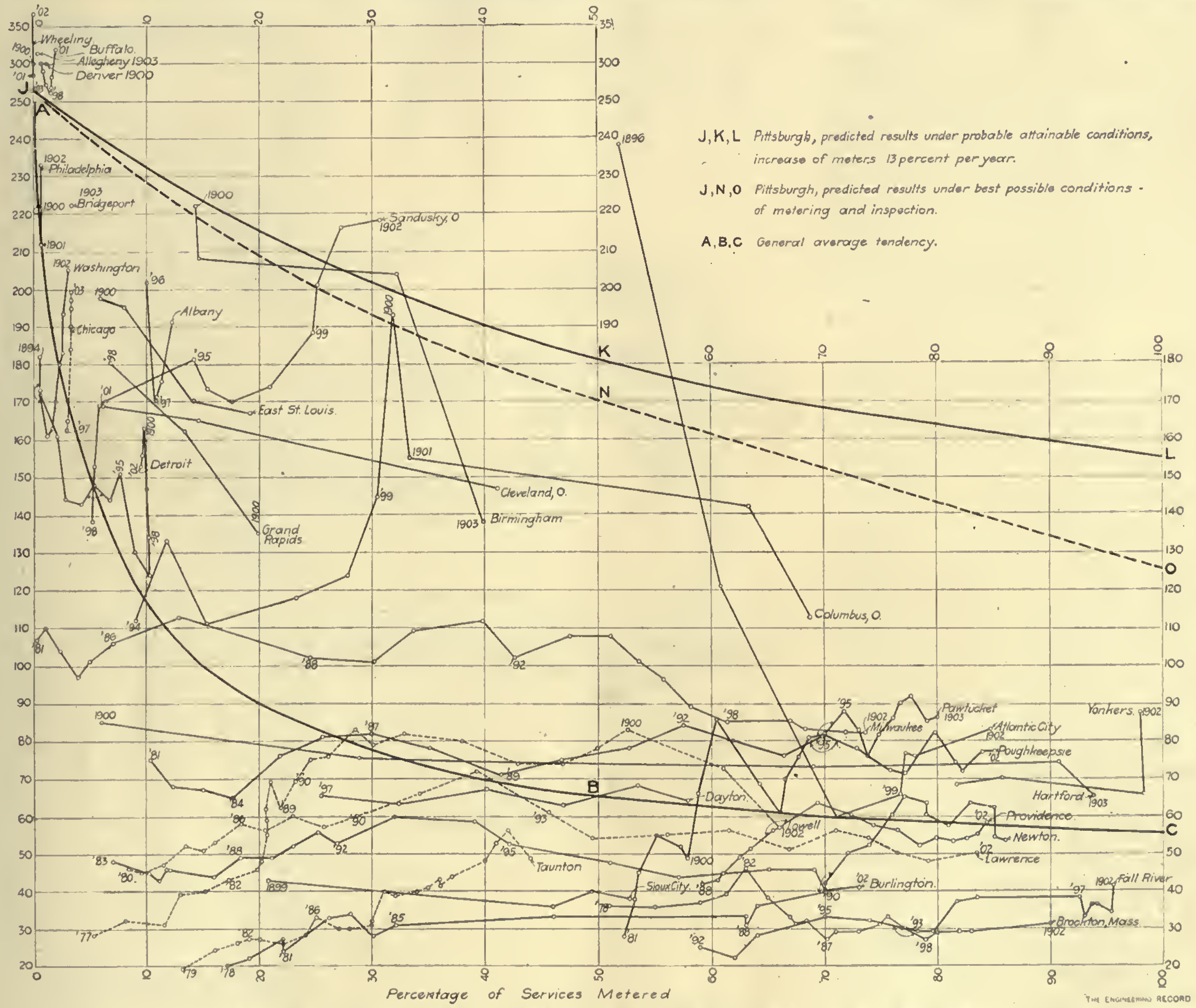


Diagram Showing the Effect of Meters on the Use of Water in Various Cities.

Prussian Steel and Iron Railroad Bridges are regulated by a code of instructions issued nine years ago by the minster for public works and recently revised. According to "The Engineer," London, the first requirement is that all bridges shall be built of masonry except in cases where it is impracticable or absolutely disadvantageous. Plate girders are recommended only up to 66-foot spans. Channel or I-beam stringers must be used and must be web-connected on one side to a full-length vertical web-stiffener angle and to another vertical angle on the opposite side which is short enough to clear the stringer flanges. The shapes from which web members of lattice girders are built must be connected by tie plates rather than long continuous rows of rivets, but I-beams are especially recommended for such members and latticing is prohibited in them. It is considered that pin bearings and roller beds are advantageously combined for short span bridges by supporting their ends on single rollers. Official tests are made with two 85-ton locomotives followed by 39-ton tenders and 26-ton cars. Counters are proportioned for a 50 per cent. increase of this load. Wind pressures are assumed at 51 pounds and 30.7 pounds per square foot for unloaded and loaded spans respectively. The maximum unit stresses for mild steel vary from 5.4 to 6.3 tons per square inch, when wind pressure is included or excluded in 66-foot spans, to 7 and 8 tons respectively for 660-foot spans. These stresses are reduced 10 per cent. for welded members. A sliding scale is also provided for the values of rivet shears which are taken at 10 per cent. less than the unit stresses where wind pressure is neglected. The writer asserts that American engineers have built numerous plate-girder spans up to 150 feet long. To the best knowledge of this journal spans of about 131 feet are maximum here, and these are very rare.

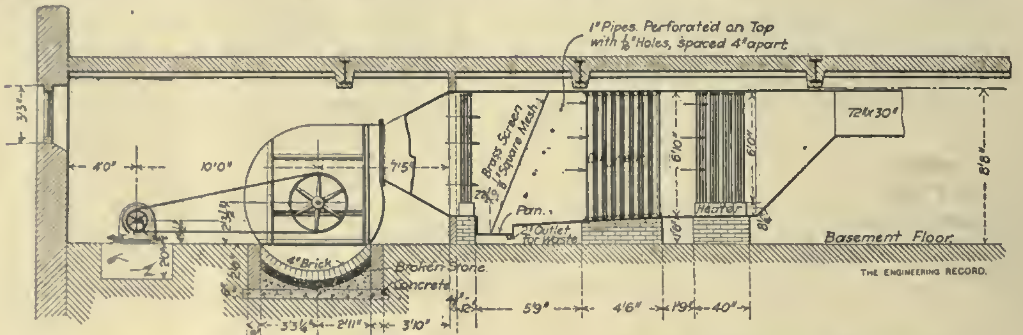
Heating and Ventilating a Works Office Building.

An instructive example of good practice in the provisions for heating and ventilating the type of detached office building forming part of the modern industrial establishment is presented in the accompanying illustrations. They show the general characteristics, together with some details, of the plant that has been installed for the administration building of the American Bridge Company, at Ambridge, Pa. It will be remembered that in the latter part of last year and in the early issues of the present volume an extended series of articles was presented, covering chiefly the structural details of the shop buildings and some of the special machinery designed for them. The class of heating plant that has been installed in this office building is that in which direct radiation is depended on for heating, but mechanical ventilation is provided for, with a circulation of the warm air under pressure—that is, on the plenum system—so that the air within the building is at a slight pressure above that of the atmosphere, thereby tending to offset the inleakage of cold air through the walls and openings. In the following account some reference will be made to the figures underlying the calculation of the system. As indicated in the detail sketches, there is a device for washing the air, in accordance with a practice that is now in vogue in parts of Pennsylvania where the air is more or less charged with smoke. The indirect heaters are of a special design and intended to receive cold water during summer for cooling the air supply.

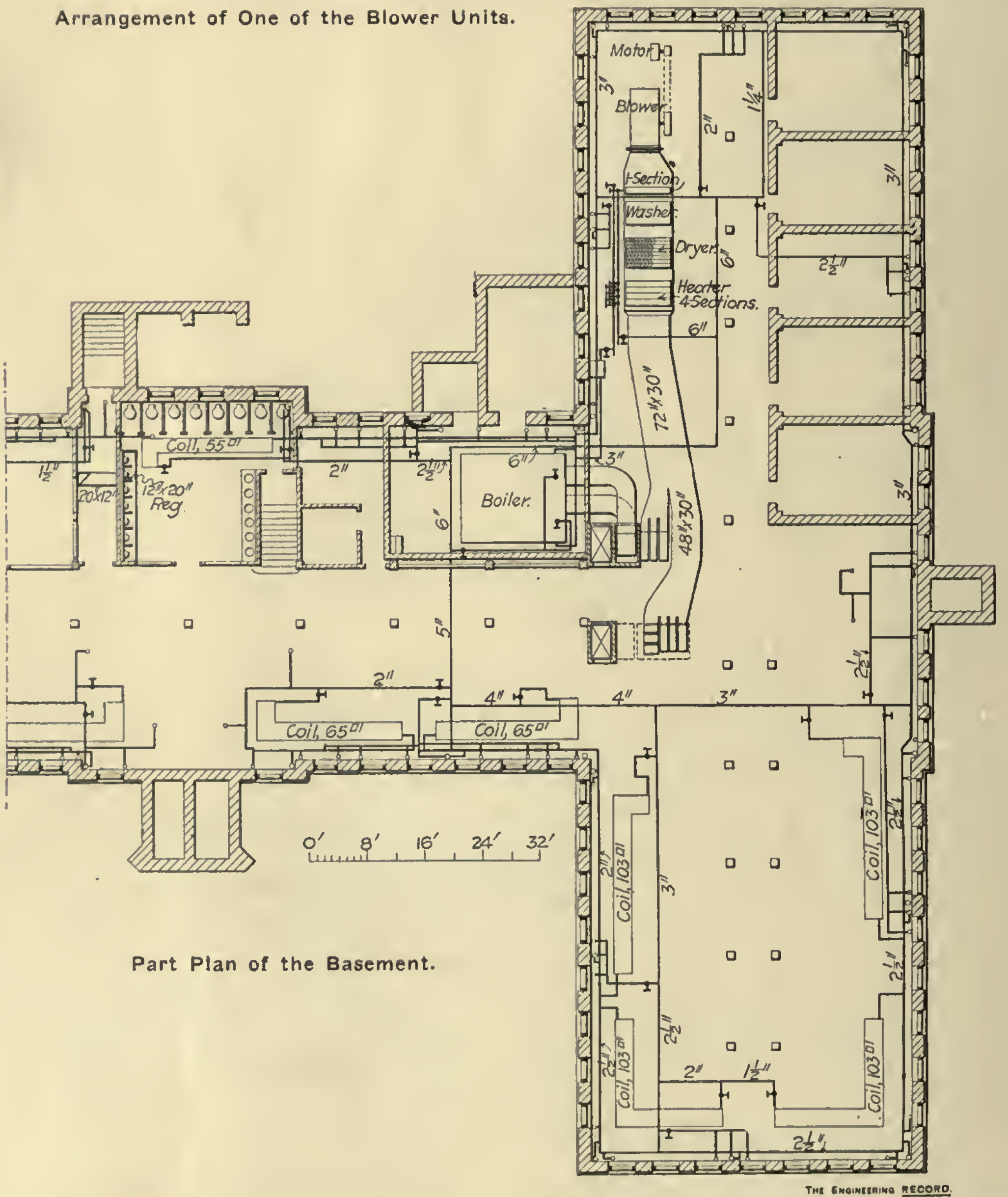
The building is a three-story and basement structure, H-shape in plan, with a court at both the front and rear, each 66x100 feet in size. The ground area of the building proper is approximately 19,000 square feet and the cubic contents are 900,000 cubic feet. Each of the wings are approximately 45 feet in width, as is also the connecting part of the letter H, and on the first floor there is a corridor running through the center of each wing as well as through the center portion, with offices on both sides. The two stories above are devoted largely to drafting rooms and are undivided, except for superintendents' offices at each end of the connecting pavilion. The basement is, of course, partly given up to the mechanical apparatus of the plant. The walls of the building are of brown paving brick and the roof is flat, covered with concrete. The floors are of reinforced concrete construction.

In laying out the plant it was found that some 2,800 square feet of heating surface in boiler capacity would be required and it was decided to install four boilers, each of which has 737 square feet heating surface. The building is symmetrical with respect to the center line across the connecting pavilion, and it was decided that the plant for both heating and ventilating could best be divided into two parts, for the two symmetrical halves. Two of the boilers were accordingly placed in one part of the basement, and the other two in a corresponding position in the other side. For ventilation a change of air four times per hour was determined on, and this meant for the part of the building to be ventilated directly, a supply of about 43,000 cubic feet of air per minute. In the decision to divide the plant into two parts, two fans were finally considered, giving a minimum length of ducts and flues to serve its corresponding portion of the structure. It will thus be seen also that the boiler plants supply the radiating service, both direct and indirect, with a minimum length of piping. Each half is independent of the other, both as to steam piping and to air ducts, but in the event of temporary disability of the one section, the other section, largely through the circulation of air, could be depended on to heat the whole building temporarily to some extent.

Taking up first the heating apparatus, the system for half the building only will be considered. The two boilers are of the water-tube type known as the Wharton-Harrison safety boiler, made by the Harrison Safety Boiler Works, and each has, as stated, 737 square feet of heating surface. Their grate area is 21.25 square feet, indicating a ratio of heating to grate surface of 34.6 to 1. Each boiler is composed of five sections of tubes. The grates are of the herring-bone pattern of 7/16-inch square mesh. Each pair of boilers is set in a single battery. The total amount of direct radiation connected to one pair of boilers is approximately 3,825 square feet and the total amount of indirect heating surface is about 1,200 square feet. Assuming the latter is equivalent in its capacity to condense steam to six times as much direct radiation, each boiler may be regarded as required to supply 11,000 square feet of direct radiation, under severe weather conditions. If each square foot of direct radiation is rated at 250 British thermal units per hour, it will be seen that this is equivalent to the condensation of 2,750 pounds of steam per hour in the entire system served by the two boilers. The evaporation of this amount of steam is again equivalent to the unit evaporation of 1.9 pounds per square foot of heating surface in the boilers per hour.



Arrangement of One of the Blower Units.



Part Plan of the Basement.

The pair of boilers supplies a 6-inch main steam line which is carried around the basement as shown in the part plan of the basement floor. The radiation on the first floor and the small amount in the basement story are supplied from a separate system of pipes from that feeding the radiation on the second and third floors. Generally the one-pipe system is employed. For the two upper floors each supply riser feeds radiation on both sides of it and the condensation is returned through return risers, draining the adjacent radiators. In other words the supply and return risers alternate around the outside walls of the building, each supply riser distributing to radiation on both sides of it on each floor, and each return riser receiving the water from radiation on both sides of it on each floor. The blowers are driven by electric motors, supplied with current from the central power station built for the works, and low pressure steam can thus be carried, with a return of condensation by gravity.

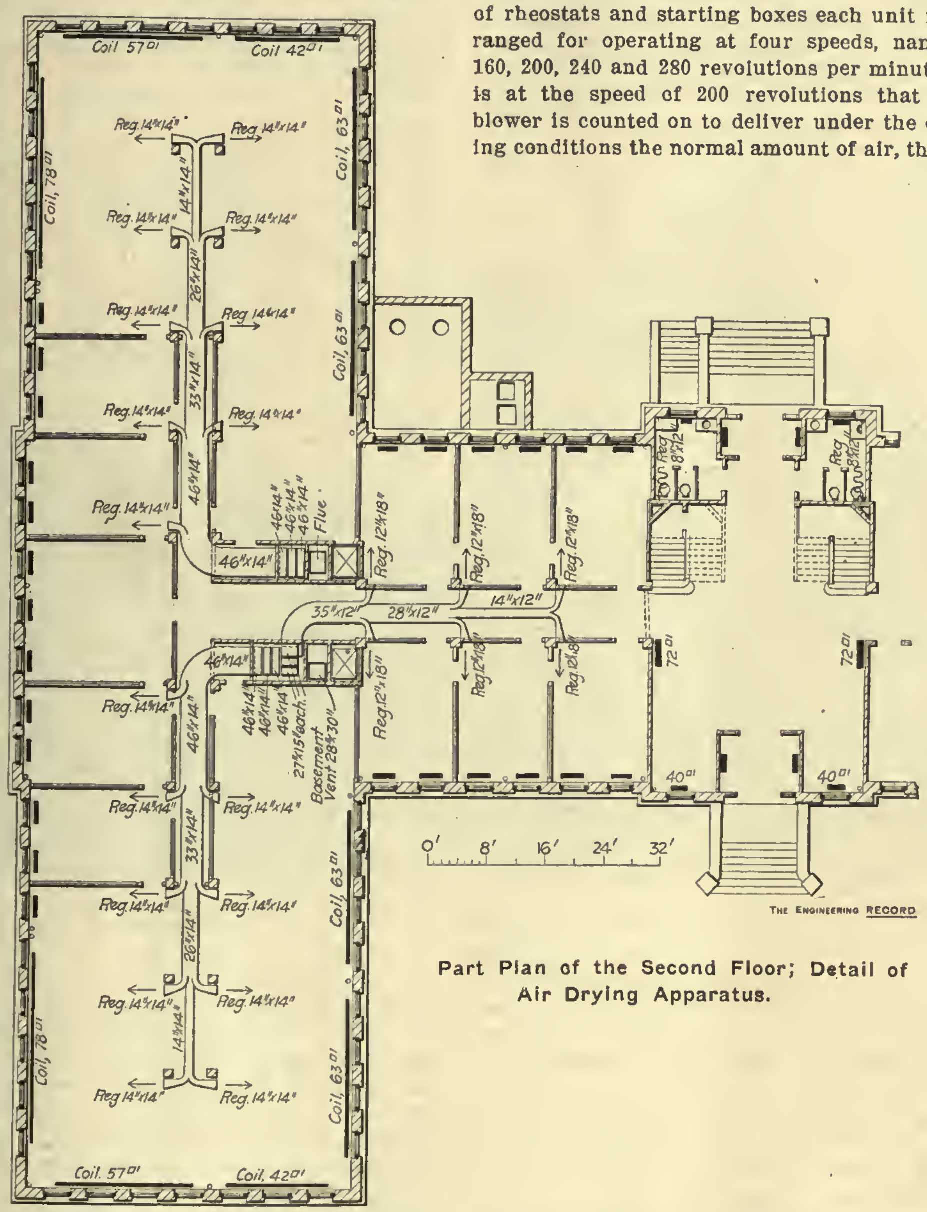
The office building is on the opposite side of the P. F. W. & C. Railway from the works, and it was not considered expedient to conduct steam for the distance required, and it was partly for this reason that the separate boilers were installed in this building. There are a few direct radiators, which are of the cast-iron loop pattern, some wall radiators under the windows in the smaller rooms, each of these consisting of two sections of radiator, each of 7 square feet of surface, but the direct radiation is mainly composed of 1¼-inch pipe coils with return bends. The condensation from the indirect coils collects, of course, at a level too low to be delivered into the boilers by gravity, and for these a No. 2½ Quimby rotary pump, direct-connected to a 1-horse-power Westinghouse motor, is provided for each of the two blower outfits. These pumps, it may be said in passing, are controlled by a No. 1 Kieley pump governor connected to the returns from the indirect heaters in such a way as to make and break the circuit to the pump motor, as occasion demands. The direct radiation is depended on for heating, as already stated, and the total amount shows a ratio of building contents to radiation of 118 to 1. On the basis of the volumes in the first, second and third stories, these ratios are 104, 116.5 and 109 to 1.

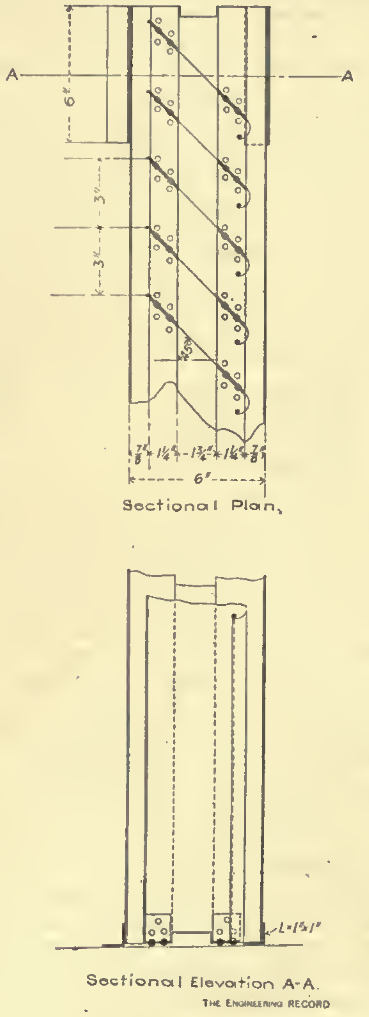
The ventilating apparatus provides for the normal delivery into the building of 43,000 cubic feet of air per minute, without any special means for the extraction of the air, beyond the points of egress that always exist in such a building, except that there are two disk exhaust fans, for creating an outflow from a blueprinting room and the toilet rooms, the amount of air so removed being approximately 11,000 cubic feet per minute.

The fresh air blower outfit is of the type in which the heating coils are on the blast side. The location of the blower is indicated in the accompanying engravings. Each is arranged to receive air through three adjacent basement windows, which are fitted with galvanized iron screens made of No. 10 wire with 1¼-inch mesh. These can be closed by metal-covered shutters swung inside of the windows and operated with a chain and pulley. Each blower, which has a three-quarter steel-plate housing with a blast wheel 6 feet in diameter, is belt-driven from a 10-horse-power Westinghouse motor. By means of rheostats and starting boxes each unit is arranged for operating at four speeds, namely: 160, 200, 240 and 280 revolutions per minute. It is at the speed of 200 revolutions that each blower is counted on to deliver under the existing conditions the normal amount of air, that is, 21,500 cubic feet. The blowers were built by the Buffalo Forge Company and are of their standard design for this class of work. In the discharge from the blower is placed the washing device and to protect this against freezing, a tempering coil is interposed between the blower and the washer.

The tempering coil consists of one section of 1-inch pipe coil, 30 pipes wide, 4 pipes deep and 6 feet high, presenting all told about 240 square feet of heating surface. Beyond the washing apparatus is the main heater, which comprises four sections of coils of the same dimensions as the tempering coil or a total of 960 square feet of surface. These coils are designed to warm the air for delivery into the rooms at a temperature of 70 to 80 degrees Fahrenheit. In construction, these so-called coils are unusual. Instead of groups of single pipes screwed into a common base, each 1-inch pipe has within it a separate ⅜-inch pipe, and the common base has two compartments, one over the other. The ⅜-inch pipes are screwed into the top of the lower compartment, that is, in the partition between compartments, passes upward through the upper compartment and is open at the top. Each of the 1-inch pipes encloses the smaller pipe, is screwed into the top of the upper compartment and is capped at the top. The inner pipe does not quite reach the closed top of the outer pipe, and the steam admitted into the lower compartment passes from the tops of the ⅜-inch pipes into the 1-inch pipes, whence the condensation is mainly collected in the upper compartment and drained off. The walls and partition of the base are ½ inch thick, except the top, which is ¾ inch thick, and both chambers are 8⅜ inches wide; the steam chamber is 3½ inches high and the return chamber, 3 inches.

The air-washing apparatus includes a device for drying the air. The washer consists of a brass-wire screen of ⅛ inch square mesh set in a brass channel frame, at an angle of 22½ degrees with the perpendicular. It extends from the bottom to the top of the chamber between tempering and heating coils, so that all air must pass through it. At a distance of 12 inches behind the screen are five 1-inch pipes equally spaced, as indicated, each of these having a row of 1/16-inch holes 4 inches apart along the top. One end of each of these pipes is capped, while the others are connected to a 1¼-inch pipe header outside of the casing. An electrically-driven Quimby pump, capable of handling 500 gallons per hour, delivers into the header. A pan is provided under the washer to collect the water and this can be drawn off and connected to the suction of the pump for use





Part Plan of the Second Floor; Detail of Air Drying Apparatus.

over and over again. The dryer, placed beyond the washer, consists of a system of baffle plates constructed of No. 20 galvanized iron. As indicated in an accompanying detail, the plates are set at an angle of 45 degrees with the direction of the air flow so that the air passing through them has to take a zigzag course and water is caught by the hooked edges. There are eight rows of these baffle plates and the width of the casing is 6 feet 6¾ inches so that there are about twenty-six plates in each row across the air duct, or over two hundred baffle plates altogether. The water caught by them drains also to the water pan to which the pump suction is connected.

The run of air ducts is a comparatively simple one. Air is supplied to the first, second and third stories only. As shown in the part basement plan, the main duct delivers to nine different flues. Three of these conduct the air to one of each of the three floors, one flue for the forward part of the corresponding wing, the second for the rear part of that wing and the third for the corresponding half of the connecting pavilion. The part plan of the first floor is typical of the duct systems for the other floors. Each flue terminates into a ceiling duct which is carried along the center line of the portion to be supplied and pairs of outlets branch from this duct with more or less flaring outlets to which registers are fixed. The air distributing systems in the wings on the second and third floors differ from that on the first in that there are ten outlets instead of nine, but all are 14 inches square. If an allowance for an increase in volume is made for the rise in temperature of the air after its passage through the heaters, it will be found under the normal condition of fan operation that the velocities in the main ducts in the basement are about 1,600 feet per minute, that the flue velocities average about 700 feet per minute and that the discharge through the registers, allowing 25 per cent. of the gross opening for the grill-work of the registers, takes place at about 320 feet per minute. The variation in the proportions of the ducts as the branches are taken from them is indicated in the drawings.

For summer operation an interesting provision has been made for pumping cold water through the pipe coils of the steam heaters for cooling the air discharged over them by the blower. Their construction by which the circulation can be made positive has already been described. This water is to be delivered by the house pump, the water entering the system through a T provided for that purpose in the steam pipe and leaving it at the return line from each heater at a point between the cut-off valve and the heater. This cooling arrangement is calculated to produce a reduction of 6 to 10 degrees in the temperature of the air. In view of the fact that the scheme has not yet had an exhaustive test, the following theoretical consideration will be of interest. The cooling of 21,500 cubic feet of air per minute through 6 degrees will require the abstraction from the heat contained in the air of 2,350 British thermal units over one minute. This is equivalent to the absorption by the heater, now used as a cooler, with its 960 square feet of surface, of 2.44 thermal units per minute per square foot. If it is assumed that the air is cooled 6 degrees from an outside temperature of 80 degrees, the mean temperature of the air while passing by the outside of the pipes is 77 degrees. If again, for the purposes of this calculation, it is assumed that the water enters the pipe coils at 50 degrees and passes out at 65 degrees, the rise in temperature will be 15 degrees, giving the water a mean temperature of 57½ degrees. The difference in temperature between the water and the air is thus 19½ degrees, so that if a cooling action of 6 degrees is realized, the cooling coils will abstract 7.5 thermal units per hour per square foot per degree difference of temperature. Again, the amount of water which heated 15 degrees, will absorb 2,350 thermal units in a minute is 156.6 pounds or 19 gallons. Similarly it can be shown that for 10 degrees cooling of the air the pipe coil surface would have to absorb 3,980 thermal units per minute or 14 thermal units per minute per square foot per degree and that the corresponding amount of water would be 32 gallons. Of course, these figures assume all parts of the pipe cooling surface in more or less active participation.

The exhaust system is comprised in two 30-inch disk fans in the attic of the building drawing from flues and discharging into the atmosphere through a 32-inch Emerson ventilator in each case. One of these fans is located over the connecting pavilion where it takes care of the exhaust from the toilet rooms located at the stairways, while the other is over one of the wings, at the top of the 28x30-inch flue drawing air from a blueprint room in the corresponding section of the basement. Each of these fans is direct-connected to a motor and normally run at a speed of 400 revolutions per minute.

The plans for the heating and ventilation of the office building were laid out by the Thompson-Starrett Company, of New York, under the supervision of Mr. James Christie, mechanical engineer of the American Bridge Company.

Some Operating Figures of a New York Office Building.

Some figures relating to the operation of a New York office building have been received from Mr. J. D. Wilson, Jun. Am. Soc. M. E., of New York. The data give the cost of operation, with a statement of the general conditions obtaining, and allow for some interesting calculations with respect to the elevator plant. The building in question is one having 112,000 square feet of rentable floor space and is 19 stories in height besides a basement, which is given over to the mechanical plant.

The scope of the mechanical plant may be indicated in general terms as follows: The steam-generating equipment comprises three water-tube boilers having an aggregate heating surface of 6,070 square feet and a grate surface of 148 square feet, or a ratio of heating to grate surface of 41 to 1. The electric lighting machinery is divided into four units employing high-speed direct-connected engines and having a total rated output of 300 kilowatts. The elevators are of the hydraulic type and three compound duplex steam pumps are provided for pumping the water, which is maintained at 125 pounds pressure. One of two of the pumps, 16x29x13x18 inches in size, is ordinarily sufficient, and the third pump is 14x20x10¼x10 inches in size. There is a refrigerating plant for furnishing iced water throughout the building and this is of the ammonia absorption type, utilizing exhaust steam and delivering the circulating water for use in the hot-water plumbing system. There is a 10x7x10 duplex steam house pump, a fire pump, two duplex boiler feed pumps, a pump for the blow-off tank and so on, and a 600-horse-power feed-water heater. The electric plant has a connected load of approximately 7,600 16-candle-power equivalents; and there are six passenger elevators, as will be explained.

The average daily coal consumption is 8 tons of No. 2 buckwheat anthracite. The cost of power, based on two years' experience, and including coal, water, supplies and wages, amounts to about 40 cents per square foot of rentable floor area per annum, and all other expenses, including the elevator service, cleaning, general upkeep and superintendence, amount to 50 cents per square foot of rentable floor space per annum, making the total cost 89.5 cents per square foot per annum. These figures, it should be emphasized, cover insurance, taxes, water rent and maintenance, as well as the general operating expenses.

The elevators are of the vertical hydraulic type, six in number, and are roped to the hydraulic pistons in the ratio of 6 to 1. They run at a speed of 500 feet per minute, with a hydraulic pressure of 125 pounds per square inch, as stated, and have a total lift or travel of 217 feet. Five of the cylinders are 14½ inches in diameter, while the sixth is 16 inches. The cars average 450 round trips per day of 10 hours. With the ratio of 6 to 1, it will be found that the pistons in the cylinders have a complete travel of 36.16 feet, and the total displacement of pressure water for the six elevators is 256.7 cubic feet per trip. As they average 45 trips per hour, the hourly displacement of water is 11,550 cubic feet. As this water must be raised to a pressure of 125 pounds by the elevator pump, or against a head equivalent to 288 feet, the horse-power represented by this work is found to be 105 horse-power. The maximum power demand as represented by all six elevators moving at the maximum speed of 500 feet per minute is, by a similar calculation, 323 horse-power. There are three pressure tanks serving the elevators, of an aggregate cubic contents of 942.5 cubic feet, so that, not counting the pipe lines connecting the tanks, the largest of which is located at the roof, the volume of all six of the operating cylinders is 27 per cent. of the tank capacity.

On the basis of 450 round trips, each of the cars travels 37 miles per day or 222 car-miles daily for the whole plant. An average of 12,000 persons are carried per day, which is between 4 and 5 per trip. Each car has a platform area of 36 square feet and the elevator well for the six cars occupies about 272 square feet or 3.1 per cent. of the total area of the typical floor, including outside walls. On the basis of the total rentable floor area, one elevator is installed for 18,700 square feet, which, if regarded as distributed over the nineteen stories, is 1,000 square feet per floor per elevator.

As to the lighting plant, the average load is 600 amperes, while the maximum is 1,800. As each lamp takes 0.43 ampere, the latter figure is equivalent to 4,180 lamps of 16 candle-power, or 55 per cent. of the total possible or so-called connected load. The average load stated is 70 kilowatts of 23.4 per cent. of the rated output of the generating plant, and the maximum is 210 kilowatts or 70 per cent.

COAL CONSUMPTION IN CENTRAL STATIONS was referred to at some length in a recent issue of the "Electrician" of London. At the Manchester Bloom Street electric works an equipment of the Babcock & Wilcox boilers, having a total heating surface of 5,140 square feet and the superheating surface sufficient to raise the steam temperature 90 degrees Fahr., showed a result on a three-hour test at full load of 2.31 pounds of coal per kilowatt-hour. The coal was a mixture of washed slack and pea coal, of a calorific value of 13,900 British thermal units per pound. Over a period of twelve months the coal consumption per kilowatt-hour was 3.8 pounds, at a load factor of 20 per cent., and the cost amounted to 0.25 cent per kilowatt-hour. The official test of the 1,800 kilowatt units at this station with saturated steam showed a steam consumption of 19.8 pounds per pound of coal; with superheated steam having 90 degrees of superheat the result was 16.75 pounds. This indicates a difference in favor of superheating of 16 per cent.

Foundations for the Sturtevant Hotel, New York City.

The Sturtevant Hotel, at Broadway and Twenty-ninth Street, New York, has street fronts of 105 and 180 feet and a steel cage framework thirteen stories high. The cellar excavation is about 26 feet deep below the curb and was chiefly in rock, although some of it was loose and shaky and some earth and gravel were encountered, especially on the Twenty-ninth Street side, where sheet piles were driven to retain it and braced by inclined shores. Most of the rock required blasting, and a locomotive boiler was installed and furnished steam for seven Ingersoll-Sergeant drills. As the site is in a congested business and theater district special precautions were observed, very light charges of explosives were used and the blasts were protected by rope mats and timber covers. Adjacent to the neighboring buildings the rock was cut away in vertical faces close to their footings, where rows of holes were drilled close together and as near as possible to the face of the wall, so that the rock could be split off easily with the least possible disturbance to the foundations.

Hoisting a Loaded Wagon with a Boom Derrick from the Excavation.

At the commencement of work the spoil was removed by wagons driven down an incline into the pit, but as the excavation became deeper this method was abandoned and the wagons were handled in and out by two guyed derricks which commanded the whole area of the lot. The horses were unhitched, the wagon tongue was secured and a couple of short chains were passed through a shackle on the lower block of the hoisting tackle. Both ends of one chain were hooked to the tops of the wheels on one side of the wagon, both ends of the other chain were hooked to the tops of the other two wheels and the wagon was lifted bodily from the street, swung over the required position in the pit, lowered to the bottom, loaded and lifted back into the street. This method saved time and enabled much larger loads to be handled than could have been taken if the wagons were hauled up an incline unless a hoisting engine had been employed for that special service. By this method there was no obstruction from a long incline and no trouble to maintain and constantly extend it, and the method was considered more advantageous than loading the rock into buckets and emptying them into wagons in the street, because it saved the wagons from the impact of large masses of stone falling out of the bucket and also enabled the men to pack the stones and get larger loads than could have been dumped from buckets. The wagons endured the strains of lifting by their wheels without injury, and the only trouble occurred when proper care was not exercised in securing the light movable pieces or when the wagons were allowed to swing against something. The accompanying picture shows a wagon suspended from the derrick-boom when it was swinging so much that the photograph was badly blurred and the wheels are invisible.

All of the adjacent buildings had comparatively shallow foundations under their walls next the excavation and were underpinned with new brick footings carried down from 10 to 15 feet to sound rock, but not to the full depth of the new cellar. The underpinning was done in alternate sections, which were so narrow that the brick walls above them arched across the opeenigs and were self-supporting without the necessity for needlebeams, none of which were used. The erection of the 1,770 tons of structural steelwork was commenced before the rock excavation was completed, and was accomplished by three guyed derricks with 45-foot beams which commanded the whole area. Messrs. Clinton & Russell are the architects of the building, and the general contract was let to the George A. Fuller Company, Mr. L. R. Barras superintendent in charge.

THE SPECIFIC HEAT OF SUPERHEATED STEAM, to which reference was made in these columns in noting the experimental work now being conducted by the National Physical Laboratory at Teddington, England, was investigated over an extended range of temperature in 1876 by Professor Weyrauch, of Stuttgart, Germany. It may not be generally known that at this date he advanced a proof that the specific heat at constant pressure was not constant, but according to his studies followed a formula for which the following is an equivalent: $c = 0.4237 + 0.0002099t$, in which c is the specific heat at constant pressure and t is the temperature of the steam in degrees Fahrenheit.

The Duties of the Isthmian Canal Commission.

The President decided this week that the Isthmian Canal Commission shall be under the War Department instead of the Department of State. This decision was doubtless due to the success of the War Department in administering affairs in the Philippines and to its many years of experience in the execution of river and harbor improvements. Although the Commission will report to the War Department, it will have almost autocratic powers in the canal zone, as is indicated in the following note from the President defining its duties:

"First—To make all needful rules and regulations for the government of the zone and for the correct administration of the military, civil and judicial affairs of its possessions until the close of the LVIIIth session of Congress.

"Second—To establish a civil service for the government of the strip and construction of the canal, appointments to which shall be secured as nearly as practicable by a merit system.

"Third—To make or cause to be made all needful surveys, borings, designs, plans and specifications of the engineering, hydraulic and sanitary works required, and to supervise the execution of the same.

"Fourth—To make and cause to be executed after due advertisement all necessary contracts for any and all kinds of engineering and construction works.

"Fifth—To acquire by purchase or through proper and uniform expropriation proceedings, to be prescribed by the commission, any private lands or other real property whose ownership by the United States is essential to the excavation and completion of the canal.

"Sixth—To make all needful rules and regulations respecting an economical and correct disbursement and an accounting for all funds that may be appropriated by Congress for the construction of the canal, its auxiliary works and the government of the canal zone; and to establish a proper and comprehensive system of bookkeeping showing the state of the work, the expenditures by classes and the amounts still available.

"Seventh—To make requisition on the Secretary of War for funds needed from time to time in the proper prosecution of the work and to designate the disbursing officers authorized to receipt for the same.

"The inhabitants of the isthmian canal zone are entitled to security in their persons, property and religion and in all their private rights and relations. They should be so informed by public announcement. The people should be disturbed as little as possible in their customs and avocations that are in harmony with principles of well ordered and decent living.

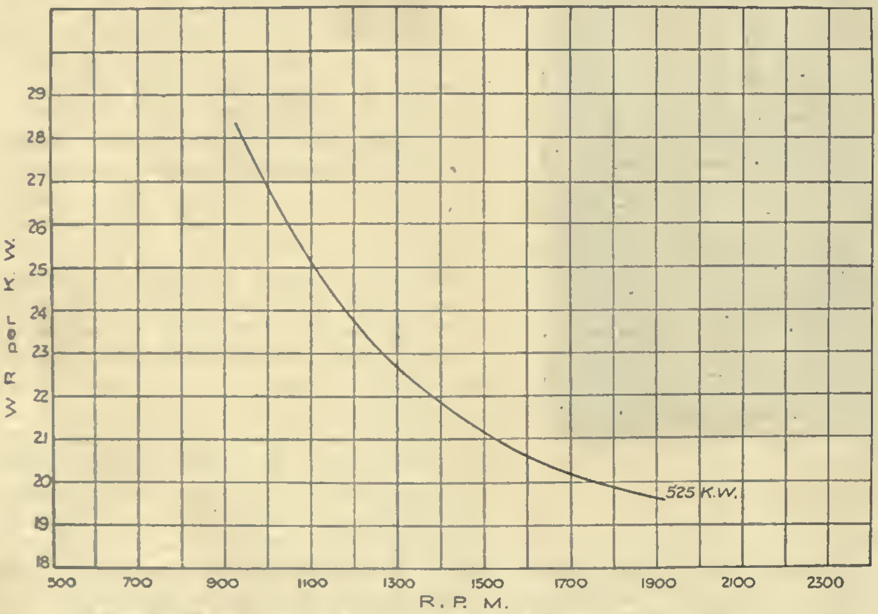
"The municipal laws of the canal zone are to be administered by the ordinary tribunals substantially as they were before the change. Police magistrates and justices of the peace and other officers discharging duties usually devolving upon these officers of the law will be continued in office if they are suitable persons. The Governor of the zone, subject to approval of the commission, is authorized to appoint temporarily a judge for the canal zone, who shall have the authority equivalent to that usually exercised in Latin countries by a judge of a court of first instance; but the Isthmian Canal Commission shall fix his salary and may legislate respecting his powers and authority, increasing or diminishing them in their discretion, and also making provision for additional or appellate judges, should the public interest require."

General Davis, of the Commission, has been appointed governor of the canal zone, and will be its chief executive.

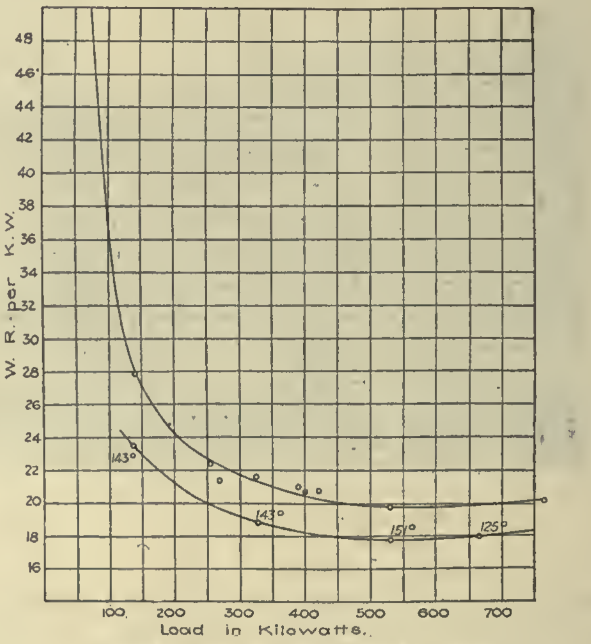
Tests of Steam Turbines at the Newport Station of the Old Colony Street Railway.

The steam turbine equipment at the Newport Station of the Old Colony Street Railway Company was briefly described in this journal on October 10 of last year. One of the turbines, which are of the Curtis type, has been tested for the railway company by Mr. Geo. H. Barrus, who had the co-operation of Messrs. Richard H. Rice and A. R. Dodge, of the General Electric Company. Tests were made with various conditions of load and with and without superheat, some of which are summarized in the accompanying diagrams. Trials were also made with regular commercial runs, and the steam consumption per kilowatt-hour under such conditions was ascertained by careful determinations of the total condensation and of the load. The builders of the turbine sets call particular attention to the records of operations under commercial loads. The wattmeter records indicate incessant fluctuations, with an average sudden variation of about 100 kilowatts under an average load of only 253 kilowatts in one test and 421 kilowatts in another. In the first of these cases the average steam consumption per kilowatt-hour was only 22.38 pounds and in the second case 20.7 pounds. The following statements concerning the trials are quoted from Mr. Barrus' report:

"At the request of your Mr. C. F. Bancroft, superintendent of motive power and machinery, and with the co-operation of the General Electric Company, I have made a number of tests on one of the Curtis steam turbines installed last year in the power plant of your Newport station, and tests of the boilers and other apparatus of the plant, with the object of determining whether the guarantee provisions of the turbine contract in the matter of performance and economy of steam consumption are fulfilled; and with the further object of ascertaining first, the economy of the turbine with other loads than those pertaining to the guarantee, and with variable commercial loads, both with dry saturated and with superheated steam, and second, the economy of the turbine based on coal consumption as well as steam consumption, together with the fuel economy of the boiler plant as a whole, and I beg to submit my conclusions as follows:



Effect of Speed on Consumption of Steam per Kilowatt-Hour.



Pounds of Steam per Kilowatt-Hour.

"*Economy Guarantees.*—At full load the turbine consumed 19.78 pounds of dry steam per kilowatt-hour, which is 1 per cent. better than the guarantee of 20 pounds. At half load, the consumption of dry steam was 21.38 pounds per kilowatt-hour, which is 7 per cent. better than the guarantee of 23 pounds. These results, expressed in terms of electrical horse-power developed, are respectively, 14.76 pounds and 15.95 pounds per electrical horse-power per hour.

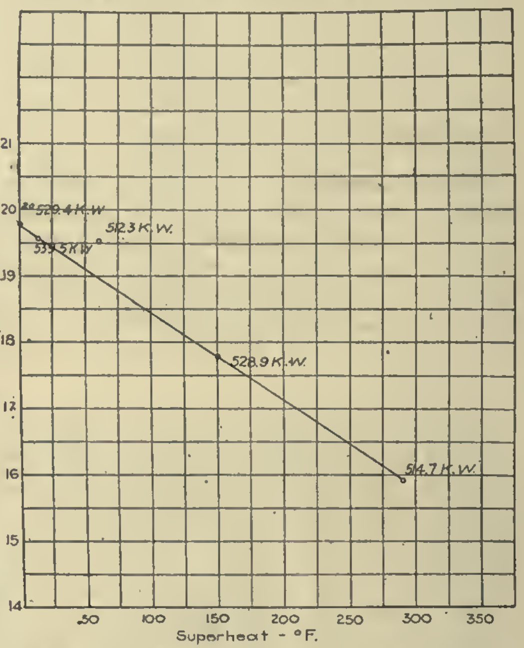
"*Mechanical Operation.*—The turbine and generator ran at all times without "undue heating, undue noise, or vibration," as called for by the contract. During the period covered by my examination and tests, one of the turbines, which carried the regular load of the station, was in operation continuously night and day, and, so far as I am aware, it was at no time shut down on account of imperfect mechanical operation. In my examination of the turbine, both external and internal, I discovered no sign of undue wear of the parts, or of deterioration, and I detected no evidence tending to show that the turbine would prove in practice to be an unreliable source of electric power.

"*Regulation of Speed.*—The variation of speed from no load to full load was 15 revolutions per minute, or eight-tenths of 1 per cent., which is 1.2 per cent. better than the guarantee of 2 per cent., the normal speed at full load being 1,845 revolutions per minute. The momentary variation of speed at full load was 30 revolutions per minute, or 1.6 per cent., and when carrying the variable commercial load of the station it did not exceed 40 revolutions per minute, or 2.1 per cent.

"*Voltage Regulation.*—The voltage fell from 2,480 volts at no load to 2,232 volts at full load, when the speed was 1,815 revolutions per minute, and the field current was constant. This reduction is 248 volts, or 10 per cent., which is the precise limit specified in the guarantee.

"*Temperature of Generator.*—The highest temperature reached by any part of the generator after a run of 8 hours with a load of 660 kilowatts was 38 degrees Centigrade above the temperature of the room, which is 2 degrees better than the 40 degree limit specified in the contract. The rise in temperature after 2 hours' run with a load of 764 kilowatts was also 38 degrees Centigrade above the temperature of the room, which is 17 degrees better than the 55 degrees named in the guarantee.

"*Additional Economy Tests with Dry Steam.*—At 50 per cent. overload, the steam consumption was 20.22 pounds per kilowatt-hour; at three-fourths load, 20.69 pounds; at one-fourth load, 27.85 pounds; and with no load save the condenser auxiliaries, the consumption was 1,408 pounds per hour, or 14 per cent. of that consumed at full load. With the variable commercial load of the station, which ranged from 333 kilowatts to 114 kilowatts, and averaged 253.2 kilowatts, the steam consumption was 22.38 pounds of dry steam per kilowatt-hour. When the commercial load was augmented by a constant rheostat load, bringing the average up to 421.9 kilowatts, the consumption of dry steam was 20.7 pounds per kilowatt-hour.



Effect of Superheat on Steam Consumption.

"*Superheated Steam.*—With a superheating of 150.5 degrees at the throttle valve, and 175.2 degrees at the superheater, the steam consumption at full load was 17.79 pounds per kilowatt hour, which is 10.1 per cent. less than the 19.78 pounds consumed with dry saturated steam. When the superheating was increased to 289.6 degrees at the throttle valve, and 334.4 degrees at the superheater, the steam consumption at full load was 15.91 pounds per kilowatt-hour, which is 19.6 per cent. less than the consumption with dry saturated steam.

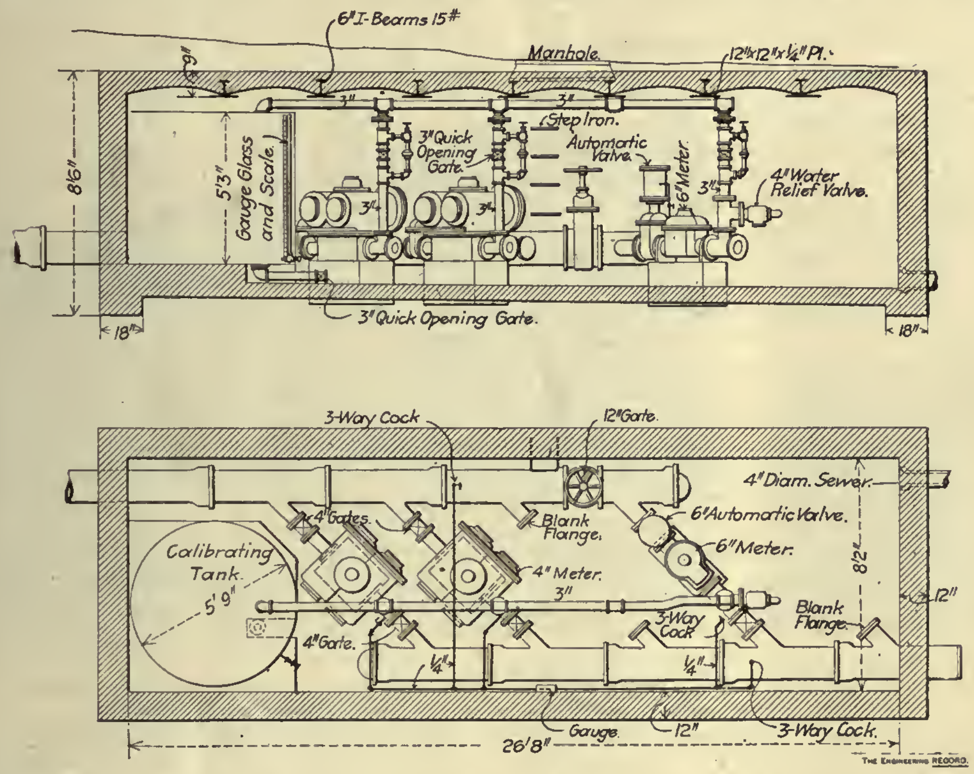
"*Coal Economy with Commercial Load.*—When one of the turbines, carrying the commercial load of the station, which averaged 253.2 kilowatts, or about half load, was operated independently with one of the boilers, the boiler being fed through the economizer by one of the steam pumps of the station, taking steam from the same boiler, the superheater being out of service, the total consumption of dry coal for all purposes on a 15-hour run amounted to 2.5 pounds per kilowatt-hour, and the cost of this coal at $4.05 per ton of 2,240 pounds was 0.47 cent per kilowatt-hour."

Summary of Commercial Runs.

	Jan. 15,	Jau. 26,
Duration, hours	12.22	15
Total coal wet, lbs................	13,517	10,206
Moisture in coal, per cent.........	3.1	6.4
Water evaporated, lbs..............	127,267	102,846
Drip withdrawn from steam pipe per hour, lbs..................	....	46
Moisture by calorimeter, per cent...	3.05	2.1
Total steam to turbine, lbs........	110,084	86,833
Steam per hour to turbine, lbs.....	9,008.6	5,789
Dry steam per hour to turbine, lbs.	8,733.8	5,667
Load by polyphase meter, kw......	407.0	234.7
Load on auxiliaries (average), kw..	14.9	18.5
Total load average, kw............	421.9	253.2
Dry steam per kilowatt-hour, lbs...	20.7	22.38
Dry coal per kilowatt-hour, lbs....	2.54	2.51

A Meter Plant with Automatic Metered By-Pass.

A meter installation of more than ordinary interest has recently been put in by the city of Webster Groves, Mo., under the direction of Mr. William H. Bryan, consulting engineer, St. Louis, from whom the following information has been obtained: Webster Groves is situated just west of St. Louis. While the distance between the passenger stations on the Missouri Pacific and 'Frisco Railroads is about eight miles, the space separating the western limits of St. Louis from the eastern limits of Webster Groves is only about a mile. Webster Groves is wholly a residential city, made up of large places owned principally by persons doing business in St. Louis. The population is about 5,000; area, four square miles; length of opened streets, about 40 miles. The topography is rolling, with elevations varying between 80 feet and 225 feet above St. Louis City directrix (ordinary high water in the Mississippi river). There is a rise westward of about 80 feet between the passenger stations of the two cities.



Plan and Sectional Elevation of Water Meter Station at Webster Groves, Mo.

The growth of this city has long been retarded by the scarcity of good water, no supply being available near at hand. In 1902 a contract was entered into with a company which proposed to build a pumping plant on the Missouri river, some 16 miles distant by air line. This company also secured contracts for a number of other municipalities in St. Louis County, and has since put in a system of machinery, basins, filters and mains, by which the water is delivered to each municipality at its city limits. The length of pipe line necessary to reach Webster Groves is about 20 miles.

It being impracticable to use fire engines, it was necessary to secure fire protection by direct pressure from the distributing mains. This made it imperative that the friction losses be reduced in every possible way, so as to provide maximum pressures at all points on the pipe line system. The latter was put in by the city, and was some ten miles in length, being 12, 10, 8, 6 and 4 inches in size, with 77 double-discharge fire plugs. The city's requirements for water were in many respects peculiar. Practically the entire demand came from residences; there is not a factory, steam boiler, railroad tank nor office building in the city. From midnight to morning the consumption would be very small.

The contract between the city and the supplying company provided for the measurement of water by meters of mutually satisfactory type, provided with approved calibrating apparatus. When the design of meter plant was taken up some apparently insurmountable obstacles were encountered. The city desired the meters to be of such a type as would interpose the least resistance at maximum flow of water for fire streams. The company insisted that they be of a pattern that would register accurately the minimum flows between midnight and morning. A delay lasting several months resulted, during which time correspondence was had with all the leading meter manufacturers of the country. Investigation showed that those meters which interposed the least resistance at large flows were not accurate at small flows, while those meters which were accurate over a wide range of capacity interposed resistance which would have killed the pressure for fire purposes.

A solution was finally reached by the adoption of an automatic valve proposed by Mr. J. A. Tilden, general manager of the Hersey Manufacturing Company of South Boston, Mass. The final approved design is shown in the accompanying sketch.

A meter house of concrete, with steel I beams in the roof, was built under the street level. In this the 12-inch main made an offset. On cross lines, set at 45 degrees, in order to reduce friction, were placed openings for five meters, three 4-inch—two to go in now—and two 6-inch—one to go in now. The two 4-inch meters were of the Worthington type, selected on account of their accuracy over a wide range of flows. The 6-inch meter is of the Hersey "Torrent" type, selected on account of its low resistance and accurate registration at high flows. On the inlet side of the Hersey meter was placed the 6-inch automatic valve, built by the Hersey Manufacturing Company, of the type described in The Engineering Record, October 31, 1903. This valve consists of an ordinary double-seated gate with its stem extending into an upper bronze cylinder, in which it is connected to a weighted brass piston provided with leather cup packing. From the inlet side of the valve there is an opening into the upper cylinder underneath the piston. From the outlet side a connection extends into the space above the piston. This valve is so arranged as to open at any desired predetermined difference of pressure, in the present instance five pounds. So long as the pressure is the same on both sides of this valve, the weight of the piston and valve keeps it closed. When a difference of pressure occurs the reduced resistance above the piston causes the valve to open.

In practice the operation is as follows: All ordinary consumption passes through the Worthington meters and is accurately registered, the Torrent meter being stationary. When a large demand for water occurs, as for instance when a fire hydrant is opened, there follows a drop of pressure, which, if it reaches or exceeds five pounds, opens the automatic valve, and such additional water as is needed passes through the Torrent meter, the difference in pressure being held at five pounds. When the pressure returns to normal by the cessation of the large demand—by the closing of fire hydrants for instance—the automatic valve closes, and the ordinary flow is again through the two 4-inch meters.

Other interesting points about this design are the provision for future meters, the construction of a calibrating tank and connections, the relief valve and the drain to the street gutter. There is a pressure gauge so cross connected as to permit readings from both sides of each meter, to approximately measure losses of pressure. The pressure carried at this point is about 97 pounds, which will throw fire streams over ordinary buildings anywhere on the lines. No strainers are provided in front of the meters, as the water has been settled and filtered. The registers are of the direct type, reading in gallons, this system being employed also on all consumers' meters throughout the city.

Shady Avenue, on which the plant is located, has a considerable down grade eastward, permitting the drain to discharge at street level a short distance away. The location under the street is unfortunate, but no other plan was practicable. The plant has now been in service some six months, and has given entire satisfaction.

The Boiler Plant of the power station of the Cleveland & Southwestern Traction Company, at Carlisle, O., includes three 500-horse-power Heine water-tube boilers, each having a Schmidt superheater superimposed on it and forming part of the setting. There are dampers by which the amount of gases allowed to flow through the superheater may be regulated. There are also openings in the side walls of the boilers leading from a point near the bridge wall to the superheater, so that the hot gases may be taken directly. Each superheater is designed to give 75 degrees of superheat.

What Constitutes Reasonable Uniformity in Municipal Accounts and Reports?—II.

A paper read before the National Municipal League by Mr. F. A. Cleveland, of Haskins & Sells, New York.

Uniformity in Principles of Accounting.—The application of schedules of uniform classification to a complete system of accounts and finally the evolution and statement of principles of uniformity, requires that we first ascertain the categories of classification common to municipal accounting. Accounts being devised as an aid to clear thinking about the affairs of a city, the discernible uniformity that may exist must have reference to the elements of common interest in administration.

As before suggested we have to deal with a corporation, a legal entity with sovereign powers and proprietary rights, the purpose of whose creation is to render service to the community, but which can exercise powers only through officers and agents equipped with the physical means necessary to make them effective. This corporation, therefore, so far as its business is concerned, has two distinct relations, the one being with respect to its own proprietorship (its assets and its liabilities), the other being the business aspect of its operations (the corporate income and expenses).

Reflecting these two relations, there have grown up two distinct systems of account, either of which may be used, and either of which may be complete. The most primitive of these is what is known as a single entry system; it attempts to exhibit in form of final statement one relation only, that of Asset and Liability. That is, in a single entry system of account, its final summaries are set up in what is known as a balance sheet, or an exhibit of present proprietary conditions. The other, known as the double entry system, attempts not only to state relations of asset and liability, but also to give a classified summary of operations. Before we attempt to outline a scheme of uniformity of accounting, therefore, it is necessary to decide as to which of these two systems of account will be used. And this in turn must again be decided by appeal to corporate purposes.

Administrative Problems Common to Municipalities.—What are the administrative interests common to municipalities? Are statements reflecting corporate conditions in terms of asset and liability sufficient? What are the problems about which both electors and responsible municipal officers must exercise discretion? Generally speaking, there are two classes of administrative problems pertaining to the management of every public corporation: (1) The citizen, in his judgment of the administration, and the controlling officer, in the performance of his duty, wish to know whether or not the corporation, as an agent of general welfare, has rendered the best service of which it is capable at the least possible cost; (2) and, it being necessary as a corporation to own properties and intrust its funds and equipment to its officers and agents, all parties in interest desire to know whether or not this proprietorship has been protected against misuse and infidelity of officers. To supply the data essential to intelligent judgment, therefore, a complete double entry system of accounts is necessary.

From this we may proceed to a consideration of the essentials common to a double entry system. Accounts being a method of collecting, classifying and co-ordinating business data, we look to the adequacy of means. A complete system of accounts would require that every transaction be recorded. This should be done by the person in charge if possible, at least by the bureau or department, in which the transaction arises. A chronological record of events kept in each department, however, could be of little use to anyone. To utilize this record and to adapt it to the purposes of control, the various transactions must be classified, and having been classified, they must then be brought into statements of final account in a central office. Both the "original entry" and the first "classification" must take place in the department; from this the classified result is reported to the central office. The items contained in this classified report must be "posted" to the central or controlling accounts. The classification of controlling accounts, therefore, must determine the classification of the detailed transactions of departments.

We now come to the classification of the controlling accounts. These being organized around the two general administrative categories, viz.: "Municipal proprietorship" and "municipal economy," within these two general categories there are also some common interests which require uniformity in statements. The relations of economy are determined, (1) by comparison of expenses with income provided and (2) by comparison of expenses with the statistics of service performed. This not only introduces us into the categories of expense and income, but also into the other branch of the Committee's investigation, viz.: physical and operative statistics.

Common Classification of Income and Expenses.—Confining ourselves to the accounting side of the problem, all cities derive their income for the support of government from about the same sources, viz.: from taxes, licenses, and miscellaneous fees of departments, etc. Organizing accounts of income accruing for the use of a city during a fiscal period according to sources, we have a common basis for the classification of revenues. Statements of taxes are taken from the tax levies; licenses may be taken from license register; and the miscellaneous fees, etc., are reported from the several bureaus and departments. For the statement of miscellaneous revenues, the schedules of the League would form a common basis for classification. The expenses are also recorded in the office of the Comptroller in the form of expense vouchers, etc., or are reported from the department. Here again the schedules of the League, based on administrative relations common to municipalities, may serve as a guide; and such a classification would be of the highest utility, it may even be said, is absolutely necessary to getting at relations of economy of administration when reduced to cost of units of service by comparison with the operative statistics.

Common Basis for Classification of Asset and Liability Accounts.—One of the most important proprietary relations of a public corporation and one which involves a problem most serious to the officer as well as the citizen, is that of ability of the government to meet its maturing obligations. A proper accounting of this relation requires a classification of assets and liabilities in such manner that the properties intended as equipment, or for continued use in the business, may be segregated and set apart from assets to which the city may look as a means of payment. Quite as important, also, is a classification of liabilities in such manner that the current or maturing liabilities may be distinguished from those long time obligations that are not a current charge. These relations having been set up, judgment as to the ability of the government to meet its maturing obligations requires that the current liabilities be compared with the assets available to meet them. The classification of the current asset and liability accounts should be similar in the accounts of cities, for the reason that the assets are derived from similar sources, and the contractural and legal liabilities are similar in kind. If such comparisons are to be made, therefore, there must be uniformity in the general controlling accounts of current asset and liability.

The long time liabilities are usually incurred for purposes of equipment or permanent improvement. The general classification of equipment used by the cities being the same, uniformity in the controlling accounts, both of bonded debt and of the permanent asset accounts, follow, and in the schedule of the League may be found a common outline as well as a common nomenclature. In conclusion, it may be said that whatever be the difference in forms of records used for "original entries" of transactions in the various bureaus and departments, common administrative interests and purposes of control would suggest a common classification of the general controlling accounts of municipalities, not primarily as a means of bringing the records of one city into comparison with those of another, but as an essential to enlightened conduct of its own affairs.

Departmental Accounts Showing Relations of Fidelity.—We turn now to the accounts of special officers and departments, in which the prime purpose is to insure official fidelity. Aside from the fact that a department record is an integral part of a general system, and for this reason the truth of departmental records is essential to intelligent controlling summary, the officer entrusted with properties or funds must also render an account of his stewardship. One of the most important of these departmental records reflecting relations of fidelity is that kept of the municipal treasury. So far as the general asset and libaility statement is concerned, no return is needed except that of "balances on hand;" to this end no classification is necessary except that the "current cash" be returned separate from the "cash obtained from bond sales for permanent improvements," etc. But from the point of view of official fidelity, a statement of "receipts" and "disbursements" should be made which will reflect the transactions pertaining to, and the final condition of each fund kept.

In this, I am somewhat at variance with those who have attempted to use the cash book as the central record of municipal account, and even with the use that has been made of the schedules of the League in many cities; in some of these, receipts and disbursements are reported according to a classification of revenues and expenses, irrespective of Treasury funds created.

Classification of Cash Receipts.—For administrative purposes money received should be shown by the Treasurer in his report according to the sources from which these receipts have been derived. Money is not revenue. Money is an asset. It may be derived from "taxes receivable" or "accounts receivable" or from "judgments receivable," from sales of bonds or other "credit contracts payable," or from the sales of properties. The receipt usually has a direct relation to an asset or liability account. The Treasurer, therefore, in his classification of receipts and for the purposes of making his report, should have direct reference to the sources from which the money came. The common sources of money receipt is the common basis for the one side of the Treasurer's report.

The Classification of Disbursements.—When money is received, it is entered directly to the credit of a fund to which that particular class of receipt has been apportioned, or it goes into the general fund of the Treasury, from which appropriations are made. The books of a Treasury should be kept with respect to the funds created, and the disbursements from each particular fund should be separately stated. These funds are created by appropriation. There is absolutely nothing gained by trying to show on the books of the Treasury the purpose for which a payment is made. This summary is made on the books of the Comptroller in entering up the warrants and vouchers to the "expense" account, or "asset" or "liability" accounts affected. The Treasurer knows nothing about "expenses," "assets" and "liabilities." He knows only "money," "money funds" appropriated, and the order or warrant of a duly qualified officer for the payment of "money." The common basis for uniformity in classification of disbursements will be found, therefore, in the similarity of funds carried as a result of municipal appropriation.

Such may be stated as the common principles which lie at the foundation of any system devised which we, as a Committee, may hope to have adopted by municipalities. Such uniformity as may come into the accounts of cities must come for the same reason that there is uniformity in the human anatomy, or in the conclusions reached by the human mind when reasoning from common premises assumed, it must come as a result of the device adopted being adapted to the purposes and ends of municipal organization and administration.

The Form of Comptroller's Report.—Looking on the problem that confronts the Committee, and recognizing that the character of the accounts must be governed by the Comptrolling purpose, it was thought that the first classification concerning which agreement should be reached is that which pertains to the central or controlling accounts. But since the purpose of the controlling accounts is that of obtaining summaries of results which are needed by citizens and officers in responsible positions, it is esteemed that consideration of the form of statement of the Comptroller's report should be first obtained.

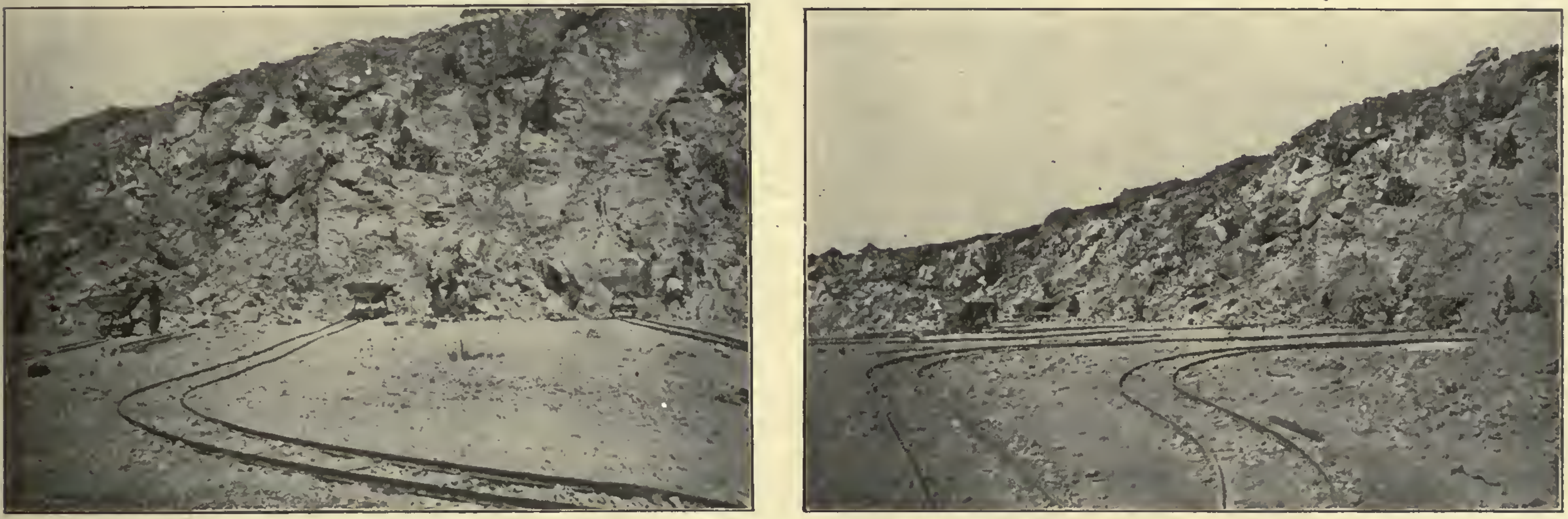
A Refuse Destructor at Burnley, England, was described in a recent issue of the "Mechanical Engineer," of London. With a six days' test the average weight of refuse burned per square foot of grate per hour was 52 pounds, and the average weight of water evaporated per pound of refuse was 2 pounds. The steam pressure averaged 150 pounds, and feed-water temperature ranged from 50 to 180 degrees. A regenerator is used to heat the air for combustion to about 350 degrees, instead of heating feed water. The temperature in the chimney flue beyond the regenerator was 650 to 940 degrees. For a period of about 51 days 1,536 tons were burned, 620,900 gallons were evaporated, an average of 1.5 pounds of water was obtained per pound of fuel and the labor cost of burning was 21.2 cents per ton.

A Quarry Railway.

The accompanying illustrations show a railway recently installed in the quarry of a cement company by Arthur Koppel, of New York. In such quarries it has been found by experience that light, portable tracks have marked advantages over heavier lines, because the men will move them to the faces as shifting is necessary. When the track consists of heavy ties and rails and requires considerable work every time it is changed, the quarry hands are prone to leave it in one place and waste much of their time in handling the stone an unnecessarily long distance. The cut shows how close to the breast the tracks in this particular quarry are kept.

The rails used are 25-pound sections spiked to wooden ties where the line is permanently located, and 16-pound sections on steel ties for the portable track. The latter is made in 250-pound sections which can be moved about without trouble, and is provided with both 9 and 15-foot switches and curves of 12 and 30 feet radius.

In this quarry there are used thirty 1½-yard steel cars dumping to either side. The gauge is 23⅝ inches. They are fitted with roller bearings which decrease not only the traction required to haul them but also the amount of lubricant needed. The bearings are dust proof. These cars have been supplied for many other purposes, both in industrial establishments and on contracting work.



Light Portable Railway Tracks in the Quarry of a Cement Company.

Oil Separation by Electricity has been accomplished by Messrs. Davis & Perrett of London, according to the "Electrical Engineer" of that city. The water is passed through a wooden tank 12 feet long, 30 inches wide and 27 inches deep, and flows in parallel streams through three compartments into which the tank has been divided. The flow of water takes place betweeen iron electrodes, maintained at 50 volts potential between adjacent plates, or 150 volts across the three in series. When the plant was handling 2,000 to 3,000 gallons of water hourly it is said that a reduction of 1.07 to 0.01 grain of oil per gallon was effected with apparently 20 amperes.

The Fuel Cost of Lighting Stations was recently discussed in the "Mechanical Engineer" of London by Mr. W. H. Roy. The average cost of 43 so-called provincial non-condensing stations, irrespective of the relative amount of kilowatt-hours sold by each, was 2.1 cents per kilowatt-hour, and for 59 provincial stations operating condensing was 1.88 **cents.**

Atlantic City Water-Works.

The peculiar location of Atlantic City, N. J., and of its sources of water supply give rise to some unusual troubles, which are mentioned in the annual report of the Board of Water Commissioners. By reference to a general description of the city's water works printed in this journal August 22, 1903, and a map accompanying that article, it will be seen that the whole territory is at an elevation but slightly above high tide level and is exposed to ocean winds.

On April 15, last spring, a hard northeast storm drove the tide back on the meadows to the canal conveying water from the Absecon reservoir to the pumping station, and, although the sides of the several flumes had been hurriedly raised, the salt water overflowed every one of them. The tide water reached nearly to the level of the water in the reservoir itself so that, to avoid their floating off by the back-pressure, it became necessary to nail the waste gates to their seats. The tide gates prevented the inflow of salt water to the canal basin, but the swamp water rose so as to find free access to it. Fortunately, by closing gates at each end of the canal and draining it at low tide, the salt water was kept out of the supply.

During the summer the water department began the raising and strengthening of the reservoir embankment by day-work. This will permit a higher level to be carried in the reservoir and will avoid the danger, that has existed heretofore, of overflowing the embankment during floods. When the improvements are completed the old waste gates will be abandoned.

Analysis of water from the Absecon Creek supply made by Mr. William R. Copeland, chemist and bacteriologist to the Philadelphia water department, showed that the chlorine, free ammonia, and oxygen consumed were rather high for surface waters, but this can be explained very readily. As Absecon lies near the coast, the storms blowing off the sea carry salt inland for several miles and deposit chloride of soda on the watershed. Moreover, the whole territory is evidently an old sea bottom and the sand beneath the soil undoubtedly contains chlorine from that source. In regard to the ammonias and oxygen consumed, it might be said that those tests are made to determine how much organic matter the water contains. And in view of the fact that the water contains a large amount of vegetable matter drawn from the cedar swamp, the ammonias and oxygen consuming material undoubtedly came from that source. So far as the hardness of the water is concerned, it may be said that the water in the canal at Absecon is unusually soft.

In connection with the new driven well supply described in the article previously mentioned, a 4-inch test well was driven.

The most striking feature of the water drawn from the test well, next to its lack of yellow color, lay in the amount of carbonic acid contained. If such spring water is run through lead (and pernaps tin-lined) pipes there is no doubt but that the free carbonic acid in the water would attack the pipe and dissolve out some of the metal. Lead pipe, therefore, should not be used to convey the well water.

Rodents have been a source of annoyance in a number of instances, especially by their digging through the banks of the canal and other earth embankments. The most serious accident from this cause occurred about 8.30 P. M., June 13, when the dam of the Bargaintown mill pond, belonging to the department, gave way, probably due to the burrowing of muskrats near the waste-gates. A gap 46½ feet wide on top and 14½ feet below the level of the roadway at its greatest depth, was formed, entirely draining the pond. As there was no pressing necessity for the use of either pond or road repairs were temporarily deferred.

The 3,000,000-gallon d'Auria pumping engine installed during 1902, in the Absecon pumping station, was officially tested in January last year. A view of this engine was reproduced with the article of August 22, 1903, which also contained a description of it. The following statement of the official trial is taken from the water board's report. The test was made in two parts. In the first, comprising ten hours, the engine was run under conditions approximating those laid down in the specifications. In the second, comprising two hours, the engine was run by the engineer under ordinary working conditions. The following are the essential data and results of the two tests as determined:

	10-hour test.	2-hour test.
Steam pressure — corrected—lbs.	88.6	79.3
Moisture in steam, per cent.	3.5	3.25
Water from condenser, lbs.	19,919	3,488
Water condensed from vacuum pump, lbs.	1,215	163
Water from drips, lbs.	101	21
Water, total, lbs.	21,235	3,672
Steam for feed pumps, lbs.	none	none
Water from separator, lbs.	133	27
Water unaccounted for, lbs.	1,794	441
Water fed to boilers, lbs.	23,162	4,140
Water equivalent of heat to feed, lbs.	1,292	189
Water chargeable to engine, lbs.	19,943	3,483
Temperature water in pump well	....	46°
Temperature to condenser	50°	51°
Temperature of feed	115°	117°
Displacement, cu. ft.	193,936	34,202
Discharge by Venturi, cu. ft.	190,000	33,500
Slip, per cent.	2.02	2.05
Suction lift, measured to plungers, feet	15.4	15.4
Suction, by manometer, feet	15.6	15.2
Pressure, feet	104.0	99.0
Total lift, feet	119.06	114.1
Capacity, gals. per 24 hours	3,411,000	3,007,000
Duty per 1,000 lbs. steam, foot pounds	71,100,000	68,500,000
Duty corrected for 3½ per cent. moisture in steam	73,679,000	70,984,000
Horse Power—Steam End	91.5	77.3
Water End	78.2	65.9
By gauge pressure	73.1	60.0
Efficiency—Steam End, per cent.	85.4	86.3
Water End, per cent.	93.6	91.1
Total, per cent.	80.0	78.6
Steam per H. P. hour, lbs.	21.8	22.54
Steam per H.-P. Hour accounted for by cards, lbs.	15.2	14.68
Loss by condensation and leakage, per cent.	30.3	35.0

Feed water was measured by passing through three ⅝-inch Trident meters in tandem. All water from condensers and drips was weighed and the moisture in steam was measured by a throttling calorimeter. Mr. Kenneth Allen is the engineer and superintendent of the Atlantic City water works.

A One-Car Street Railway, owned by the State of North Dakota at Bismarck, transports the members of the Legislature to and from the Capitol.

Discussion of Published Data on the Thermal Efficiency of the Rotary Kiln, and Possible Reduction of Fuel Requirement.

By Henry S. Spackman, M. Am. Soc. M. E.

Does the minimum consumption of fuel in the rotary kiln now obtained in good practice, i. e., 85 to 95 pounds of coal per barrel of cement produced, represent the maximum working efficiency of the kiln? Or can the thermal efficiency be increased, either by a modification of its general proportion and detail, increasing the ratio between the length and the diameter and reducing the air admitted to the kiln, thus utilizing in the kiln itself a greater proportion of the heat generated, or by the recovery of and utilization, outside of the kilns, of the heat now carried off by the waste gases and discharged with the clinker, crediting the amount of heat so saved to the fuel consumption of the kiln?

Unfortunately, in considering this question, few data are available. During the past ten years upward of 45,000,000 barrels of Portland cement have been produced in the rotary kiln, yet we have to-day practically no definite knowledge of what actually occurs inside the kiln. The various steps in the process by which the raw material, consisting principally of carbonate of lime, silica and alumina, is transformed into a homogeneous clinker, are largely matters of surmise.

What are the temperatures actually produced in the different parts of the kiln, and what are the temperatures actually required? What is the amount of heat given off by the chemical combination of the lime with the silica and alumina? By what successive steps is the heat utilized? In what form and manner are the chemical elements combined in the clinker itself? None of these questions can be definitely answered, and any theoretical calculation of the thermal efficiency of the rotary kiln must be largely based on hypothetical assumptions.

Yet, with each kiln installed, the cement maker in practice must answer these questions, and to aid in making this decision, what data are available. The papers known to the writer treating of this subject can be counted on the fingers of one hand, and of these, three only bear directly on the subject under consideration, two of which are of very recent date. The papers referred to are: "Fuel Consumption in Portland Cement Burning" by S. B. Newberry, "Cement and Engineering News," July, 1901. "The Thermal Efficiency of a Rotary Cement Kiln" by Jos. W. Richards, "The Journal of the American Chemical Society," January, 1904. "Test of a Process for Utilizing Waste Heat from Rotary Cement Kilns" by R. C. Carpenter, "Sibley Journal of Engineering," March, 1904.

Prof. Newberry's paper is based on theoretical calculations and assumptions only; Dr. Richards' on a test made by him of a rotary kiln in the plant of the Dexter Cement Company, Nazareth, Pa.; and Prof. Carpenter's on a twelve-hour test of two kilns in the works of the Cayuga Lake Cement Company, near Ithaca. As indicated by the title, Prof. Carpenter's test was intended primarily to determine the efficiency of the boilers attached to the kilns, but it contains valuable data on the thermal efficiency of the kiln itself, and it is with this portion of the paper that we have most to do. Unfortunately, in their original form, these papers, a general summary of which will be found in Table 1, are not readily comparative, different units having been taken by each author as a basis for calculating the work done, and the results are stated in different terms; Prof. Newberry using as a basis for his calculations 600 pounds of raw material; Dr. Richards 100 kilogrammes of coal burned, equaling in his case two barrels of cement; while Prof. Carpenter uses one hour's run of two kilns.

In Table 2 will be found the results given in Table 1 reduced to a uniform basis of British thermal units required to produce one pound of clinker.

TABLE 1.—GENERAL SUMMARY OF PAPERS BY NEWBERRY, CARPENTER AND RICHARDS.

	Richards.	Carpenter.	Newberry.
Analysis of Clinker.			
Silica	21.27	19.92	23.4 b
Aluminum oxide	6.42	8.22	7.8 b
Ferric oxide	3.18	3.34	
Calcium oxide	66.70	63.34	65.6 b
Magnesium oxide	2.43	2.38	.7 b
Analysis of Coals.			
Moisture	0.60	2.19	1.40
Volatile combustible matter	38.10	32.90	89.80 b
Fixed carbon	53.24	54.66	
Ash	8.06	10.25	8.80 b
	Calories.	B. T. U.	B. T. U.
Theoretical heating power per lb. of fuel	7,900	14,022	13,400
General Data.			
Size of kiln	6x60′	7′ & 5′ 6″x60′	a
Production per hour in lbs. of clinker	3,635	8,018	a
Pounds of coal used to produce one barrel of cement, 380 lbs.	110	89	71.7
Temperature of waste gases in stack	820°C	1,820°F	1,500°F
Temperature of air entering kiln	250°C	480°F	60°F
Temperature of clinker leaving kiln	1,200°C	2,500°F	2,500°F
Air supplied to kiln in excess of theoretical requirements for complete combus. of coal	132%	48%	Th'retical
Summary of Tests.			
Heat supplied to kiln—	Calories.	B. T. U.	B. T. U.
Heat in air entering kiln	100,000	2,041,000	a
Theoretical heat from coal burned in kiln	790,000	26,450,000	960,780
Heat of combination of the ingredients forming clinker	142,819	2,880,000	a
Total heat supplied to kiln	1,032,819	31,371,000	960,780

Approximate distribution of heat—

	Richards. B. T. U.	Carpenter. B. T. U.	Newberry. B. T. U.
Heat in clinker	100,050	4,409,540	228,000 b
Heat in chim. gases	676,000	14,859,859	356,298 b
Heat in flue dust.	2,112	a	a
Loss by imperfect combustion	12,248	0.00 c	a
Evap. of water	1,446	303,200	20,832
Expulsion of carbon dioxide from carbonates	182,690	6,789,375	344,250
Decomposit'n of sulphuric anhydride	a	238,140	11,340
Loss by radiation, conduction, etc.	58,273	4,770,886	a
Total heat accounted for	1,032,819	31,371,000	906,720

Note.—"a" indicates item not considered; "b" indicates item figured from data in paper quoted. Dr. Richards uses 100 kilogrammes of coal as basis for his calculations, equal in his case to two barrels of cement, and all heat measurements are given in kilogramme calories. Prof. Carpenter uses one hour's run of two kilns as the basis of his calculations, and Prof. Newberry one barrel of cement, both giving heat quantities in British thermal units. Figures given do not in all cases correspond to those given in original publications, having been subject to correction by the authors.

"c" No CO in flue gas.

Disregarding the heat recovered from the clinker, or generated by the chemical combination of the materials, and considering only the heat supplied by the fuel, a study of these tables shows that with the admission to the kiln of only the amount of air theoretically necessary for combustion, and a stack temperature of 1,500 degrees Fahr., 2501.6 B. T. U. are theoretically required to calcine one pound of Portland cement clinker of the analysis given, of which 1573.8 B. T. U. or 63 per cent. of the total number are expended in useful work, of which 593.7 used in heating material and discharged with clinker are largely recoverable, the remaining 927.8 B. T. U. or 37 per cent. being carried off by the waste gases, showing a theoretical efficiency of 63 per cent. for the kiln. Prof. Carpenter's test, made under conditions of actual manufacture, shows a working efficiency of 44 per cent. of heat from fuel, 1464.1 B. T. U. being utilized for useful work. In comparing these results it must be remembered that Prof. Newberry's calculation is based on the admission to the kiln of only the theoretical amount of air required for the combustion of the fuel, a condition hardly obtainable in practice, and that no allowance is made by him for such unavoidable items of loss as radiation, conduction, incomplete combustion, etc. With the admission of 1½ times the theoretical amount of air, using otherwise the same figures, the theoretical requirements, as given by Newberry, would be 88.2 pounds per barrel of cement, checking very closely with the figures obtained by Prof. Carpenter with 48 per cent. excess air of 89.4 pounds.

TABLE 2.—A REDUCTION OF TABLE 1 TO A COMPARATIVE BASIS OF BRITISH THERMAL UNITS PER POUND OF CLINKER.

Heat Supplied to Kiln Per Pound of Clinker.

	Richards. B. T. U.	Carpenter. B. T. U.	Newberry. B. T. U.
Heat in air entering kiln per pound of clinker..	521.6	254.5	a
Theoretical heat from coal burned in kiln per pound of clinker.....	4,121.6	3,298.8	2,502
Heat of combination of the ingredients forming 1 pound of clinker per pound of clinker produced	745.	359.1	a
Total heat supplied to kiln per pound of clinker	5.388.2	3,912.4	2,502

Distribution.

	Richards. B. T. U.	Carpenter. B. T. U.	Newberry. B. T. U.
Heat in one pound of clinker discharged from kiln	522.	549.9	593.7
Heat in chimney gases per pound of clinker produced	3,526.9	1,853.3	927.8
Heat in flue dust per pound of clinker produced	11.	a	a
Heat lost by imperfect combustion per pound of clinker produced.	63.9	0.0	a
Heat used in the evaporation of water per pound of clinker produced	7.5	37.8	54.2
Heat used in the expulsion of carbon dioxide from carbonates necessary to produce one pound of clinker	952.9	846.7	896.4
Heat used in decomposition of sulphuric anhydride per pound of clinker	a	29.7	29.5
Heat lost by radiation and conduction and in other ways not considered	304.	595.	a
Total............	5,388.2	3,912.4	2,501.6
Coal used in pounds per pound of clinker.	0.289	0.234	0.188

Comparing the results obtained by tests of the kilns under actual working conditions, and considering the different analyses of the raw material, we find they check closely with the exception of heat lost at stack, and this wide variation is explained by the great difference in the quantity of air entering the kilns. Considering only the heat generated by the combustion of fuel, and disregarding that recovered from the clinker or generated by chemical action, we find that from 12 per cent. to 17 per cent. of the heat generated by the fuel is discharged with the clinker after it has done actual work, and 56 to 85 per cent. with the waste gases; the latter, in the rotary kiln as usually installed, is a total loss.

In the past year or two there has been an endeavor to utilize this waste heat to a greater extent in the kiln itself, by increasing the length of the kilns. Since the writer's connection with the cement business, he has watched with interest the change in practice affecting the length of the kilns. The rotary kilns first installed, designed for burning crude oil, were from 30 to 40 feet in length, and these were gradually increased both in length and diameter, some kilns 5 feet in diameter by 80 feet in length being installed for the wet process. With the general adoption of powdered coal as fuel between 1898 and 1899, practice settled down to a 6x60-foot or 7x60-foot kiln as the standard. Then came a slight reaction in favor of the shorter kilns, some plants being equipped with kilns 6 or 7 feet in diameter and 40 feet in length; these represented the extreme reached by the advocates of the short kilns. Now the pendulum is swinging in the opposite direction, a powerful impetus having been given it by the installation in the works of the Edison Portland Cement Company of kilns 9 feet in diameter and 150 feet long, and most of the works now building, or recently built, have installed kilns running from 80 feet to 100 feet, Edison still holding the record with his 150-foot kilns.

Accurate statements of the results obtained by this increase in length are not available, cement manufacturers generally objecting to making public the results obtained, fearing that the publication would result to the advantage of their competitors. The general impression is that a large increase in production coupled with some reduction in fuel consumed has resulted from this increase in the length of kilns.

It is, however, a question whether this claimed economy in fuel consumption is not due to the reduction of excess air entering the kilns as well as to increase in length. With the increase in the size of the kilns, and a larger production, a greater amount of fuel is burned in the kiln per hour, with little or no increase in the size of the openings through which the air enters the kiln. As is shown plainly by the tables, a reduction of the amount of air entering the kilns in excess of that required for combustion is followed by a decrease in the coal consumed per barrel of cement produced. A decrease of excess air from 132 per cent. to 48 per cent. showed a saving of about 20 pounds in coal used per barrel of cement produced. A reduction of the excess air admitted to the kiln to the lowest point at which perfect combustion can be obtained should show further savings. The length of the ideal rotary kiln would be theoretically that at which the waste gases leave the kiln at the temperature at which they cease to do energetic work, as any increase in length beyond this point would only act in cooling the gases. What this length should be to discharge the gases at 400 degrees Fahr., the temperature assumed for the following calculation of coal consumption is a matter of conjecture, but would probably be between 120 and 150 feet.

Assuming the raw material to be 14.75 silica, 6.25 iron and alumina, 73.21 carbonate of lime, 2.10 carbonate of magnesia, 0.60 sulphur, 1.00 alkali, and 2.00 water, and the coal to contain moisture 1.4, total carbon 75.0, hydrogen 5.0, oxygen 8.0, nitrogen 1.0, sulphur 1.6, ash 8.0, having calorific value of 13,400 B. T. U. per pound of coal, and the kiln to be of such length that the gases are discharged to the stack at a temperature of 400 degrees Fahr., with air supply of 25 per cent. in excess of the theoretical air requirement, approximately the theoretical heat consumption would be as follows:

	B. T. U.
Heating 0.03 lb. water 60° to 400°...........	37.4
Heating 1.53 lb. mix, 60° to 1,500°, at 0.22..	484.7
Decomposing 1.14 lb. carbonate of lime, at 765.	872.1
Decomposing 0.032 lbs. carbonate of magnesia at 383	12.2
Decomposing 0.009 lb. sulphur at 1890.........	17.0
Heating 1 lb. mix (1.56 minus 0.56), 1,500° to 2,700° specific heat, 0.246 (Richards).....	295.2
Heating 0.52 lb. carbonic acid gas, 60° to 400°, at 0.24	42.4
Heating products of combustion, 2.30 lb., 60° to 400°, at 0.246..........................	192.3
Heat lost by radiation..........................	297.5
Total..................................	2,250.8

The result is equivalent to 0.168 pounds of coal of the analysis assumed per pound of cement produced, or 63.8 pounds per barrel of cement. If 50 per cent. excess air was admitted to the kiln, which represents the best practice of to-day, the coal consumption would be 0.170 pounds per pound of cement produced, or 64.6 pounds of coal per barrel. Loss through radiation, etc., used in this calculation was assumed at 50 per cent. of that found by Prof. Carpenter, the reduction being made on the assumption that improvement in detail of the kiln would reduce this loss.

Considering next the taking of the waste gases from the kiln at a high temperature, and utilizing them for the generation of steam in the boiler, we find by using the same general calculations, but assuming the waste gases to be discharged at a temperature of 1,500 degrees that the theoretical heat requirements would be 3,470.6 B. T. U., equivalent to a coal consumption of 0.259 pounds per pound of clinker produced, or 98.4 pounds per barrel of cement, and that the waste gases would carry to the boilers 1,259.0 B. T. U. per pound of clinker, which, with a production of 3,800 pounds of clinker per hour, or ten barrels of cement, would equal 4,784,200 B. T. U., which would be equivalent with 70 per cent. efficiency in the boiler, to 100 boiler horse-power, equal with an evaporation of ten pounds of steam per pound of coal to a saving of 300 pounds of coal, which, if credited to the kilns, shows a coal consumption of only 68.4 pounds.

With 50 per cent. air admitted to the kiln, 3,872.6 B. T. U. would be required per pound of clinker, equal to 0.289 pounds of coal per pound of clinker, or 109.8 pounds per barrel of cement. The waste gases would carry to the boiler 1,661.0 B. T. U. per pound of clinker, which, with a production of 3,800.0 pounds of clinker per hour, would be 6,311,800 B. T. U., equal at an efficiency of 70 per cent. in the boilers to 133 horse-power, which, at 3.0 pounds of coal per boiler horse-power, would equal 399.0 pounds of coal to be credited to the kiln, or 69.9 pounds of coal per barrel of cement produced.

Prof. Carpenter, in his paper, gives the following results from a test of an installation of a 300 horse-power vertical boiler, arranged to take the heat from two 7 and 5½ x 60-foot rotary kilns:

Cement produced per hour in two kilns, 21.2 barrels.

Coal burned per hour in two kilns, 1,889 pounds.

Temperature of feed water, 212 degrees.

Dry coal used in boiler per hour, in addition to waste gases, 652 pounds.

Water per hour from and at 212 pounds, 14,034.

Boiler horse-power developed, 406.8.

From the data obtained by this test, Prof. Carpenter calculates that 264 boiler horse-power was produced from the waste heat, which would be equivalent with an allowance of three pounds of coal per boiler horse-power, to a saving of 792 pounds of coal, which, if deducted from the 1,889 pounds per hour burned in the kilns, would show 1,097 pounds of coal used to produce 21.2 barrels of cement, or 51.7 pounds of coal per barrel of cement, showing apparently a greater economy obtainable by the recovery and utilization of the heat in the waste gases of the kiln, than by increasing the length. The much greater economy obtained by Prof. Carpenter's test of an actual working installation, over the calculated, is explainable by the fact that heat generated by chemical combination and recovered from the clinker, has been entirely disregarded in these calculations. Richards found this to equal 30 per cent. of the heat generated by the combustion of fuel, and Carpenter 18 per cent. These calculations are largely approximate, and valuable only for purposes of comparison, and not as representing accurately the heat consumption in the kiln, and apply only to the dry process. Any variation in the analysis of the raw materials or the calorific value of the coal affect considerably the fuel requirement, and the specific heats used in the calculations are probably erroneous, being mostly determined for lower temperatures than those occurring in the rotary kiln.

Nor must it be supposed that the only thing necessary to secure the economies indicated is to increase the length of the kiln, or install boilers at the stack, for it is more than probable that numerous difficulties will be encountered in operation. However, the possible economy appears great enough to warrant the expenditure necessary to secure it, and while more or less disappointment may be the lot of the pioneers, an increase in length of the kiln, or the installation of boilers to recover the waste heat, even though not perfect in detail, should result in considerable economy.

In conclusion, the writer wishes to express his appreciation of the courtesy of Profs. Carpenter and Newberry, and Dr. Richards in furnishing data in addition to those contained in their papers, and to express his indebtedness to Dr. E. W. Lazell for his assistance in preparing this discussion.

Practical Points in Sewage Disposal Works.

Much research work of great value relating to the purification of sewage has been done in this country, especially by the engineers, bacteriologists and chemists of the State Board of Health of Massachusetts. English sanatarians, however, seem to hold a prominent place in this line of investigation at present, as, indeed, they have for a number of years, and they seem now to be the leaders in the practical construction and management of disposal works. The more urgent necessity for rendering sewage at least inoffensive before turning it into their streams, doubtless accounts for this to a considerable degree. In a paper before the Society of Engineers, not long ago, Mr. Henry C. H. Shenton discussed the latest practice in sewage disposal, particularly from the point of view of the engineer. The following paragraphs are extracted from his practical and interesting review of the field:

There are two main stages in the process of sewage disposal which, whatever may be said to the contrary from a theoretical standpoint, are practically at the present time quite distinct, except in exceptional cases. The first of these stages is the removal of sludge from the sewage, and the second is the final purification of the sewage or effluent, and it is quite distinct from the first stage. Probably this is rank heresy from the chemist's standpoint. It is well known, for instance, that a considerable amount of purification may take place in a septic tank. Practically speaking it will be of assistance to regard the two steps as distinct from each other, as, however useful the purification which takes place in a septic tank may be, no one would think of using one if it were not for the fact that it will liquefy sludge.

The author has made a careful study of existing sewage works in many parts of England, and it has led him to the conclusion that each and all of the systems he has mentioned have their uses, and it is not too much to say that they have all produced good results in certain cases.

Turning to details, the author thinks the septic tank needs most consideration as regards the methods for the first stage of sewage purification. The best methods of precipitation have been well thought out long ago, and are not generally economical or so suitable for ordinary works. The septic tank is used as a preliminary for land treatment, for filters, for contact beds, or for continuously aerating filters, and has to a great extent replaced the older methods, being more economical and a much better preliminary for the aerobic action to follow. There is not the slightest doubt, whatever prejudice one may at first have had against the septic tank, that it is practically a most useful, and even indispensable, part of the greater number of the smaller sewage works recently constructed. It is only fair to state that the idea that a large mass of putrid sewage kept in a tank would be very objectionable does not seem to have been borne out in practice. Where a septic tank is not disturbed, there is practically no smell. An ordinary sewage screen or open channel full of crude sewage at the top of the works will generally smell much worse than any septic tank. This fact will be obvious to any unprejudiced person who inspects many works. The remark does not refer to plain open tanks, which are sure to be disturbed by the wind at times, and are, therefore, not to be recommended.

In the author's opinion the dimensions and details of construction of the septic tank need careful consideration by the engineer. At most places the depth does not exceed 7 feet, but the author is of opinion that it is possible that the depth of 7 feet might be increased with advantage. It is very evident to him that 7 feet is near the minimum depth for a septic tank, especially if that tank is only lightly covered. In such tanks the scum may at times be, say 3 feet thick, and 2 feet or 3 feet of sludge may also accumulate, which would reduce the capacity of the tank to practically nothing. There are, however, plenty of instances of tanks filling up in this way and recovering, and almost the whole of the solid matters in sludge and scum have been liquefied. If, however, the tank were, say, 6 feet deep or less, it would probably have had to be emptied, simply because it had suffered from a temporary fit of indigestion, and this would have been of no account if it had been deeper. If, for instance, it had been 10 feet deep, there would have been still 4 feet of liquid between the sludge and the scum.

Perhaps the most general practice at sewage disposal works has been to turn the old chemical precipitation tank into a septic tank; such a tank is often 5 feet deep at the inlet end and 4 feet 6 inches deep at the outlet end. The first thing done has been to simply let the sewage run through it without any scum board or trapped outlet. Any amount of solid matter has come out with the effluent, but a great deal has been liquefied also by the septic action, with the result that the amateur engineers of the district have been much pleased at the successful application of theoretical principles, and that a certain definite saving has been effected by getting rid of the sludge difficulty. The contact beds or filters, however, have later on become clogged, and the contact bed principle has been severely blamed in consequence. Later on the septic tank—falsely so-called—has been found to be sludged up, and has had to be emptied, and the district councillors of the place where such occurs will tell you that engineers have still a great deal to learn on the subject of sewage disposal.

Such a tank is altogether too shallow, and there is no cover to keep it from smelling or to prevent the wind breaking the scum. The inlet pipe may break up the scum to any extent, and the scum may go off freely at the outlet. It is an open cesspool, pure and simple. It is a little improved by the addition of scum boards, but these scum boards are very often far too shallow to prevent scum being given off. It would be very much better if the scum board or outlet pipe were carried down to the middle of the tank, where about 18 inches of scum and the same amount of sludge may accumulate in the tank without solids passing away in the effluent. But the tank will never be a good job unless it has sufficient depth; this depth the author thinks should be at least 7 feet. This will allow for the various changes which take place in a septic tank, and a liquid effluent, free from solids, will be the result, even if the scum is occasionally 3 feet thick, and the sludge also 3 feet thick.

The author had on one occasion to remodel some sewage disposal works, where the old chemical precipitation tanks were re-used, to form a septic tank, where the depth at the outlet was 7 feet 6 inches. After producing a liquid effluent for sixteen months the whole of the sludge at the bottom of the tank suddenly began to ferment violently, and formed such a thick scum for a few days that solid matters were given off at the outlet. During this action there was practically no sludge at the bottom. If the tank had been made deeper this temporary inconvenience would not have been experienced.

In the author's opinion the best form of tank under ordinary conditions is one covered with a light roof. If the tank is roofed with brickwork or concrete, and is not carefully ventilated, it seems that there is danger from gas exploding inside. Such cases have occurred, and lives have been lost in consequence.

It should not be necessary to empty the septic tank often. Mr. Strachan, in his evidence given before the Royal Commission, said he estimated that septic tanks filled up at the rate of about one-sixth of their capacity per year. This represents what should happen. It ought to be possible to arrange a tank in such a way that nothing but the humus, or black matter left after the sewage has been dealt with, is removed from the tank. Obviously it is wrong to take out organic matter which, if left in the tank, would be liquefied by natural processes, and the author takes it that Mr. Strachan considers that humus will accumulate in a well-designed tank at the rate of one-sixth of its capacity per year. This may be rather an ideal state of things, but it is what should be aimed at in construction and working.

One more point in the septic tank is very important. Again and again one sees works designed with a storm-water overflow coming out of the septic tank; this is surely a mistake. Storm water, up to three times the dry weather flow or more, may well flow through the tank on to the beds, but when the limit is reached at which the overflow comes into action, there can be no possible advantage in taking clean water into the septic tank in order to let it overflow. Obviously the common-sense method is to let it overflow out of the sewer before reaching the septic tank. The contact bed and the continuously aerating filter may well be considered together, more or less under one head, although at first sight there would appear to be very great differences between them. The aim of both is to bring the sewage in contact with the bacteria, and though they do it in different ways, both have the same difficulties to contend with, and both are dependent for their success on giving sewage the right amount of contact with bacteria. In the first place, neither of them will properly deal with sludge. In this respect the contact bed has some advantage.

If there is plenty of fall, and the area is limited, the continuous filter or the contact bed can be deepened, and area may be thereby saved; the advantage applies to both. The chief difficulty with which both the contact bed and the continuous filter have to contend is the accumulation of black material or humus. This material is, generally speaking, retained in contact beds and discharged from continuous filters, and there is no doubt, in the author's mind, that it ought to be discharged in both cases, or it will ultimately clog up the beds. In the case of contact beds, he thinks that it might be desirable to have some sort of settling pit, channel, or channels, on the surface of the first bed to intercept it. The quantity intercepted would probably be small, as this humus must not be confused with sludge. Sludge should not be given off from the septic tank at all, but if by any chance any comes out, it might be well to catch it if the beds are being worked hard.

In the second place, the author thinks it would be a good thing to make provision for washing out the first contact beds to some extent occasionally—e. g., by opening a large valve when the bed is full, so as to create a good rush out. The humus washed out might be caught in channels on the second beds, or it would probably remain upon the surface, where it could be cleaned off, or it might be well to have a settling pool or channel to catch it between the first and second beds. These ideas are perhaps rather more theoretical than practical, as it must be years before a bed could accumulate sufficient humus to clog it up altogether, and then it would not be so very difficult to take out the material and sift it. In the case of the continuous filter, the interstices being very large, this matter gets washed out together with clinker dust, and becomes a nuisance in the effluent. It is perfectly harmless, but it looks nasty, and it generally has to be intercepted in long channels or pools, or by fine sand filters. It may be considered as a matter requiring the careful attention of the engineer in both cases.

There is one very important difference between the continuous filter and the contact bed. The contact bed can, at a pinch, be overworked severely, and made to do three or four times its ordinary work and produce at the same time a good effluent, provided it receives plenty of rest afterwards. This cannot be done with the continuous filter. As soon as the flow reaches the point at which it begins to run at all quickly through the filter, purification practically ceases. Such filters are generally arranged with a sprinkler which will not deliver more than the quantity per minute which the filter can purify. Any excess must overflow somewhere else, and it is therefore necessary to make sure that the filters are not only able to deal with the daily flow, but also to deal with the quickest rush of sewage. The contact bed might be filled suddenly, but a filter of anything like the same area would need some separate storage tank or other arrangement to deal with the same sudden rush. This is one of the practical points which may sometimes induce the engineer to use contact beds in preference to filters in certain cases, notwithstanding the fact that a continuous filter would deal with the same flow and produce an excellent effluent, provided the flow could be regulated to suit it.

Another consideration with regard to the continuous filter is the sprinkler. Sprinklers must obviously need considerable attention to ensure the proper delivery of sewage regularly over the whole surface of the filter. There are some admirable sprinklers made, but they need a good deal of looking after. There can be no doubt that cold weather must affect continuous filters in some degree, and this remark refers particularly to small filters. It is generally admitted that the continuously aerating filters should not be constructed of a less depth than 4 feet, and the author thinks that it will be wise to make them deeper than this wherever possible. He has seen very bad results produced through making a filter of this kind 3 feet deep.

The contact bed possesses some distinct advantages over the filter. It can be more easily and perfectly controlled. There need be no difficulty as to distributing sewage over the surface, seeing that the whole bed is filled before any effluent is allowed to escape. There is not the objection of cold weather affecting it adversely as in the case of the continuously aerating filter. If contact beds do not deal with sludge as satisfactorily as was at first supposed, it is quite clear that they have worked for years taking crude sewage, and there can be no doubt that, if sufficient area were allowed, they could deal with it well. This is not, as a rule, practically possible, and so it has very often been found desirable to put in a septic tank, so as not to overwork the first beds. But it is probable that the design of first beds will be perfected in such a way that sludge may be liquefied more thoroughly on them.

There has been a tendency, especially at experimental works, to overwork the first beds, and then to call public attention to the fact that they have sludged up, without giving the beds a chance to recover. It is a very common thing for an ignorant manager to let the surface of his beds get more or less covered with black matter, probably scum from the septic tank. The general appearance is bad, and any ordinary observer would think that the beds were sludged up. This probably, is quite incorrect; the so-called sludge is black earthy matter without smell, which, in the author's opinion, should never have reached beds which have to do hard work. If we dig down 1 foot or so below the surface in such a bed we shall generally find the bed much clearer, and quite without smell. If we test it we shall very likely find its capacity good in spite of its appearance. If a contact bed is permanently clogged, this clogging, except in exceptional cases, must be due to either road grit or mineral matter, or to the humus already referred to. Road grit should always be kept off beds. The idea of a bed getting sludged up with organic matter does not seem worth troubling much about. It is never likely to happen except where the bed is much overworked, and if it does happen the bed will rapidly clear itself if allowed to rest. It cannot remain permanently clogged in this manner. As a matter of fact, the difficulty due to the clogging of beds has been greatly exaggerated.

Mr. Baldwin Latham pointed out, in evidence given before the Royal Commission, that the reduction of the capacity of the Manchester contact beds had gone on to a certain extent, and had then stopped entirely, indicating that some of the solid matters had been washed out. These clogging matters were sandy, not organic. The depth of contact beds is generally from 3 feet to 4 feet, but they can be made much deeper, and shallow beds can also be made, say 2 feet deep, or even less. Such shallow beds will give good results in ordinary temperatures, but it seems likely that their capacity would be seriously reduced in times of severe frost, and it must be remembered that the area of shallow beds will be very large.

There are comparatively few works at the present time which do not combine two or more methods in the treatment of their sewage. At some very well-known works near London, there is a large flow of domestic sewage, and the land available is limited in area and unsuitable in character for the treatment of sewage. The method adopted is (1) chemical precipitation, (2) filtration through burnt clay ballast filters, (3) contact bed treatment, and (4) lateral filtration through the surface of the clay land which had been carefully mixed with ashes. The result is an excellent effluent, which actually purifies the dirty river into which it flows, and it is very clear that each of the steps mentioned, combined with the most careful management, are necessary to produce a final effluent at this place.

Letters to the Editor.

The Public Library and the Engineer.

Sir: One of the most striking features of the twentieth century engineer's work is its diversity. Applied science touches humanity at many points, necessitating the widest knowledge of the activities of men, in the successful engineer. The specialist in hydraulics, electric motors or sewerage is a natural product of the scientific advance of the last century, but while his particular knowledge must run in a deep groove, he cannot attain the broadest success as an engineer without a fund of general information about other branches than his own.

The importance of keeping in touch with the latest development in science, theoretical and applied, cannot be overestimated. The engineering field is so large and the different branches so interconnected, however, that this is no easy task. Economy of time and concentration of resources are vital. Every tool which can be sharpened for use must be pressed into service.

One of these tools is the public library. Its possibilities as an aid to all who live by engineering are almost unlimited. Its realized efficiency, alas, is far below the standard of good practice in countless instances. It is my purpose in this communication to point out some of the ways in which the public library's usefulness to engineers may be increased.

At the outset, it is only fair to acknowledge that many of us owe more thanks to the liberality of the library than can be expressed in a single paragraph. It does not require a good memory to recall the inspiration its technical books and magazines furnished in our student days; the willingness of the attendants to supply us with the library's utmost resources in every investigation which we carried on, and the open handed purchase of new books at our request by the librarian himself. There is little doubt that the library did the best it could for us, according to its lights and means.

It is one thing to care for the student, however, and another to satisfy the requirements of the professional engineer. I think that almost every one who has had occasion to use the public library in the solution of specific problems arising in daily practice will agree with me in the statement that the majority of these admirable institutions are better fitted to supply information upon the mythology of the Greeks, the customs of the Romans and the moral influence of sixteenth century sculpture than they are equipped to give us the best published data on train resistance, gas engines or the cost of building masonry dams. I do not wish to undervalue literature and the fine arts, nor to turn the public library into a commercial clearing house of technical statistics, but if the highest efficiency is to be reached, more attention to the ever increasing demands of applied science is imperative.

Rarely does one find a librarian possessing the slightest engineering knowledge of use. Ten to one it will be impossible to secure the exact information one is searching for in a library unless one knows to a certainty the precise publication in which the facts ought to appear. Even the published indices of engineering literature are at present unable to record in accessible form all of the essential details treated in the avalanche of articles which they endeavor to segregate. Certainly, the librarian cannot undertake such a task, if he is to faithfully discharge his duties and do the greatest good to the greatest number. Far too often the valuable data desired is hidden away in some obscure article or book, which no one realizes contains it. The information may be in the library —if it could be found, the value of the library would be striking and effective, not only in terms of dollars, but in time and broad usefulness.

The efficiency of the public library's reference department depends primarily upon two factors: The resources at hand, and the use that is made of them. I have touched upon the latter first, as most large city libraries are today supplied with some sort of engineering books and periodicals. There are exceptions, such as a library which I visited a few weeks ago in a manufacturing city of about 40,000 inhabitants—a city famous for its engineering establishments, steel works, mills and industrial plants. The reading room was well supplied with periodicals which live by publishing the shallowest fiction, but possessed not a single copy of any journal devoted to the applications or theoretical study of electricity.

In another library, catering to the literary appetites of nearly 150,000 minds, the latest book supplied on telegraphy was a worm-eaten dusty volume of the vintage of the late seventies or early eighties, illustrated with crude wood cuts and awkward drawings; while it contained, of course, absolutely no hint of the existence of either machine or wireless transmission. The latest electric railway and telephone books were conspicuously absent, while the supply of cheap fiction was inexhaustible.

Doubtless, many libraries are hampered in their usefulness by lack of funds. No one realizes better than an engineer the compromises which must often be made between conflicting conditions, in attaining definite ends. But in these progressive days there would seem to be but little excuse for inferiority in quality, however limited the quantity may be. It is a pleasure to realize that a few libraries make special efforts to purchase only reliable scientific books and periodicals, but the greater part of them have little conception of what constitutes an authoritative work, and it is not to be wondered at.

The improvements possible in the services which public libraries render engineers depend a great deal upon the co-operation of engineers themselves. In these days of public spirit, it should not be difficult to find an engineer in each of the great branches of the profession in the important cities who would be willing and glad to advise the library executives in regard to the purchase of books and periodicals, without compensation, other than the satisfaction which attends public service. The counsel thus offered by a practical professional man would be of incalculable advantage in the separation of wheat and chaff in technical literature. Again, if engineers would make special effort to supply the public library in their home cities with one or more copies of the books, articles, papers and monographs which they publish, the efficiency of the library would be increased.

Having briefly considered the quantity and quality of the library's resources, it remains to touch upon the methods of getting the most out of the material at hand. The keystone of the whole structure of successful utilization is the index. Some form of the card catalog or periodic alphabetical summary of all engineering literature is absolutely essential.

At the present time the work of indexing technical literature is needlessly carried on by many separate individuals. Such work need be done but once, if it is done properly. Perhaps the index of the "Engineering Magazine" is as comprehensive as any classification now in operation. In a purely electrical field, the "Digest" of the "Electrical World and Engineer" is highly praiseworthy. It is a question in the writer's mind, however, if something still more detailed is not worth while. Often an article contains information which would scarcely be recognized as belonging to the same family as its title—information which is soon lost to the world if it is not classified in some index. To carry out such an index as this would probably be a matter of considerable expense, but if this expense were divided among all the public and private libraries, colleges, engineers, etc., who would benefit by the work, it would require but a nominal contribution from each individual annually. A suggestion of the methods of carrying out this work would be for all the subscribers to the index to receive weekly card index packages for their files, each card to be printed at a central office, where all the index work is done by experts trained in each particular branch of engineering. Each subscriber would then be equipped with the means of immediately locating every published article and item of importance bearing upon his particular needs, and there is not the shadow of a doubt that the efficiency of every public library in the world which had this service would be enormously increased.

It is not the purpose of this contribution to suggest who shall do this work, carrying out the indexing plan in greater detail than any organized classification at present in existence accomplishes. Rather is it the intention to have pointed out a line along which there is need of increased efficiency. These are days in which the stoppage of every form of industrial leakage is receiving the attention of all those who have to do with the great forces of civilization. "Efficiency" is the battle cry of the times, and waste or unimproved opportunity—whatever we may call it—is the common enemy of all progressive men. If this statement has only furnished food for thought, its object will have been attained. The improvement of every form of information mechanism is a matter worthy of careful study, and of all the tools which the engineer can use in keeping abreast of his profession, the public library may truly be said to have the greatest opportunity for usefulness within its reach. Co-operation between the engineering profession and the library management will pay compound interest on the investment. The engineer alone understands his own needs, the librarian his own perplexities. A harmonious meeting on common ground will clear the problem of many absurdities and pave the way toward greater usefulness on the part of both public library and engineer. Yours truly,

Howard S. Knowlton.

Denver, Col., May 4.

An African Cableway.

Sir:—In your issue of last week you published a description of the cableway which will be employed near the Victoria Falls Bridge over the Zambesi River in Africa. You state that it will have a main cable 8¼ inches in circumference, a span of 870 feet and will carry a 10-ton load. This information is interesting as showing an unusual application of an old device, for your article indicates that the only novelty lies in the use of the cableway as a link in a railway until the river can be bridged.

Now you must agree that there is nothing particularly wonderful about this cableway, in span, capacity or other feature, and the purpose of this note is to suggest that in such articles it would be of assistance to your readers to have the novelty, or excuse, on which they are based mentioned, so that a busy man can grasp it at a single perusal. In the case of the article in question it seemed to me at first that an enterprising cableway manufacturer must have suddenly wafted into the editorial sanctum from the torrid surroundings of the Zambesi with a moderate portion of hot air which found expression in a nice little write-up. After a more careful reading it appears that there is really an interesting suggestion, particularly to the military engineer, in the use of a cableway for transporting 40,000 tons of railway material needed beyond an unbridged river. The above suggestion is made because there is so much trade advertising done under the guise of reading articles, that reputable papers will certainly find it to their advantage to avoid, as in this case, the appearance of giving puffs.

Yours truly, Cableway.

New York, May 11.

Natural Gas is employed in the boilers of the plant of the Union Utility Company, operating the electric railway at Morgantown, W. Va. At a meeting some time ago of the Engineer's Club of Philadelphia, Mr. W. L. Webb stated that the furnaces are supplied with Kirkwood burners, and the gas is received at a pressure of 120 to 150 pounds per square inch. Before passing to the furnace it is reduced to a pressure of a few ounces.

Elastic Foundations for steam hammers, high-speed engines and other machinery have been made in Germany for some time by using impregnated felt sheets through which vibrations will not be transmitted. The material is now being introduced in England by the Patent Woolen Cloth Company, Elmwood Mills, Leeds, for the same purpose and also in bridge construction where it is essential to keep the vibration of passing trains from reaching adjoining property. The material is stated to be a pure wool felt made in strips up to 60 inches in width and 1½ inches in thickness. It is impregnated with mineral fats and its upper surface subjected to a sort of preservative process to resist dampness.

The Hudson River Tunnel at Morton Street, New York, affords an interesting lesson in the improvement of air compressors since it was started thirty years ago, particularly as Ingersoll-Sergeant apparatus has been used from the outset. When the work was begun the machines were of the water-injection type, but as construction proceeded they were replaced by compressors with poppet inlet valves and water-jacketed cylinders. When the Hudson Improvement Company resumed operations two years ago a better equipment was provided. On the Jersey shore there are four compressors, one a duplex machine with 16-inch steam cylinders, 20½-inch air cylinders and 16-inch stroke, and three straight-line machines with 22-inch steam cylinders, 24-inch stroke and 26¼ and 22¼-inch air cylinders. On the Manhattan shore there are two duplex compressors like that on the other side and a straight-line engine with 22-inch steam cylinders, 24-inch stroke and 22¼-inch air cylinders.

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The Business Side of Engineering.

Elsewhere in this issue there is printed the first part of an address made before the University of Illinois a short time ago by Mr. John W. Alvord. There are some readers of The Engineering Record who will find very little in it of novelty, although they will doubtless hold that a more thorough teaching of the facts it gives would be highly desirable in engineering schools. It was written with the advice of one of the most famous banking houses in the country, as a result of the author's experience with many young engineers, whose inability to understand the business side of their work led to trials and tribulations. At this season, when so many young men are about to leave school to enter upon the practice of their profession for the first time, it is appropriate to call their attention particularly to this contribution.

It is the civil engineer who most often is open to the charge of having unbusiness-like ideas. The mechanical, electrical and mining engineers are necessarily kept in touch at all times with the fact that their work is a mixture of science and finance. Whether they are engaged in making machines for the market or producing and smelting ores, the criterion of the value of their work is the balance sheet. With the civil engineer such a check is not directly present to guide him. The choice of a pavement is often recommended on other grounds than an analysis of its final cost to the people who pay for it. Bridges are bought very often by methods which no one would follow in private affairs. Even in mill architecture, there is a tendency to construct buildings far more permanent in character than the probable progress of the industry they house would warrant.

It is a good thing, therefore, that Mr. Alvord calls attention in a logical manner to the business side of engineering. He is not making himself particularly popular when he says that the value of engineering work is often overestimated by those performing it, but everyone in positions of responsibility will agree with him. Much engineering work is underestimated and very poorly rewarded, but the people who do it under such circumstances are alone to blame. There is no law which has forced them to become engineers and none which makes them retain their unprofitable duties. Their very complaints are an indication of their lack of business qualifications. It is praiseworthy to labor for a time in a poorly compensated position if by so doing a good future is assured, but it is folly to keep on giving time and knowledge after it is certain they will not be properly paid for.

It is necessary to recognize, however, that there are very few important positions open to the engineer in which high technical ability is alone needed. Some great corporations find it profitable to carry on purely scientific work, and employ men for this purpose who have no connection whatever with any other branch of the business. In some of the German manufacturing establishments there are distinct research departments which are engaged on investigations of the most scientific nature. As a rule, however, the money value of engineering knowledge and experience depends considerably on the ability of their possessor to use them promptly and clearly for some company or city which cares not a whit about the methods followed in reaching the results it wishes. At the present time more than one engineer is finding himself losing ground to a rival who very likely does not know so much but has the gift of stating what he does know in compact and convincing form.

Beyond doubt, if engineers would devote some of the time spent in writing long reports to studying how to make those reports concise, they would be gainers. If they would learn how to deal with business men in a business way, they would be better off. The average city councilman does not care anything whatever about the coefficient of friction in a pipe line, but he does like to keep the meetings of the council down to the shortest possible limits. Long reports bore him. No mill agent asking advice about a new engine cares whether the cylinder ratio is one to three or one to twenty; what he wishes is a statement of the engine he ought to buy and the reasons for the choice in terms of dollars and cents, and not in cylinder condensation and other technicalities.

These observations are not intended to reflect on the value of engineering knowledge of the broadest and most thorough nature. That kind of knowledge needs no approval in an engineering paper. It is essential for continued great success. But along with it must go the business knowledge which makes the technical information of the greatest use. This is particularly true in the West, where much work must be done with very small sums of money, and the engineer is required more than anywhere else to be a master of the art of making every penny count.

Lateral Earth Pressures.

There has probably been more written on the theory of earth pressure, since a "theory" was first recognized, than on any other one subject in engineering design and construction. It is one of the oldest subjects in engineering literature, although not the oldest. The uncertainty as to the amount and character of some of the elements affecting the actual value of earth pressure as found in engineering work has opened a wide field for hypothesis and has resulted in a great number of theories of earth pressure and proposed methods of computation. One of the earliest of these and one which served for a long time a most useful purpose was based on the "principle of least resistance." On the other hand, probably the most rational and simple treatment is that of Rankine which, like all other work of that master of engineering science, is in the highest degree scholarly and characterized by as great a degree of accuracy as can be found in any working theory of earth pressure; at any rate, as an analytic treatment of the general problem it has never been excelled as a working hypothesis for practical purposes.

The great difficulty encountered in the application of any theory of earth pressure ever written or, it is not rash to say, that ever will be written, lies in the simple fact that any analysis must be based upon certain specific assumptions or data relating to the quality of material and its condition in the actual work, whereas actual materials to be held in place by retaining walls or other structures vary indefinitely both as to quality and as to condition. The "earth" to be retained may vary in texture all the way from soft mud, almost a liquid, to rock fragments which, if placed with but little care, may be maintained in mass with a vertical face. In other words, the materials under consideration may exert a lateral pressure ranging from the greatest possible to nothing. It is obvious that no theory of earth pressure can be made to cover any such widely-varying set of conditions without the use of at least a correspondingly varying empirical factor.

In spite of these evident features of the general problem which demand the most widely extended experimental observations to reach anything like a rational basis for computations in any given case, there is probably no branch of engineering design which, at present, must be based upon so little adequate experimental data as those problems which involve the treatment of earth pressures. It is not entirely out of place, therefore, to refer again to the publication of such a paper as that on "Lateral Earth Pressures," by Mr. E. P. Goodrich, in the March "Proceedings" of the American Society of Civil Engineers. There may be abundant room for variation of opinion as to the accuracy of all the details of a set of experimental results like those set forth by Mr. Goodrich, determined by him and other experimenters, but there can be no question that such experimental work leads to results on the whole of marked value and that they constitute a distinct step forward in this special line of engineering work.

No one who has not undertaken to conduct actual tests of this kind realizes the number and character of the difficulties which beset it and which must be avoided if results are to be correct. In the first place it is not easy to determine the actual degree of moisture in any material even so simple in character as sand. Again, in any apparatus of dimensions practicable to be used in ordinary experimental work of this kind it is almost if not quite impossible to avoid "arching effects." Indeed it is not altogether certain that such effects can be entirely avoided in laboratory work. Also, as pointed out by Mr. Goodrich, and as is well known, the effect of applied pressures may produce obscurity in results which otherwise would be easily interpretable. The same mass of earth, even if a constant degree of moisture be maintained, will exert a very different pressure where fresh in place from that which is exerted several weeks or months or years afterward.

All these and other agents or influences must be seriously reckoned with in any given class of material which can be called earth. There are an indefinite number of other sources of disturbance or obscurity arising from the various degrees of fineness or coarseness of material or from its wetness as distinguished from dampness or moisture. The observations made many years ago by Sir Benjamin Baker on actual retaining walls with the material back of them have become almost classic in this connection. He recognized the fact, also stated by Mr. Goodrich, that above a certain point at least the coarser the material supported the less will be its lateral pressure. In the other direction it may be stated, at least as a general truth, that the wetter the material is the greater will be its lateral pressure, and there is no question more perplexing to an engineer designing a retaining wall to support wet material than the determination of the effect of the wetness with which he has to contend.

Obviously it is the business of an engineer in the face of such problems as these to settle upon the best general working hypothesis in reaching equations for general use, and then make such modification of the empirical quantities entering them as his best judgment may indicate in order to meet most effectively varying conditions and changing materials. It is gratifying as well as relieving to read one of Mr. Goodrich's conclusions, as follows: "Rankine's theory of conjugate pressures is correct, when the proper angle of friction is found, and probably adaptations of his formulas will be of most practical value." This conclusion, we may venture to write, is confirmed by the practical experience of at least a considerable number of engineers. Rankine's theory, like all other theories, contemplates a fine, dry, granular earth which is probably rarely or never found in actual engineering practice, but for an all round working hypothesis and for a rational treatment of the forces existing in masses of earth, it is probably the best ever written, and largely so both because of its general character, i. e., freedom from special limitations, and for the reason that it carries an empirical quantity "the angle of repose" which can be easily and rationally adapted, at least with a fair degree of approximation, to a wide range of materials. It is in this direction that such investigations as that of Mr. Goodrich are the most valuable. It is absolutely essential that the equations of Rankine's or any other theory be made applicable, in a working way, to the exigencies of practice and that can be accomplished most simply and effectively through empirical quantities whose rational values, based upon actual determinations, furnish a safe basis of action for sound engineering judgment.

The New York Water Supply Legislation.

Two weeks ago attention was called to a bill awaiting the signature of Governor Odell, of New York, which was calculated, if signed, to set back seriously the time of completion of needed works for the additional water supply of New York city. The bill has now been signed and already the political opponents of the governor are denouncing him vigorously for his action. A careful consideration of the bill and his statement of reason for approving it shows that, all things considered, his action may be beneficial to the city rather than the reverse, provided the authorities are not led away by the crazy talk of certain newspapers into imagining vain things. As a matter of fact, the governor states that he will call a special session of the legislature provided the city cares to introduce a bill which will grant security to all vested rights while repealing the prohibition to draw water from Dutchess county. This means, it is safe to say, that he will convene the legislature if the city will agree to extend to the people of that county the same legal protection which the State of Massachusetts gave to the residents on the catchment basins of the Metropolitan water-works. At the present time, the New York laws do not afford such protection, and although the advocates of a veto of the bill just signed made all sorts of verbal promises as to what the city would do for everybody affected by the construction of the works, the governor intimates very strongly that he will not be doing his duty unless these promises are embodied in laws before the city begins to condemn property.

In approving the bill which shuts out New York from using the water of Dutchess county, until it is repealed or amended in the manner he suggests, the governor expresses his full sympathy with the view that the needs of New York City are paramount to those of any other community in the State. He does not deny that the plans of the Advisory Board of Engineers which recommended the new works were intended to meet every direct injury due to the works by providing an adequate substitute. What he insists upon is that the intentions of the engineers and of the city's representatives, as expressed at the recent hearings, shall be reduced to binding laws before the city is given the right to utilize any part of the waters of the county. It is because he fully appreciates the importance of the statements made by Mr. John R. Freeman and others at the recent hearings on the subject, to the effect that New York must begin the construction of its new works at once, that he offers to convene the legislature for the passage of the acts which will permit the undertaking to be commenced.

The present laws are insufficient to protect the people against serious indirect loss of a nature clearly stated in the governor's message. The drainage basins which the new law protects against the city have towns largely devoted to manufacturing, and upon the operation of the mills depends the prosperity of a large part of the population of the county. It is peculiarly a rural manufacturing county which the State must protect against indirect as well as direct injury. Governor Odell says he is satisfied from the engineers' reports that the same safeguards of the manufacturing interests can be provided in New York as in Massachusetts and other States. The indirect interests demand special attention, however. While the owners of the mills may recover damages for any of their property or rights which are taken for the water-works, under existing laws of the State, there are other forms of property which will be seriously injured without new legislation. For example, the savings banks of the county have loaned over three million dollars on the property of operatives and residents in these mill villages, which the present laws leave without any protection in case the mills are closed by reason of the construction of the water-works. That this is not an unfounded fear, the case of the mill village of Glenham, in Dutchess county, is cited. In the lifetime of the late A. T. Stewart this village gave employment to hundreds of operatives, but since it has been closed the value of all property has lapsed to practically nothing. Should the same thing occur in hamlets depending on mills which the proposed works may close, there will be a loss to the savings banks which is wholly unmerited by any lack of business judgment on their part.

This view of the subject is one which engineers familiar with the ideas of justness held in other States and abroad will approve. It is expected that in all condemnation proceedings the mill owners will get all and generally more than the full measure of their rights. But the idea that the laws of the State of New York do not protect as well the owners of small industries or business enterprises is abhorrent. The governor is right in preventing the city from proceeding into Dutchess county for an additional water supply, until the laws are properly amended. The bill just signed is needlessly harsh, but the offer to call a special session of the legislature for the express purpose of modifying it places the responsibility of any further delay in the matter with the officials of New York City. Knowingly or not, they have tried to place themselves in a position where small savings banks, the proprietors of small stores, and others doing business in mill villages and hamlets on the catchment basins of the proposed reservoirs and the rivers now fed by them, who will be crippled by the proposed works, would be without legal redress. Governor Odell proposes to protect these people until the city will become legally responsible for any injury they receive as a result of the construction of the works for a new supply.

Approximate Calculations.

It is a perpetual source of wonder to many older engineers that the technical schools of the country do not train their undergraduate students in approximate methods of calculation. Fifteen years ago even the slide rule was an unknown instrument in most schools, and it is doubtful if its value is properly pointed out in all of them to-day. The slide rule is, however, an "adventitious aid," and the young engineer is not properly equipped for his work unless he is able to perform many computations with greater rapidity than ordinary methods permit. Perhaps one reason for this lack of training in such rapid calculations is to be found in an equally unfortunate failure in many schools to inculcate in the student an appreciation of the value of time and of the folly of useless work. The value of the work done by the average engineer, to himself as well as his employer, depends largely on his application of the old adage about time being money. It is because so many do not recognize the truth of this saying that they go through life without much of either at their own disposal. This is no place to discuss the methods of teaching the value of time, but there are several reasons for pointing out the importance of saving it by approximate methods of calculation.

No small part of the calculating required by engineering problems is for results which must be so modified by factors of safety or by constants of uncertain value, that close accuracy is not only needless but is deceiving. The engineer prides himself on being pre-eminently a man dealing with the truths of nature, and he must not deceive himself or his employers by the use of numbers carried to several places of decimals, when accuracy stops with the figure in the hundreds place. As the schools now teach methods of computing, this pretense of accuracy is more a matter of habit than of intention, but the habit itself is due to lack of knowledge which every undergraduate should possess. In his problems he often has to multiply together two numbers having several figures each. He knows that these numbers are approximate, and if a slide rule is handy he obtains the product on it with sufficient accuracy for the purpose in hand. But if the slide rule is not available, probably ninety-nine out of a hundred young men will put down the numbers and multiply them together in the usual manner. Now all this denotes a half-training which is not desirable. If such a computation is suitable for the slide rule it is equally suitable for approximate multiplication, with the multiplier inverted and only a portion of the partial products written down and added. In the same way, short methods of division are not employed. As a matter of fact, there are many computations which require an accuracy a little too great for the ten-inch slide rule which are still within the scope of short multiplication and division, and the school which teaches the use of the rule and neglects the other labor and time-saving system is doing only half its duty.

Again, an engineer often has to solve two simultaneous equations of a complicated character. This can sometimes be done after considerable mathematical work by the old-fashioned algebraic methods. Those who are really properly equipped for their work rarely attempt this, however, but plot the two curves on cross-section paper. Where they intersect is the point whose ordinate and abscissa give the desired values. This is really one of the most simple uses to which squared paper is put by those acquainted with the assistance it offers to computers not bowed down by a sense of fictitious accuracy. It would be idle to point out here what more can be done by plotting curves on such paper, and by many other approximate methods of obtaining desired results. The purpose of this article is simply to state that in this very busy age it is the duty of the technical schools to teach young men to save time by employing methods of calculation which are more expeditious than multiplication, long division and the use of logarithms. These methods sacrifice accuracy, but no engineer is equipped for his work until he is trained to recognize the proper limit of accuracy in each step of his work.

The Legal Requirements for Storm Water Sewers.

A suit involving the capacity of the Mill Creek sewer in St. Louis, which has been dragging its way slowly through the Missouri courts, is of general interest not only because it relates to the size of one of the largest sewers in the country, but also because it affords renewed assurance of the protection the law will give to reasonable engineering practice in sewer design. This enormous drain receives the sewage and storm water from a district of about 6,400 acres. At the Mississippi River it is sixteen by twenty feet in cross-section, while at its upper end, about five miles distant, it is ten feet in diameter. It was begun in 1864 and the last extension was completed thirteen years ago. It was designed to carry off a rainfall of one inch per hour, which was the maximum employed in good engineering practice at the time it was planned. It was originally built with a timber bottom and heavy masonry walls and arch. Eight years ago the side walls were found to have settled somewhat in one place, forcing the timber bottom out of place from an inch to a foot, but this settlement was repaired as soon as it was discovered.

On July 8, 1898, there was the most severe storm in the city in the history of the Weather Bureau. There was a maximum rainfall of 1 inch in 10 minutes, 2.56 inches in 62 minutes and 5.10 inches in 24 hours. This was preceded the day before by a rainfall of nearly 2 inches in 24 hours, which left the ground in a condition to shed the succeeding precipitation rapidly. As a result of this heavy storm, the sewer overflowed, and the plaintiff in this case (Gulath *v.* City of St. Louis, 77 S. W. Rep. 744) had the contents of his store injured. He brought suit against the city for damages, holding that it had neglected to keep the sewer in repair and that it was of insufficient capacity for its purpose, a fact which he had reported to the city before his property was flooded.

The State Supreme Court holds that the sewer was properly maintained, and that any charge of negligence on the part of the city was unwarranted. It also considers the evidence conclusive to the effect that before the construction of the sewer the site of the store of the plaintiff was overflowed "many times" by the creek which occupied the route of the present drain. Since the latter was built, there have been but three occasions on which it overflowed, all of them after unusual storms. These facts show that the plaintiff could not truthfully claim that the construction of the sewer worked additional injury to his place.

The most important claim in his behalf was that the sewer was not large enough and should have been increased in capacity after it was first overflowed. The court decides that experience proved it was amply sufficient to meet the demands on it under ordinary conditions, and that overflow occurred only in case of extraordinary storms. Such exceptional storms, "acts of God" in legal parlance, need not be taken into account by the engineer in designing such works. "It would be strange doctrine," says the court, "to require the defendant to anticipate such a storm as has never occurred." It would substitute guesswork for judgment.

It will be a matter of considerable satisfaction to municipal engineers to hear that the law has been so interpreted in Missouri. No man can tell what the rainfall will be for all time to come, and if a drainage system is large enough to carry off all the rainfall of most storms it is manifestly answering its purpose. To make it larger than is necessary for any recorded rainfall, or large enough for one recorded but once in the history of a city, is requiring the taxpayers to expend a large sum of money to prevent an occurrence which may never arise. Nobody cares to contemplate the flooding of a cellar with the overflow from a combined sewer, yet it is illogical to spend large sums of public money to prevent improbable damages. When the city engineer has designed a sewer to carry off all the drainage that it is reasonable to expect from a given district, he has fully complied with his obligations. This is common sense and it is also law in most States. The authorities of St. Louis are to be congratulated that this view has been taken in the suit against them, and that the famous Mill Creek sewer, one of the landmarks of American municipal engineering, has been declared as successful in law as it is in service.

Notes and Comments.

THE RIVER SURVEYS of the U. S. Geological Survey will soon prove of much engineering and industrial importance. During last year, the hydrographic and topographic branches of the bureau surveyed nearly 1,050 miles of rivers, running levels and taking elevations of various river stages, road crossings, stream junctions and other points. A careful traverse was run, using the compass for direction and the stadia for distance. The results were plotted on a map to the scale of 1:22,500, on which were placed the outlines of both banks, all road intersections, and the names of islands and rapids. The river bottoms were sketched in 10-foot contours so far as practicable. The width of broad flats and the character of their soil or rock were noted, and memoranda on the character of the stream and its bottom at sites available for dams were recorded. As the data concerning the discharge of the various streams and their possible development for power are accumulated, it is proposed to publish the results for each river system in a form similar to the geologic folios. These geologic folios are of great value to the mining interests and the hydraulic folios should have equal value to mill men.

THE FIRE HAZARDS in American cities will be investigated by the National Board of Fire Underwriters. From $90,000,000 to $100,000,000 is lost annually in this country by fire, and the leading insurance companies are convinced that much of this loss could be prevented without much trouble or expense. A committee of the Board has been appointed which will define the congested district of cities and determine their hazards. A staff of fire-protection engineers is now being organized to make the necessary investigations and recommend improvements in building laws, water supplies and fire departments. Technically educated men are desired for this staff, which is being organized by Mr. Herbert Wilmerding, 46 Cedar street, New York. Fire-protection engineering is one of the youngest specialties and has an important future which no one can now fully appreciate. It was only a short time ago that the fire insurance business was very much of a gamble, but with the advent of careful engineering inspection it has been slowly developing and has a future in which the engineer will play an important role.

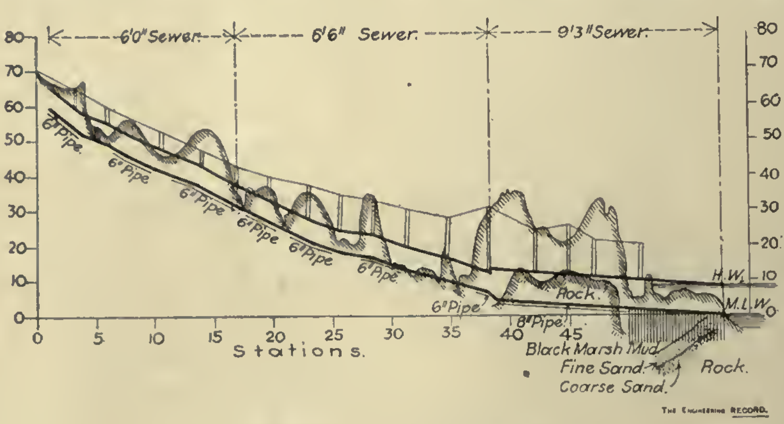
THE ADIRONDACK FIRES of a year ago are discussed in an unusually interesting paper by Mr. H. M. Suter, of the U. S. Bureau of Forestry. Those fires, lasting from April 20 to June 8, burned over 600,000 acres of timber land and caused a direct loss of $3,500,000. About $175,000 was spent in fighting them, and they were finally extinguished only by heavy rains. Their effect on several industries was severe. The State has a fire-warden service, but Mr. Suter reports that it is inadequate because it makes no provision for preventing fires, only for fighting them. A permanent force of rangers and a carefully executed system of fire lanes and other preventative measures is recommended. The details of such a service can only be worked out after a study of all the local conditions, but it is highly desirable that the work should be inaugurated at once. This great timber tract is one of the most important in the East, and the lack of proper care paid to it by the State is too well known to need comment. The methods of the foresters of Europe seem completely ignored and a repetition of last year's experience may be expected every spring until efficient management is insured.

A Reinforced Concrete Sewer at Wilmington, Delaware.

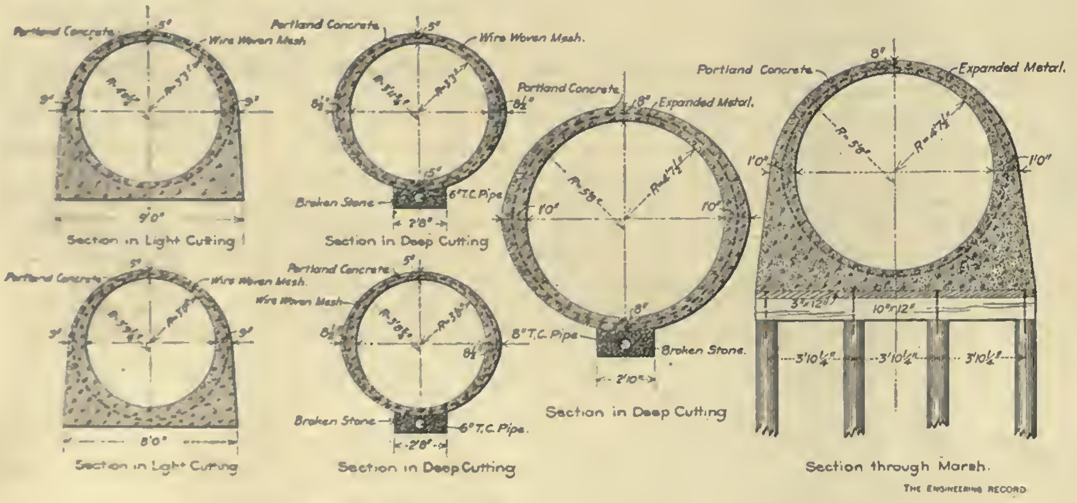
By T. Chalkley Hatton, Consulting Engineer.

During the year 1903 the Board of Directors of the Street and Sewer Department of Wilmington, Del., has constructed a reinforced concrete sewer, some of the details of which may be of interest. This sewer is known as "Price's Run sewer," is 7,436 feet in length, consisting of 1,726 feet of circular sewer 9 feet 3 inches internal diameter, 2,426 feet of 6 feet 6 inches, 1,371 feet of 6 feet, 804 feet of 5 feet and 64 feet of 4 feet 9 inches internal diameter. Its purpose is to carry to tide water the sewage and storm water from an area within the city limits of about 600 acres. The difference in elevation between the upper end and the outlet is 58.033 feet, maximum grade per foot is 0.0157, and the minimum grade is 0.00303 per foot, the latter being the grade of the 9-foot 3-inch section. The sewer discharges directly into the Brandywine River at an elevation of 0.793 below mean low tide, and the mean difference of the tide is 5.8 feet.

The accompanying drawings show the profile of the sewer and the cross-sections of the larger sizes. Seven hundred feet of the 9-foot 3-inch section was built through a marsh abutting upon the river, which was submerged at each high tide to a depth of 1 to 4 feet. The cutting through this marsh was 8 feet in depth through river silt and water-bearing gravel, and 160 feet was built through the old channel of the river, the excavation being made through a soft blue liver which was very difficult to hold in place with the most careful sheathing. One of the drawings gives a cross-section of the sewer which was built through this marsh. The foundation consisted of pine piles, from 36 to 8 feet in length, four piles to each bent, spaced 3 feet 10½ inches centers and the bents spaced 4 feet between centers. Each bent was capped with a 10x12-inch yellow-pine cap and the whole floored with 3x12-inch hemlock timbers laid with joints evenly broken. Upon this floor the concrete was laid to correspond with the cross-section as mentioned.



Profile of Price's Run Sewer.



Section in Light Cutting

Section in Deep Cutting

Section in Deep Cutting

Section through Marsh.

Section in Light Cutting

Section in Deep Cutting

Cross Sections of Price's Run Sewer, Wilmington, Del.

The first work done was to drive the piles, a more difficult job than might at first appear, as it was necessary to use a land machine, whereas twice in each twenty-four hours a floating machine would have been the proper plant, and at such times work was suspended. The piles were driven to rock in most cases, a follower being used to drive the pile below the surface of the marsh so that the full length of the timber cofferdam was built on each side of the center line of the sewer, parallel with it and about 49 feet on each side, to keep the tide water from the work. This cofferdam extended about 500 feet, and was filled with the first mud taken from the sewer trench. The cofferdam consisted of 2x12-inch hemlock close sheathing driven into the mud of the marsh, each line of sheathing 4 feet apart, held in position with two runner boards upon each side, which were held by 6x6-inch posts driven upright into the mud and top planks nailed across the top to keep them from spreading. The cofferdams were carried about 4 feet above the highest surface of the marsh, and answered the purpose very well, except upon two occasions, when heavy floods, accompanied with extremely high tides, broke through sections of them, the water carrying the mud into the trench excavated, breaking the heavy ditch braces and entirely filling the trench. This mud was so diluted with water that it all had to be re-excavated with hand buckets, which, of course, was a very tedious and expensive work.

When it is understood that the bottom of the excavation was 2.62 feet below mean low tide in the river and 8.42 feet below mean high tide, through a quality of soft mud which would readily pull a tight rubber boot from the foot of a workman, one can easily comprehend that the construction of this portion of the sewer was not free from unusual expense and difficulties. The trench was sheathed with 2-inch hemlock planks, butted joints, driven below the extreme excavation at all times, where possible, with upper and lower rangers of 6x6-inch timbers 16 feet long and cross-braces of 6x6-inch timbers 13 feet long, spaced 8 feet between centers. But even with this substantial bracing, which was very carefully placed, the mud slipped and oozed into the trench in numerous places, requiring its rehandling. One of the accompanying views shows the sheathing and abundance of water which had to be taken care of every time the main pump took a kink, which, as usual, was of too frequent occurrence.

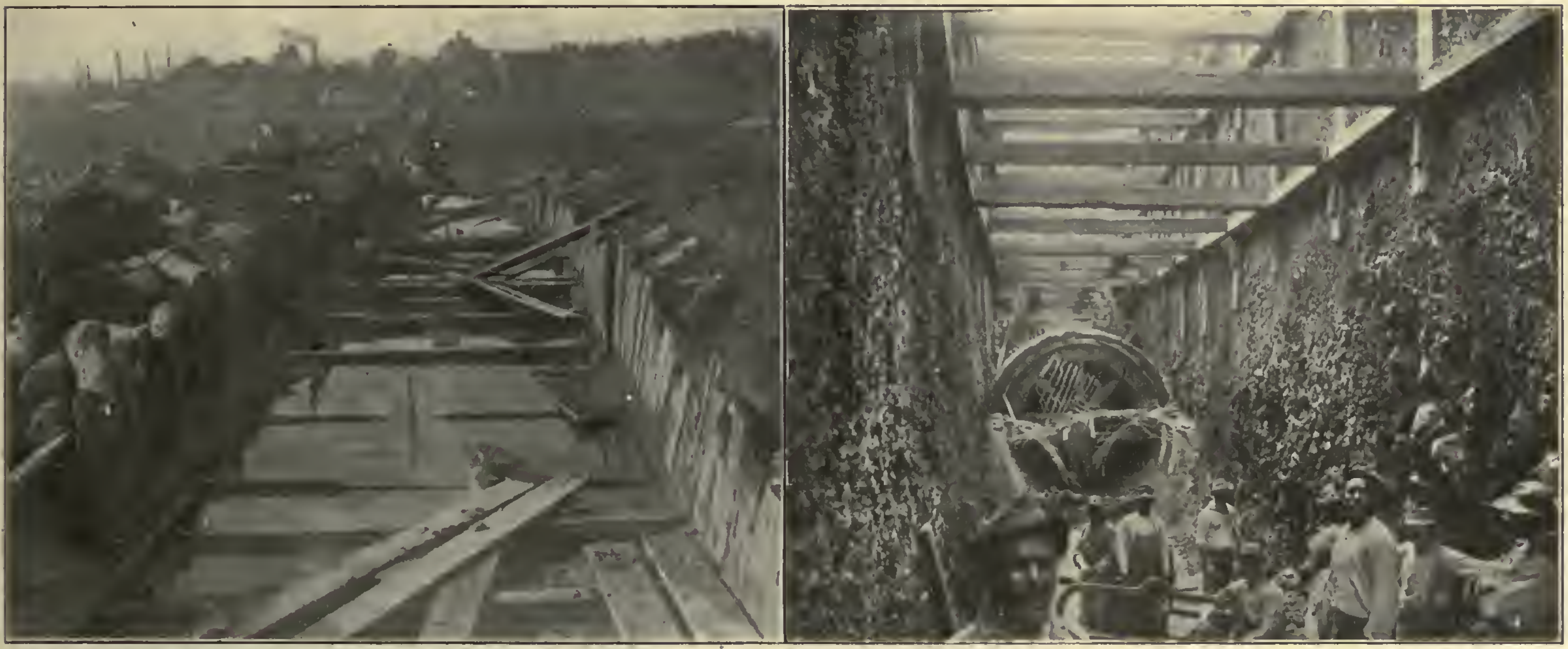
Before beginning the excavation a pump well was sunk at the land end of the marsh, and outside of the line of excavation over this well a 5-inch centrifugal pump was placed, run by an electric motor. An 8-inch terra cotta underdrain was laid from this well to the center of the excavation and was then continued through the center of the excavated trench under the caps. This underdrain was one of the principal features of the work, for without it nothing could have been accomplished, but keeping it in service was a source of great concern. Necessarily it was laid at a flat grade, nearly level, as the grade of the drain was opposite to the grade of the sewer, and the velocity of flow being sluggish, the soft mud carried in suspension into the drain precipitated on the bottom and clogged it up.

Eleven hundred feet of the 9-foot 3-inch section of sewer was built where the cut ranged from 22 to 34 feet. The material excavated was hard clay underlaid with a blue granite, the latter forming about one-third of the material excavated. Skeleton sheathing only was used, the excavation being made by a Carson-Lidgerwood cable machine. In the cross-section of the sewer built through this deep cutting, it will be noticed the thickness of the sewer at the crown is but 8 inches, which is 5½ inches less than the writer has been in the habit of using for a 9-foot diameter arch where the material used was brick. This thickness, however, has withstood the shock resulting from dumping a cubic yard of dirt and rock from the cable buckets at various heights from 3 feet to 10 feet, and the weight of 25 feet of loose filling, without any apparent fracture. Care was taken to fill up the interstices left in the sides of the excavation below the springing line by the removal of extra rock or earth, with broken stones from the trench, or concrete where the spaces were not too great, so that the invert would have a firm and close contact throughout. The section through the marsh, which has the same thickness of crown, is above the natural surface and without any covering of earth. During the past two months upon two occasions, it has been subjected to the heavy poundings of tons of ice resulting from the breaking up of the ice on the Brandywine River, and no damage occurred to it, these tests being a pretty good illustration of the ample strength of the work.

As will be noted by examining the profile, some of the 6-foot 6-inch and 6-foot sections were built above the natural surface of the ground, and in such places the cross-sections marked "light cutting" were used. The cross-sections of the sewers in trenches deep enough to cover the arch are marked "deep cutting." These sections, while only 5 inches at the crown, have already withstood, without fracture, all the load they will be subjected to at any time.

It is admitted that the small amount of material used in the construction of this sewer was a bold departure from the minimum usually recommended by engineers, especially in view of the fact that little has been written to instruct the engineer in the strength imparted to the concrete by reinforcing metal, and the writer has gone into some detail in the description in hope that his experience may be of some benefit to the profession in the saving of superfluous material in future works.

Two progress photographs of the 6-foot 6-inch section of the sewer are reproduced for the purpose of showing the method of placing invert forms and centers to preserve the form of the sewer. This method is by no means original, nor may it be the best, but its use was very economical and resulted in good, smooth work, both inside and out. The bottom of the invert had to be smoothed up with a coat of plaster; a few places at the springing line where the center did not come in close contact with the invert and the extrados of the arch were washed with a coat of thin cement mortar, but otherwise the interior of the sewer was as smooth as a well-plastered wall. The concrete was well rammed in between the inner and outer forms in 4-inch layers, which was the depth of each lagging, each lagging being placed as the concreting progressed. Four rammers were used to each 16-foot section and the concrete was mixed moderately dry to make the smoothest work. Whenever a wet mixture was placed, small honeycombed places would result in the interior surface.



Wilmington Reinforced Concrete Sewer: Flooded Trench through Marsh; Deep Cut in Clay and Rock.

The concrete for the invert consisted of 1½-inch stones mixed with stone dust and Portland cement, mixed in the proportion of one of cement and two of dust and six of stone. That for the arch consisted of ¾-inch stone, dust and Portland cement, mixed in the proportion of one of cement, two of dust and five of stone. The stone was of blue granite well selected as to size. The use of the ¾-inch stones for the arch was for the purpose of securing smoother work, and also to use the output of the crusher, but proved of no special advantage in securing smooth work, for in the places where the 1½-inch stones were used the result was equally as satisfactory.

The reinforcing metal used in the 9-foot 3-inch section consisted of expanded steel, 6-inch mesh No. 6 gauge, in sheets 8x5½ feet, and was supplied by Merritt & Company, of Philadelphia. A single layer of this metal was placed around the sewer, approximately 2 inches from the inner surface, its position being carefully maintained by the men ramming, and with but little difficulty, the sheets first being bent to conform to the radius of the circle. Each sheet was lapped, one mesh over its neighbor, at both ends and sides, but was not attached to it, except as the concrete would embed the meshes together, except the top sheet, which was fastened to the adjacent sheets with No. 8 wire. This was done because walking over the center during the depositing of the concrete was liable to move the sheet out of its proper place.

The reinforcing metal used in the balance of the work consisted of a wire-woven fabric furnished by the Wight-Easton-Townsend Company, of New York. This fabric came in continuous rolls 5½ feet in width and about 100 lineal feet to the roll. The wire was a No. 8 gauge with a No. 6 wire for selvage, and the mesh was 6x4 inches. This fabric was placed by first cutting the sheets to the required length to entirely surround the sewer, and embedding it in the concrete, as the latter was placed, in the same manner as was done with the expanded metal, except over the center where, the fabric being more pliable than the expanded metal, was held the proper distance from the wooden center by means of a number of 2-inch blocks placed between, which were removed as the concrete was placed. The fabric has one advantage over the expanded metal, that it is all in one sheet and can therefore be placed a little more expeditiously, whereas the advantage of using the metal is that it is more rigid and thus better maintains its relative position in the concrete. The only reason for using both kinds of metal was for the purpose of testing each. The expanded metal was delivered at a cost of 4 cents per square foot, and the fabric at 2½ cents per square foot.

A very close account has been kept of the different items of the work, but for the purpose of this article the cost of the concrete will perhaps be the essential feature. With cement at $1.30 per barrel delivered, stone and dust at $1.21 per cubic yard, labor 18¾ cents per hour, and 0.94 cubic yard of concrete per foot of 9-foot 3-inch sewer, the average cost of placing the concrete was as herewith tabulated.

Cost of Placing Concrete.

1.31 bbls. cement, $1.30	$1.703
0.84 cu. yd. stone, $1.21	1.016
0.42 cu. yd. dust, $1.21	.508
Labor at 18¾ cts., including foreman	.987
Setting forms and metal	.045
40 sq. ft. of metal, 4 cts	1.60
Plastering invert	.07
Cost of forms, 1800 ft., per foot	.082
Total	$6.011

This cost represents the total cost of furnishing and placing the materials comprising the sewer, the concrete costing $4.60 per cubic yard exclusive of setting forms or supplying the material for the forms.

The cost of furnishing, driving and cutting off piles was 30 cents per lineal foot of piles left in the ground, with the piles costing 8 cents per foot delivered. The cost of excavating in the deep cut, including the rock, has been $1.64 per cubic yard, including sheathing, underdraining and pumping, and the cost of excavating the trench through the marsh, including pumping, ditching, cofferdams, underdraining, superintendence, engineering, etc., has been $4.60 per cubic yard.

Cost of 9 ft. 3 in. sewer through marsh	$32.00
Cost of 9 ft. 3 in. sewer, average cutting 24.5 ft.	24.00
Cost of 6 ft. 6 in. sewer, average cutting 12 ft.	10.00
Cost of 5 ft. 0 in. sewer, average cutting 11.5 ft.	6.70

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS has announced its programme for the joint meeting with the Institution of Mechanical Engineers, of Great Britain, at Chicago, May 31 to June 3. Only one paper is promised on shop management questions, by Mr. Harrington Emerson, on the wages problem. Two relate to refuse destructors, by Messrs. George Watson and C. Newton Russell. The steam turbine will be the subject of four papers by Messrs. Francis Hodgkinson, E. S. Lea and E. Meden, W. L. R. Emmet and Prof. A. Rateau. Related to these is a paper by the Prof. C. V. Kerr, on "The Potential Efficiency of Prime Movers." The power plant of tall office buildings is to be discussed by Messrs. J. H. Wells and R. P. Bolton. The remaining papers on power-plant questions are as follows: Middlesbrough dock, electric and hydraulic power plant, by Mr. Vincent L. Raven; the use of superheated steam and of reheaters in compound engines, by Prof. L. S. Marks; and commercial gas engine testing, by Mr. Wm. P. Flint. The remaining papers are to be presented by Mr. Wm. J. Keep, on "Cast-Iron Composition, Strength and Specifications"; by Mr. Wm. Campbell on "The Effects of Strain and of Annealing"; by Prof. J. T. Nicolson, on "Experiments with a Lathe-Tool Dynamometer"; by Prof. E. A. Hitchcock, on road tests of locomotives, and by Prof. W. F. M. Goss, on locomotive testing plants.

Important Considerations in the Designing of Large Aqueducts.

In The Engineering Record of December 19, 1904, a brief summary was given of the report of the commission on an additional water supply for New York City. Appendix III. to this report, from which the following extracts are taken, contains a discussion on certain economies in construction and other improvements aimed at in the design of the cross-sections of the aqueduct proposed for conveying the additional supply of water into the city. The aqueduct is intended to have a capacity of about 500,000,000 gallons per day, and, as located by the preliminary surveys, will be partly in cut-and-cover and partly in tunnel.

These designs involve some novel features, based partly on previous works and partly on present studies. The proposed changes from existing types are, however, not extreme, and consist of certain modifications by which economy may be effected without any sacrifice of necessary strength or stability. This is especially the case with the design of the tunnel section.

The waterworks tunnels thus far built have generally been costly, averaging double or more than double the cost of an equal length of cut-and-cover work. The chief reason for this has been the costliness of the material used for lining and the disadvantageous arrangements that have been adopted for excavation, whereby unnecessary and useless work was performed at a high cost. In the Wachusett aqueduct, a considerable length of tunnel through firm rock was left unlined, and in consequence, built at a low cost. Circumstances are such that this method cannot often be adopted. A decided step toward greater economy in tunnel work was made in the Weston aqueduct by the use of Portland cement concrete as a tunnel lining. This material, so much cheaper than brick, has proved a conspicuous success for this purpose. By the proposed design, the cost of tunnel work is expected to average not more than about 1⅔ times the cost of cut-and-cover work.

The Weston aqueduct, in Massachusetts, is, without doubt, one of the most economical of all masonry aqueducts of its size now existing. It is almost identical in general design with the Wachusett aqueduct, built in the same State a few years before. Prior to the construction of the Wachusett aqueduct, the Sudbury probably represented the best type of cut-and-cover aqueduct construction in this country. The Old Croton aqueduct and the Cochituate aqueduct were the pioneers, but both of them have developed serious structural defects. By comparing the various sections of aqueducts built at different times, the approach to the horseshoe type of section is noted, which has become practically standard. The gradual introduction of concrete in the designs is also a matter of significance. Brick is being displaced and rubble masonry has almost entirely disappeared. In the Wachusett aqueduct brick was used for invert and side wall lining in the cut-and-cover sections, and for all tunnel lining. Brick was only used for invert and side wall lining in cut-and-cover sections of the Weston aqueduct, but concrete was used for tunnel lining.

The chief reasons for the retention of brick lining are: First—That it furnishes a hard, smooth inside surface of good hydraulic properties. Second—That it is necessary to supplement the natural cement concrete or rubble backing, formerly much used for the side walls and bottoms, with carefully laid brickwork, in order to obtain good watertight work. Third—The force of habit, or perhaps it would be fairer to say, the knowledge gained by experience that brick makes a very satisfactory lining.

Wilmington Sewer: The Nine-Foot Three-Inch Section with Expanded Metal.

All brickwork is expensive, especially when occurring in a four-inch lining. First-class bricklayers and scrupulously careful inspection are required. Hence the total cost of the small amount of brickwork is out of proportion to its actual value. The use of the brick, moreover, necessitates the retention of the horseshoe shape, as it is practically essential to build the side walls at such an inclination as will prevent the brick lining from tending to separate from the concrete backing. In the proposed section the brick is entirely omitted, different classes of Portland cement concrete being used wholly. It is expected that some economy will result from the entire elimination of the brick from the section, and an especial advantage will be obtained by substituting work performed by common labor for that performed by skilled labor controlled by labor unions of uncertain temper.

A serious objection heretofore to the use of large monolithic masses of non-reinforced concrete masonry has been the tendency to crack on account of elongation or contraction due to temperature changes. With an aqueduct of large diameter these cracks are liable to cause serious leakage and even become a source of danger. Some cracks, due to this reason, in the concrete arch of an aqueduct recently built, were observed to have a width of about ⅜ inch.

In the Wachusett aqueduct it was found that in general transverse cracks occurred in the arch at places where a day's work had terminated during construction. In the Weston aqueduct lead water stops were inserted at intervals corresponding with a day's work in laying concrete, to prevent leakage at these points. It was noticed, however, that when an interval between these water stops was longer than about 50 or 60 feet, cracks often developed between. The conclusion formed after studying these aqueducts is that a complete vertical transverse joint may judiciously be inserted at intervals of about 50 to 70 feet in any concrete aqueduct of large size. In forming these joints, paper or soft soap or some other suitable material may be used to prevent adhesion of the newly laid concrete to that of the section already built. Thus the aqueduct will consist of a series of short separate lengths, each of which will be practically independent. Leakage at the joints can be easily prevented by lead water stops built into the masonry.

It is proposed to shape the arch and side walls to a curve approximating a parabola, this shape more nearly coinciding with that of the true line of resistance of the arch under working conditions. The bottom inside corners are rounded in order to distribute the thrust of the side walls over a larger area, and also for hydraulic considerations. The inside thus more nearly approaches a triangular than a horseshoe shape.

The horseshoe type of tunnel was used in the New Croton, the Weston and Wachusett aqueducts. In the Weston tunnels concrete was used for a lining, but in the other two aqueducts, brick backed with rubble. The Wachusett tunnel was, for a large portion of its length, unlined except paving on the invert. The hydraulic qualities of the unlined tunnel were found to be so poor that it is necessary to run the aqueduct under a head in order to obtain its full capacity of flow. To obtain the same flow through two tunnels of the same slope, the one unlined and the other lined, it has been found to be necessary to use a waterway for the former approximately double the sectional area of the latter, with tunnels of the size under consideration. By smoothing up the rough surface of the rock excavation with concrete, the total cost of the tunnel will be as economical as if the lining were entirely omitted, and the general results will be much more satisfactory for obvious reasons.

The most economical section for tunnel excavation, in rock, in tunnels such as those under consideration approximates a rectangular shape. In driving these tunnels the first process is to make the heading cut or the upper portion of the excavation, and it has been found by experience to be so inconvenient to excavate a tunnel with a circular top that contractors will make considerable sacrifice to drive the heading with practically a level top. A sheet showing an actual average section of the rock excavation of the Wachusett Tunnel as compared with the prescribed line of tunnel excavation brings this fact out prominently. It is reasonable to infer that by adopting a section of tunnel approximating a rectangular shape, more economical unit prices will be obtained for excavation than with the circular section, and it will also be possible to make a profitable use of the whole section of excavation.

The hydraulic properties of the rectangular side lined tunnel will be satisfactory, and such that similar depths in the tunnel and the proposed cut-and-cover aqueduct will give flows of not unduly disproportionate amounts. With the side lined tunnel proposed, a skewback above the high water line will be left in readiness for the subsequent addition of a segmental concrete arch should it become necessary at any time.

This design of tunnel does not essentially vary in type under the different conditions which may be encountered in this class of work. It is proposed to use Portland cement concrete for the invert and side walls. At frequent intervals weepholes will be left at the bottom of the side walls, and there may be a longitudinal drain next to the rock, connected with the weepholes. By this means a head of water against the back of this side lining will be prevented. Three types of tunnel are shown in the report, practically identical in everything below the skewback. In the first the arch is omitted when the cut is through sound rock; in the second a 10-inch arch is turned in places where there is reason to suspect future danger of caving, although perhaps the roof may be quite stable at the time the tunnel is cut; the third provides for a cut through disintegrated, shattered and caving rock, and is built with heavy timber supports. The arch in the latter case is 18 inches thick and is designed to carry a load of about 12 tons per foot.

The proposed aqueducts have been designed to carry 500,000,000 gallons daily when flowing at a depth of eight-tenths of the inside vertical diameter. In computing the discharges, the formula, $V=C\sqrt{R S}$, was used. The data on which chief reliance was placed were those obtained from the careful gaugings of the Wachusett aqueduct, giving values of C corresponding to hydraulic mean radii of 3 and under. This curve of coefficients has been extended for higher values of R by paralleling the curve plotted from the original gaugings of the New Croton aqueduct, and was adopted for clean aqueducts. The highest value of C from this curve is 146.5, which is considerably lower than that given by Kutter's formula for values of N corresponding to a roughness equal to that of the Wachusett aqueduct. A comparison of the curves of coefficients of the Croton, Sudbury and Wachusett aqueducts and the Stony Brook conduit, shows the unmistakable tendency of these curves to flatten out for the higher values of R, and also the danger of estimating with higher coefficients than those shown by the curve adopted.

The Wachusett aqueduct is lined with brick for a depth of about 5 feet and arched with concrete. The bricks were laid with great nicety, and a true and smooth surface was obtained; the concrete arch was skim-coated with cement, and finished with a cement wash applied with a brush, each stroke of the brush being lengthwise of the conduit. The capacity of the Sudbury aqueduct has been diminished at times 13½ per cent. through the growth of slime on the inside surface, the Cochituate aqueduct as much as 11¾ per cent., and the Wachusett from 10 to 11 per cent. It has been considered advisable to allow for a diminution of 12½ per cent. in the carrying capacity of the open trench portion of the proposed aqueduct, as a safe margin on this account.

The lining of tunnels has been proved to be inferior in hydraulic qualities to cut-and-cover work. The New Croton aqueduct, practically an all tunnel aqueduct, shows materially lower coefficients than the Sudbury or Wachusett, although lined with the same material. The brick-lined portion of the Wachusett aqueduct tunnel has been found to approximate closely the Croton aqueduct in this respect.

In making an allowance for growth of slime in the tunnels, it has been considered that the carrying capacity of a tunnel which, when new, is much rougher than an open trench aqueduct, will not deteriorate so much as the latter. It is believed that the growth of slime inside an aqueduct retards the flow by an action differing essentially from that of a roughly constructed interior surface. The fine hair-like filaments of the organisms forming the slime, by an action akin to that of eel grass on a larger scale, act as a brake on the velocity of the whole prism of water without necessarily causing eddies or swirls in the current. On the other hand, roughly constructed lining, or on a larger scale a rough rock surface, will retard flow by causing eddies and swirls.

It is probable that the formation of slime on the sides of a rough unlined tunnel would not sensibly affect its carrying capacity, already extremely low; and by analogy, it seems fair to infer that with a lined tunnel of considerably rougher surface than a cut-and-cover aqueduct, the proportionate loss will be much less in the former than in the latter. Mr. Freeman found that in the Croton aqueduct, between Goulds Swamp siphon and Ardsley, the original capacity had apparently not been diminished more than 4 per cent. after many years' constant use, although in the upper portion of the same aqueduct the capacity had lessened much more. It has been considered sufficient to allow a reduction of 5 per cent. in the capacity of tunnels consequent upon the growth of slime. This will reduce the coefficients of both cut-and-cover aqueduct and lined tunnel to about the same amount when foul.

The formation of slime in unfiltered surface water takes place with great rapidity, and cannot be prevented or held much in check by yearly cleanings. The reduction of flows in the Sudbury, Wachusett and Cochituate aqueducts takes place very largely in the first few weeks after cleaning, and reaches a maximum after about four or five months' use; after that time apparently no appreciable increase takes place. As it is not practicable to clean and inspect an aqueduct oftener than at intervals of from six to twelve months, it is evident that the fouling due to slime formation will exist most of the time during operation to a greater or less extent. The larger and more serious obstruction will, however, be removed or prevented from forming at each annual or semi-annual cleaning.

The appendix from which these extracts have been taken were written by Mr. E. G. Hopson, the department engineer in charge of the studies relating to the aqueducts. The members of the commission were Messrs. William H. Burr, Rudolph Hering and John R. Freeman.

Price's Run Sewer, Wilmington: Forms for Invert and Arch of Six-and-a-Half-Foot Sewer.

A Steel-Tower Transmission Line, 100 miles long, serves for the support of conductors from the plant of the Guanajuato Power & Electric Company, Mexico. The towers weigh 1,500 pounds apiece and are of the four-post windmill type standing 40 feet above the ground on a base 8 feet square. About the top is a square wooden platform for the convenience of workmen. Each of the four legs carries a 3-inch piece of angle-iron which rests on the bottom of the post holes. The cross pieces answer both as supports and anchors. Three conductors are carried in the usual triangular formation. The top insulator pin is screwed on the end of a 3-inch iron pipe extending 6 feet above the top of the tower, and the two others are fastened to two 4-inch channels forming a cross-arm at the base of this pipe. The towers cost, in lots of 500, $53 apiece; including the insulators, with twelve towers per mile, the total cost is $690 per mile. A sag of 7½ feet is allowed between towers. According to Mr. L. A. Sanford, a gang of six Mexicans assembled three towers daily. As an average, 4 miles were strung, the slack pulled up, and the cables tied in at the insulators in a day. The main cables were not transposed, but the telephone wires, placed about 7 feet below the cross-arms, were transposed every two towers. A sag of 7½ feet was allowed between towers. Two to five mules were used to pull each cable. In rough country the slack was pulled up every mile and temporarily held with steel guys. In level country a two-mile pull gave good results.

A Mechanical Filtration Plant for Watertown, New York.—I.

Watertown is a community of about 23,000 inhabitants situated on the south side of the Black River about 10 miles from its point of discharge into the east end of Lake Ontario. For over twenty years this municipality has pumped its water supply from the river through an intake situated a short distance upstream from the town. Above the intake the river drains a watershed of 1,877 square miles, flowing by the town with a swift current due to the considerable fall in its bed. This water-power has been fully developed, and the water-works pumps are driven by water wheels, forcing the water for the city supply to a reservoir about 150 feet above the river level. The supply of water is drawn from the river above the second dam upstream from the pumping station, and the city's sewage is discharged into the river some distance downstream from the pumping station, so that there is no pollution of the supply from the city sewers. Several towns farther up the river, however, also discharge their sewage into the stream and there has resulted a gradually increasing degree of pollution.

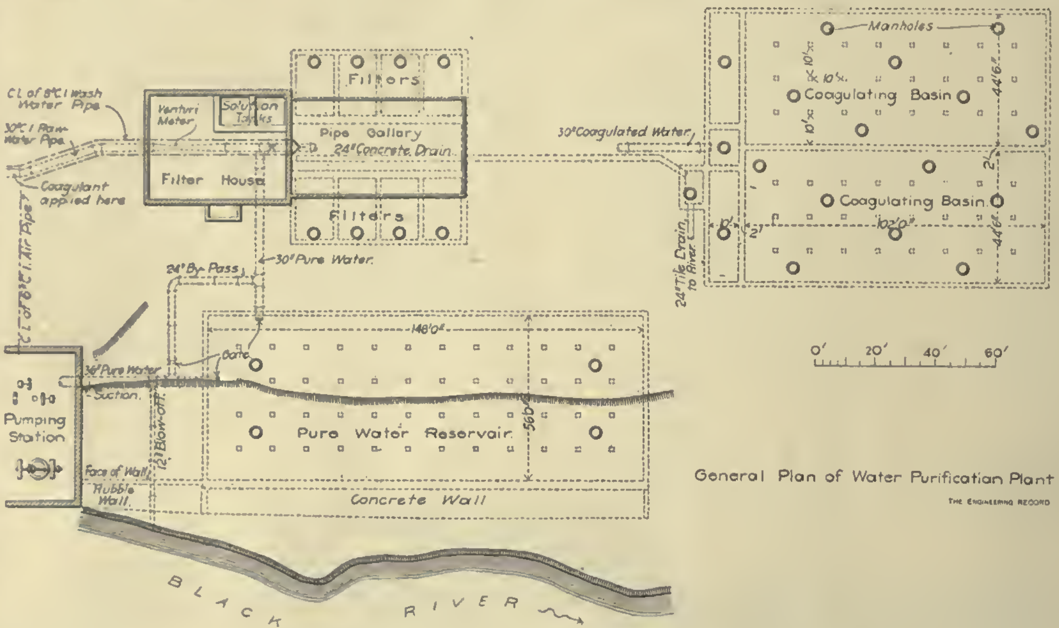
In 1901, Mr. Allen Hazen, of New York City, was retained to make a study of the water-supply situation and recommend means for improvement. He reported in favor of a mechanical filter plant to treat the water with the aid of sulphate of alumina as a coagulant. Drawings and specifications for such a plant were prepared in Mr. Hazen's office, and contracts for the construction and equipment of the plant were awarded in August, 1903. It was the intention to have the filters ready for service by July 1, 1904, but delays incident to the severity of the past winter have retarded the progress of the work. During the winter Watertown was afflicted with a serious epidemic of typhoid fever.

This plant is of the same type and of the same general arrangement as the plant built by Mr. Hazen and Prof. Williams at Ithaca, N. Y., and described in this journal August 29, 1903, although differing in some respects. Probably the most novel feature of the Watertown plant is the design of the rate controllers for regulating the flow of the effluent from the filters. These controllers have been tested by experiment; the loss of head demanded for their operation with the maximum discharge is only 9 inches, and they can operate submerged. The very small loss of head and the possibility of working submerged, that is, with the water in the filtered water reservoir above the level of the controller, permits a gravity arrangement of the plant. As the head available is limited the use of other appliances would have involved a second pumping of the water. Attention may also be directed to the effluent collector and air-pipe systems of these filters.

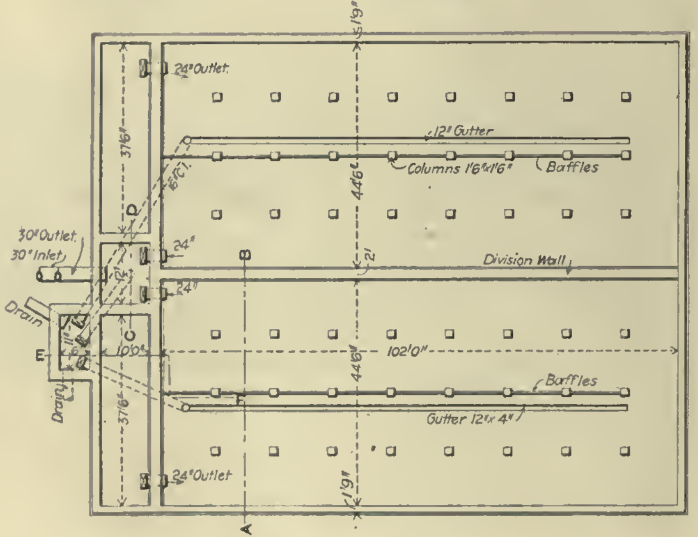
The filtration plant is located on the bank of the river close to the pumping station. Accompanying illustrations show the general arrangement and many of the details. The plant includes eight filters, each having a capacity for filtering 1,000,000 gallons per twenty-four hours; a coagulating basin divided into three sections, holding together 1,000,000 gallons; a filtered-water basin holding 800,000 gallons when full and 500,000 gallons at is usual level; a pipe gallery; an operating house containing an office, a laboratory, coagulating apparatus, and the necessary accessories. The principal structures are of reinforced concrete.

The river water is conducted from the intake to the pumping station through a 30-inch pipe line 2,600 feet long, which is being extended through the pipe gallery to the coagulating basin. The solution of sulphate of alumina will be introduced into this pipe at a point very near the beginning of the extension, and the water will then flow through a 30-inch Venturi meter. In this way advantage is taken of the mixing which will naturally occur in flowing through the pipe and the meter. From the coagulating basin the settled water will flow back to the filters through another 30-inch pipe, and the effluent will be conveyed to the filtered-water reservoir through a third 30-inch pipe. The filtered water may, however, be by-passed around the corner of the reservoir through a 24-inch pipe connecting into the 36-inch suction pipe from the filtered-water reservoir to the pumping station.

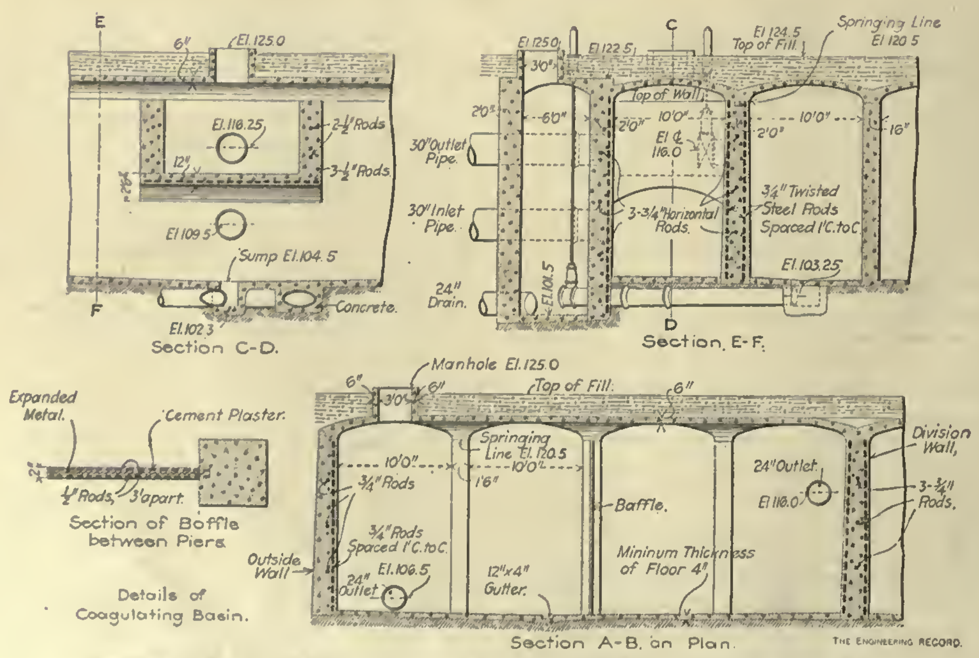
The existing pumps will be used for pumping the filtered water. There is abundant water power for the pumping. With the present arrangement of the station the pumps work against a pressure of about 80 pounds per square inch and will have a suction lift from



General Plan of Water Purification Plant



Plan of Coagulating Basins. (Roof removed.)



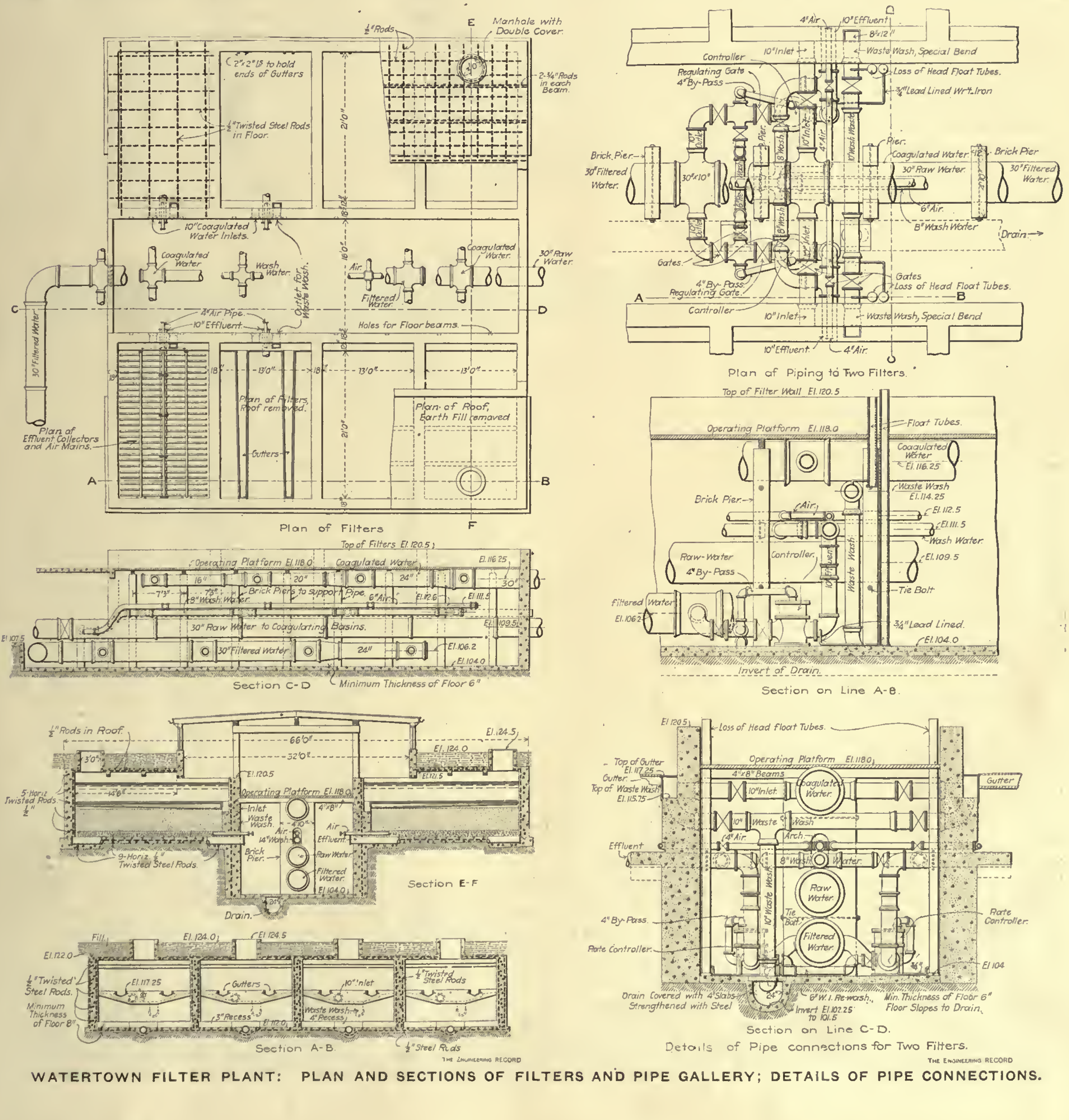
General Plan of Watertown Filter Plant; Details of Coagulating Basin.

the filtered-water reservoir of from 8 to 21 feet, according to the height of water in the reservoir. At a later date the pumping station may be remodeled and the pumps set at a lower level, so as to reduce the suction lift. The daily average consumption of the city is about 3,500,000 gallons. The raw river water is highly colored, but has practically no turbidity.

The site selected for the filtration plant is on the steep slope of the river bank, the natural surface of the ground having had a fall of nearly 25 feet in the 200 feet of the total width of the plant. There is but little soil over the limestone rock, so that practically all of the necessary excavation is in hard rock. This fact accounts for some of the features in the arrangement of the plant, which were designed to economize rock excavation. The presence of the rock makes it possible to use thin, flat concrete bottoms for the filter tanks, coagulating basins and filtrated-water reservoir, instead of the inverted groined-arch floors so familiar from the frequency of their occurrence on earth foundations. The rock is taken out as nearly as practicable to the required elevations and after trimming is leveled up with concrete. If, however, any depressions in the rock are over 8 inches deep, they may be filled to within 4 inches of the floor surface with lean concrete. The minimum thicknesses of the various floors are indicated on the drawings.

One of the long walls of the filtered-water reservoir is practically at the edge of the water at ordinary stages of the river and is therefore made very massive in order to resist floods with their burdens of ice and driftwood. This wall will be of concrete 1 foot thick at the top, on a level with the top of the earth filling over the reservoir roof, and about 12 feet thick at the bottom, its river face having a slope of 1 horizontal to 1½ vertical. The heel of the wall is in a groove 4 feet wide and 1 foot deep, cut into solid ledge, and is further secured by heavy steel dowels 3 feet long, 1½ inches in diameter, spaced 3 feet apart along the center line of the groove and sunk about 1½ feet into holes drilled into the rock. The lower ends of these dowels are split and wedged, and the holes in the rock are filled with sulphur. The upper ends of the dowels have large flat heads. The top of the wall is given additional security by embedding in the concrete ½-inch twisted steel rods 2 feet apart longitudinally, which are turned well down into the wall and extend through the whole width of the adjoining arch of the reservoir roof. One-man stones may be embedded in the concrete of this wall up to 20 per cent. of the volume of the wall.

All the structures underground are of concrete, with most of their walls, floors and roofs reinforced with steel rods, as indicated on the drawings. The operating floor and superstructure over the pipe gallery are of wood. The



WATERTOWN FILTER PLANT: PLAN AND SECTIONS OF FILTERS AND PIPE GALLERY; DETAILS OF PIPE CONNECTIONS.

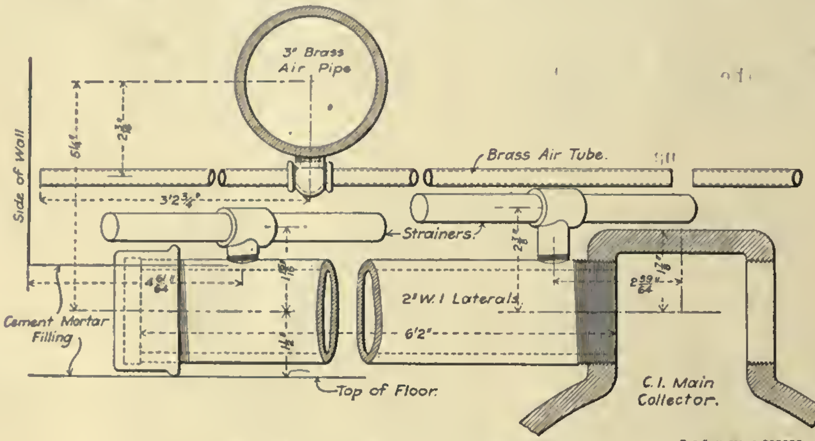
filter house has stone walls and a wooden roof covered with slate, and its main floor is of Ransome concrete-steel construction. In appearance the filter house will correspond with the pumping station. All the concrete for the coagulating basins and the filtered-water reservoir is being mixed in the proportion of 1 barrel of Alpha Portland cement, 11 cubic feet of sand, measured loosely, and 19 cubic feet of ballast, also measured loosely. For the filters and the coagulant-solution tanks the concrete was made in the proportion of 1 barrel Portland cement, 8 cubic feet of sand and 14 cubic feet of ballast. Sand for the concrete is obtained from a bank nearby and rock taken from the excavation is crushed for ballast. The principal dimensions of the structures are shown on the drawings. Wherever practicable and economical the outside walls are being built against the trimmed faces of the rock excavation.

The filters are grouped in two rows of four with the pipe gallery between, about 7 feet of the length of the filters of each row being covered by the superstructure over the pipe gallery. The remaining portions of the filters are to be covered by flat slab-and-beam construction reinforced-concrete roofs, with 2 feet of earth filling on top, sodded. There is one 3-foot diameter manhole in each filter. The roofs of the filtered-water reservoir and the coagulating basin are of the groined arch type so well known in filtration works, with a minimum thickness of 6 inches at the crowns. The pipe gallery is unusually commodious, the arrangement affording easy access to all the pipes and valves.

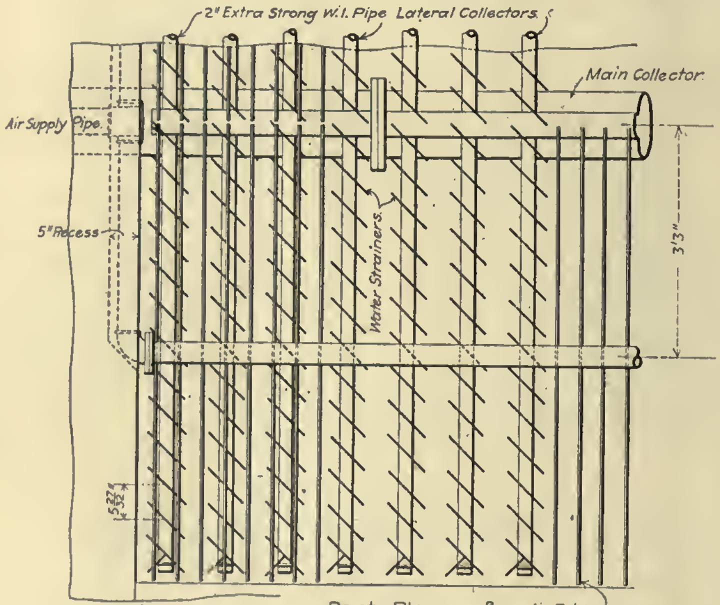
The greater part of the floor of the filtered-water reservoir is level at elevation 102, but in the two bays nearest the pumping station it slopes down to elevation 98.5, forming a hopper-shaped bottom with the apex at the end of the suction main. The suction main projects about 3 feet through the wall and is set with its bottom as close as practicable to the floor. By this arrangement it is feasible to empty the reservior to its bottom without drawing the water below the top of the pipe. Both the inlet pipe and the suction pipe are controlled by gates inside the reservior, with indicator posts standing above the earth filling over the roof.

The coagulating basin is divided into three quite separate chambers. The first chamber, 10 feet wide, extends across the full width of the basin at the end toward the filters, and is designated as the receiving and distributing chamber, since into it the 30-inch raw-water main discharges the water dosed with the coagulant solution and from it two 24-inch pipes, at opposite ends, as shown on the drawings, distribute the water at floor level to the other two chambers, in which the greater part of the subsidence takes place. Each subsidence chamber has a baffle or partition wall extending along its center line from the wall of the receiving chamber to within 10 feet of the wall at the opposite end. This partition consists of slabs of cement plaster reinforced with expanded metal and ½-inch twisted rods, supported by the middle row of roof piers, and reaches from the floor to the springing line of the roof arches. Each end of each slab or baffle is built into a 3x3-inch vertical groove in the pier. Each baffle is pierced by a rectangular hole 8 inches high and 12 inches wide at one of its lower corners, for the purpose of facilitating the removal of the matter deposited on the floor. On one side of the baffle partition in each chamber is a gutter 12 inches wide and 4 inches deep, formed in the concrete of the floor, which leads to a 16-inch cast-iron drain pipe buried beneath the floor. These two drains, together with one from the receiving chamber and another from the pipe gallery, are led to a drain well built against the outside of the end wall of the coagulating basin. From this well a 24-inch vitrified drain pipe leads to the river.

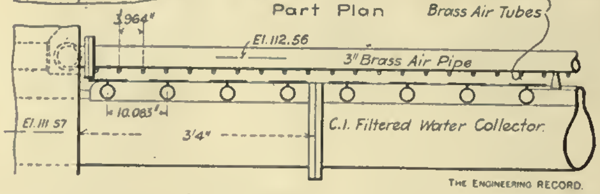
The settled water will be drawn from the subsidence chambers through two 24-inch outlet pipes, placed close to the division wall, with their center lines about 10½ feet above the floor. These pipes will discharge into an outlet box 10 feet wide, 12 feet long and 6½ feet deep inside, made of concrete and carried on an arch sprung between the two walls of the receiving chamber, as shown, at such a height as to have the tops of its walls at the springing line of the roof arches. A gate on each of these pipes inside the outlet box controls the flow from the subsidence chambers. From this outlet box the settled water enters the 30-inch main leading to the pipe gallery. In the gallery the diameter of this main is reduced successively to 24, 20 and 16 inches, as the pairs of 10-inch inlets are taken off to supply the filters on the opposite sides of the gallery.



Details of Collector and Air System.



Part Plan



Part Sectional Elevation.

Part of Strainer System.

Watertown Filter Plant: Effluent Collector and Air Pipe Systems.

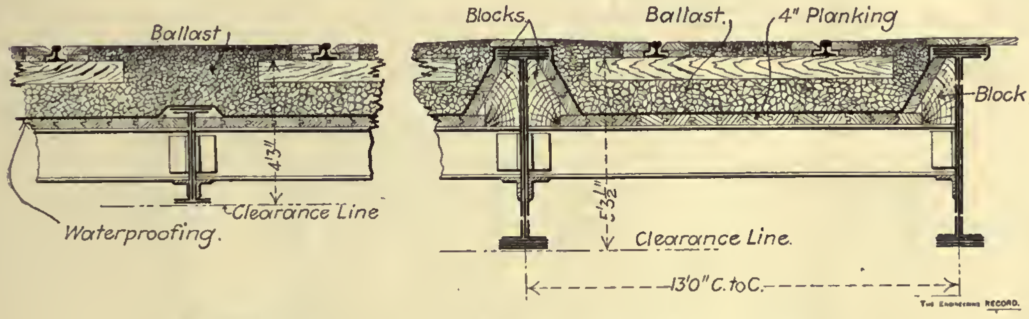
Each filter tank is 21 feet long and 13 feet wide inside and has a total depth of 8½ feet from the finished surface of the floor to the top of the wall separating the filter from the pipe gallery. The main collector is of cast-iron, in shape resembling a pipe with a monitor on top, as indicated by the large detail drawing, and is made in flanged sections about 6 feet long. The interior diameter of the body is about 6 inches at the upstream end; it increases to 10 inches at the downstream end of the second length, and is uniform beyond. The top is level so that the slope due to the change in diameter in the two sections is at the bottom. The monitor is uniformly 3 inches square in cross-section inside.

The laterals are 2-inch extra-heavy wrought-iron pipe screwed into the vertical sides of the monitor of the main collector, so as to make practically continuous lines across the filter; they are spaced 10.083 inches center to center and are capped at their extremities, about 2 inches from the face of the wall. The body of the main collector is buried in the concrete of the floor, along the center line of the filter, so that only the monitor projects above the floor surface. After the laterals shall have been laid, the spaces between them will be filled with fine concrete about 3 inches deep, covering the pipes to their tops and leaving exposed only the portion of the top of each lateral into which the strainers are screwed. The area of the waterway of each lateral is 2.9 square inches.

The strainers are of brass made up of a short tee, the nipple end of which screws into the top of the lateral, and two short pieces of pipe, screwed into the tee, with their outer ends closed. There are slits in each arm of each strainer, to admit the water, but narrow enough to exclude the sand. Each strainer is about 9 inches long and is set at an angle of 45 degrees with the axis of the lateral. The area of the waterway through the throat of each tee is 0.0706 square inch, excepting in the strainers at extremities of the laterals, which have three arms, or tubes, and an outlet area of 0.1018 square inch. The strainers are spaced 5 27/32 inches apart on centers along each lateral and arranged as indicated in the detail drawing.

There are 600 two-tube and fifty three-tube strainers connected to the twenty-five lines or pairs of laterals in each filter bed. The strainers, except those next the main collector, stand only 1¼ inches over all above the tops of the laterals; those next to the collector are set 7/16 inch higher, so that their ends may project over the top of the monitor. With this system of strainers the inlet openings for the effluent are so distributed that it is believed a very uniform flow of water through all parts of the sand bed is obtained.

The air for agitating the sand during the process of scrubbing the filters will be supplied through a system of piping, all of brass, entirely distinct from, and in no way connected with, the effluent collectors. A No. 2 Root blower, to be installed in the pumping station, will force air under the required pressure through a 6-inch cast-iron main extending to the farther end of the pipe gallery. From this main a 4-inch branch will be taken through the wall of each filter just above the main collector and will end in a tee. Each way from this tee, in a 5-inch recess formed in the inner face of the wall, will extend a 3-inch pipe to the center line of the space between the main collector and the adjacent side wall of the filter, and from an elbow at each of these points a straight and level 3-inch pipe will be laid the full length of the filter. These pipes will be supported on small cast-iron chairs standing on the concrete filling between the laterals so that their center lines will be about 1 foot above the center line of the main collector, or 5¼ inches above the center lines of the laterals, and their tops will be about 6 inches above the surface of the concrete filling.



Ballasted Plank Floor for a Railroad Bridge in Cleveland.

The outlets for the air are not in the tops of the 3-inch distributing pipes just described, but in their bottoms, thus differing from the usual practice heretofore. At intervals of 3.964 inches close tees are tapped into the pipe, and from these tees 5/16-inch inside diameter tubes extend horizontally in each direction perpendicularly to the center line of the 3-inch pipe, one to the wall and the other to the center line of the filter. The clearance at the wall is ¼-inch and that between the ends of the tubes meeting over the main collector is ½ inch. There will be sixty-three pairs of tubes connected to each 3-inch pipe, thus making 252 of these tubes in each filter. There are sixteen slots in each tube with a combined air opening of .0255 square inch, giving a total area of air openings of 6.4 square inches in each filter; the ends of the tubes are closed. The total cross-sectional area of the tubes is 19.3 square inches. The center lines of these tubes will be only 2 inches above the surface of the concrete filling between the collector laterals, which will be the real surface of the finished floor.

After the air system is finished, three 2-inch layers of gravel will be placed in the bottom of the filter, just covering the 3-inch air pipes. The gravel in the bottom layer will pass a screen of two meshes per linear inch and be held on one of four meshes; the second layer will pass four meshes and be held on eight, and the top layer will pass eight and be held on sixteen. On the gravel will be placed to a depth of 3½ feet sand having an effective size of 0.35 millimeter and a uniformity coefficient of 1.5 after washing. Sand and gravel of satisfactory quality for the filters will be gotten from a bank nearby.

Across the inside face of the front wall of each filter, just above the level of the sand surface, there is a gutter 12 inches wide formed in the concrete, of the shape indicated on the drawings. The side of this gutter next to the sand is a ¼-inch steel plate bolted to the face of the wall, set with its top edge exactly level and 1 foot above the sand surface. To this plate are connected two tapering steel gutters extending the full length of the filter and having their top edges level at the same elevation as the top of the plate. These gutters are intended for the removal of the dirty water when the filter is being washed. They discharge into the concrete gutter in the front wall, from which a 10-inch cast-iron drain pipe leads through the wall to a vertical pipe discharging into the concrete drain beneath the pipe-gallery floor. The waste wash pipes for opposite filters are combined into one vertical pipe. The front gutter also aids in distributing the coagulated water as it enters the filter.

(To be continued.)

The Bracing of Poles for Electric Transmission lines by means of head guys from one pole to another appears useless as a protection against windstorms. At a recent meeting of the Chicago branch of the American Institute of Electrical Engineers, the statement was made that a pole line protected by head guys had entirely gone down while pole lines alongside of it protected by side guys had remained intact.

Gas-Engine Driving of Electrical Machinery, where the synchronous operation of alternators is desired, can be improved by the use of a turbo-alternator set in parallel with the gas-engine unit. This suggestion is made in an instructive paper on power-plant design by Messrs. C. H. Merz and W. McLellan, before the Institute of Electrical Engineers, on the assumption that the turbine unit will act as a sort of fly-wheel and steady the whole system. They have adopted the arrangement in the case of a power station by them.

A Ballasted Railroad Bridge with a Plank Floor.

A through plate girder bridge recently designed to carry the tracks of the Erie Railroad over a street in Cleveland has a ballasted floor contained in wooden troughs between the girders. The construction is very simple, as shown in the accompanying sections, and consists, for the 60-foot spans, of 18-inch 55-pound I-beams about 16 inches apart riveted to the girder webs and carrying a solid floor of tongued and grooved 4-inch creosoted pine planks. Inclined side planks of the same thickness are fitted under the top flanges of the girders to retain the ballast and keep it clear of the girders. The upper surface of the floor and side planks and the top flanges of the girders are waterproofed by several layers of tar paper and hot asphalt. The floor beams are set on grade so as to give the planks a drainage pitch to one end of the bridge. The troughs are filled with stone ballast leveled up to the tops of the rails, which are about level with the cover boards bolted to the top flanges of the main girders to protect the waterproofing there. The top flange rivets are countersunk so as to afford continuous bearing for these planks. The shorter deck spans have the floor boards just clear of the under side of the top flanges of the main girders, above which the ballast is filled in continuously from one track to the other. This bridge has not yet been constructed, but is essentially like the design which has been used for a number of years in some other places including a large number of crosings for the tracks of the Chicago & Western Indiana Railroad. The design produced herewith was made by the Erie Railroad Company, Mr. M. R. Strong, bridge section engineer.

There are a large number of wooden floor bridges of this character in Chicago, which differ slightly from the accompanying illustration in the details of the flooring and waterproofing. A number of them have the floors calked with oakum and covered with three thicknesses of Hydrex waterproofing felt, which weighs about 16 pounds per unit of 100 square feet. It is laid from the lower to the upper end of the span, shingle fashion, each course being 3 feet wide and extending continuously across the floor. Each course laps 24 inches over the upper edge of the preceding course and is flashed up a few inches at each end, where it is cemented to the vertical web of the through plate-girder. The felt is laid in hot Hydrex waterproofing compound and is covered with a sand cushion about 8 inches thick, which precedes the stone ballast. The joint between the upper edge of the flashed felt and the girder web, although thoroughly cemented, was found to be the weak point in the construction on account of the vibrations from the constant heavy traffic. It is now protected by riveting just above it a horizontal bent strip of rolled steel about ¼ inch thick. This strip resembles an angle with a very oblique root and forms an inclined apron covering the edge of the felt and deflecting any water from above, so that it will be discharged over the horizontal portion of the felt. This prevents any possibility of water soaking into the upper edge of the flashing, even if it becomes loosened, and protects the felt there. In order to guard against the possibility of having the felt punctured by the carless use of picks and shovels, it has been recommended to cover it with light boards, under the ballast. The felt and cement are put on the market by Messrs. F. W. Bird & Son, East Walpole, Mass. Mr. E. W. DeKnight, their New York representative, claims for this type of floor that it is considerably cheaper in first cost than an all-steel floor, that it leaves all of the steel work, except the bearing, for the creosoted timber, exposed for inspection and painting; that it is an excellent sound deadener, and that it affords perfect waterproofing.

The Fraser River Bridge.

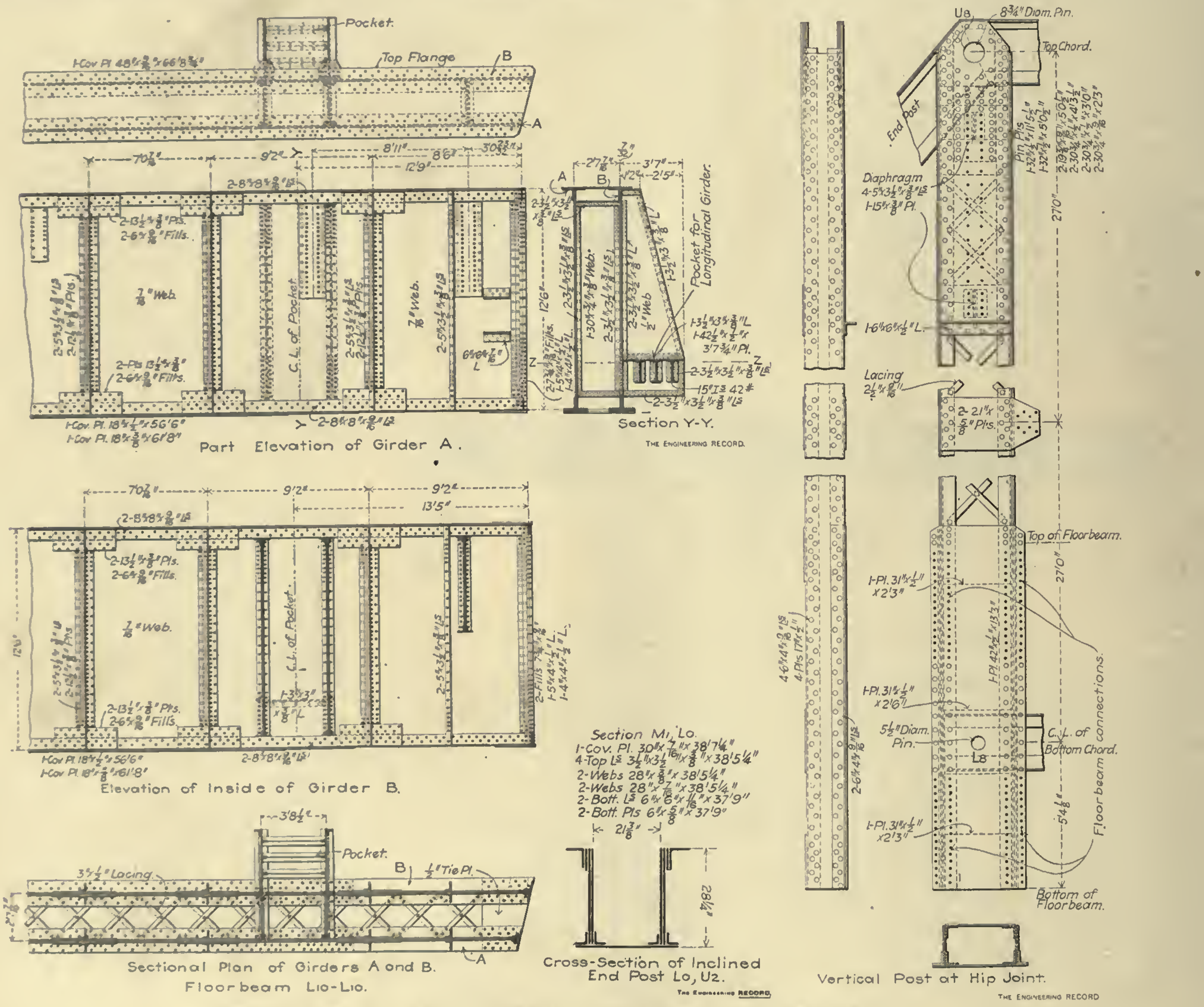
Part IV.—The 225-Foot Span.

The 225-foot span on the west side of the river has its center line in the axis of the bridge and carries on it the elevated highway floor, and at the lower chord level carries two divergent curved railroad tracks which are 117 feet 9½ inches apart at the shore end and have their center lines tangent at the river end. To accommodate this arrangement of tracks, the main trusses of the bridge have their center lines at an angle and are 20 feet 6 15/16 inches apart at one end, where they are supported on a single pier, and 135 feet 6 inches apart at the opposite end, where they are supported on two separate piers. The pin-connected Pratt trusses correspond in most respects to those of the other spans in this bridge, except that they have special vertical posts and built bottom chords without eye bars. They are 54 feet deep on centers and are made with five main panels 46 feet 5⅜ inches long, which are divided by verticals, horizontals and sub-diagonals.

The lower chords are connected at main panel points and at the sub-panel point nearest the river end by plate-girder floor beams, which, at the shore end, have unusual dimensions and special construction. The floor beams carry double pairs of oblique stringers, which are web-connected to them, and the panels between floor beams are thoroughly braced with main diagonals and secondary systems of riveted members to take lateral stresses. There is no system of horizontal diagonal members to form lateral trusses with the top chords, as the distances between the latter are so great that such members could not be advantageously designed. Transverse rigidity is secured and stability is provided for the main trusses by stiffening each top chord laterally, by connecting them with horizontal transverse struts at the tops of the inclined end posts and by providing heavy portal braces, as shown in the plan and cross-section diagrams.

A lattice-girder truss 11 feet deep and 10½ feet from the center line of the main truss is braced to the latter with transverse and zigzag members so as to form, with the top chord of the latter, a horizontal truss designed to resist the calculated wind pressure. The tranverse struts connecting the main trusses at both ends are made up of pairs of lattice-girders thoroughly braced together in the horizontal planes of their top and bottom chords. The longitudinal trusses EE which give lateral rigidity to the main trusses have T-shaped top and bottom chords each made with pairs of 7x3½-inch angles and 18x½-inch web plates. The web members are pairs of 6x4-inch angles, and all connections are riveted. At the ends opposite the tops of the inclined posts they have solid web plates 5½ feet wide, which are spliced with portals PP in the planes of the inclined posts. Each portal has one strut continuing the line of the top chord of truss E to a point near the foot of the inclined post. It is made with four 5x3½-inch angles, and, with the zigzag braces of the end post, trusses the latter.

The transverse strut at the river end of the bridge has two lattice-girders, C and D, each of them consisting essentially of an upper transverse strut connecting the top chords of the horizontal trusses and kneebraced from its center point to the lower chords of the trusses. Both girders have solid web plates at the ends which, in girder D, are extended to connect with the main trusses. The girders are connected by zigzag braces in the planes of the top and bottom chords. The strut at the shore end has two girders A and B braced together with zigzag members in the planes of the top and bottom chords, so as to virtually make a skeleton rectangular tube. The main girder A has heavy T-shaped flanges made with pairs of 7x3½-inch angles and 18x½-inch web plates. The web members are pairs of 5x3½-inch angles and all connections are riveted. At the ends

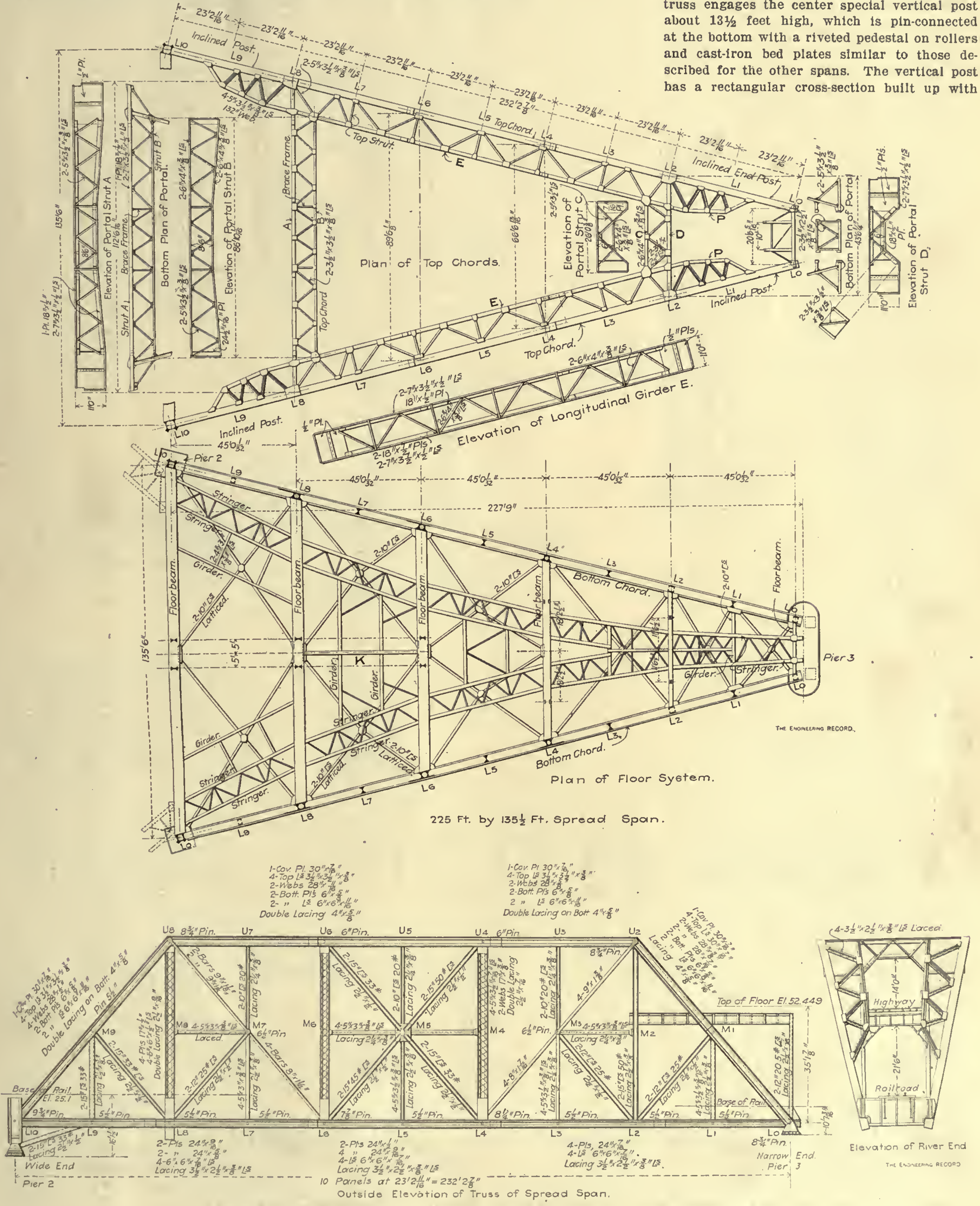

Pocket.
Top Flange
B
A
Part Elevation of Girder A.
7/8" Web.
C. L. of Pocket
Pocket for Longitudinal Girder.
Section Y-Y.
THE ENGINEERING RECORD.
Elevation of Inside of Girder B.
7/8" Web.
C. L. of Pocket
Section M1, L0.
1-Cov. Pl. 30"x 7/16"x 38'7¼"
4-Top L's 3½"x3½"x 3/8"x 38'5¼"
2-Webs 28"x 3/8"x 38'5¼"
2-Webs 28"x 7/16"x 38'5¼"
2-Bott. L's 6"x 6"x 1/2"x 37'9"
2-Bott. Pls 6"x 5/8"x 37'9"
Pocket.
½" Tie Pl.
3½" Lacing
Sectional Plan of Girders A and B.
Floorbeam L10-L10.
Cross-Section of Inclined End Post L0, U2.
THE ENGINEERING RECORD.
U8
8¾" Diam. Pin.
Top Chord.
End Post
Diaphragm 4-5x3½x3/8 L's 1-15x3/8" Pl.
Lacing
Top of Floorbeam.
5½" Diam. Pin.
L8
C. L. of Bottom Chord.
Floorbeam connections.
Bottom of Floorbeam.
Vertical Post at Hip Joint.
THE ENGINEERING RECORD

Fraser River Bridge: End Floorbeam and Vertical Post of the Spread Span.

the top and bottom flanges are connected by ½-inch web plates about 14 feet long, which connect to the stiffening trusses E and to the main trusses. Girder B is connected to the stiffening trusses only and is made much lighter. Each flange is made with a pair of 6x4-inch angles and the web members are pairs of 5x3½-inch angles. Both girders have horizontal top flanges and tapered bottom flanges, which reduce the depth from 11 feet at the ends to 8 feet 6 inches at the center. The lower chord panel points of the longitudinal girders EE are kneebraced with pairs of angles which engage transverse connection plates on the vertical members and extend to the top chords and to connections near the centers of the vertical posts, thus rigidly bracing the bottom of the longitudinal truss.

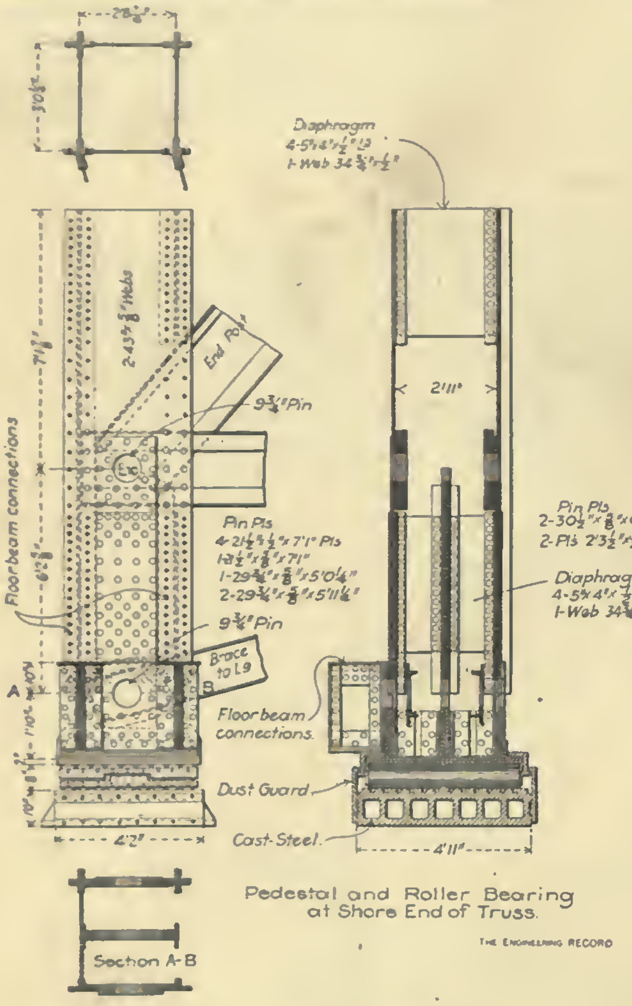
The bottom laterals are arranged so as to make angles of about 45 degrees with the trusses. Most of them are pairs of 10-inch channels from 28 to 40 feet long, approximately, with their flanges turned inwards and connected by tie plates. The ends are field-riveted to horizontal connection plates engaging the trusses, floor beams and stringers.

The lower chord pin at the shore end of each truss engages the center special vertical post about 13½ feet high, which is pin-connected at the bottom with a riveted pedestal on rollers and cast-iron bed plates similar to those described for the other spans. The vertical post has a rectangular cross-section built up with



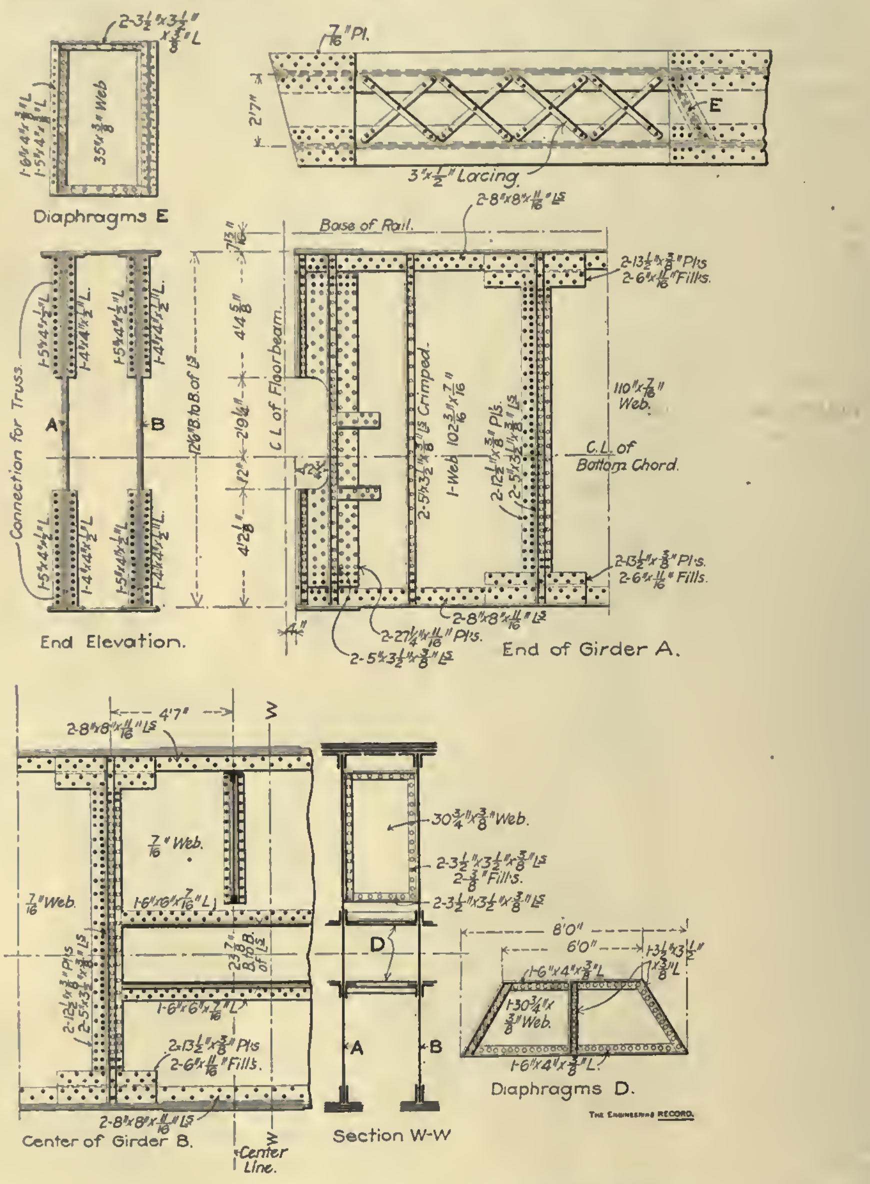
FRASER RIVER BRIDGE: PLANS AND ELEVATIONS OF THE SPREAD SPAN.

four web plates and sixteen chord angles, including the bent angles which are field-riveted to it over the floor beam connection. The pin through the foot of this post engages the lower end end of an inclined strut reaching to the foot of the nearest sub-vertical post and serving as a kneebrace to stiffen the post and prevent any rocker action. Vertical post L8 U8 has a special rectangular cross-section and virtually consists of two plate girders with their webs perpendicular to the axis of the bridge. The lower part of it is continued to 5½ feet below the center of the lower chord pin and receives the flange connection to the lower part of the floor beam. This floor beam is 12½ feet deep and 4 feet wide with double webs which are notched to clear the lower chord pin. Vertical post L6 U6 is similar to L8 U8, except



Pedestal and Roller Bearing at Shore End of Truss.

The Engineering Record



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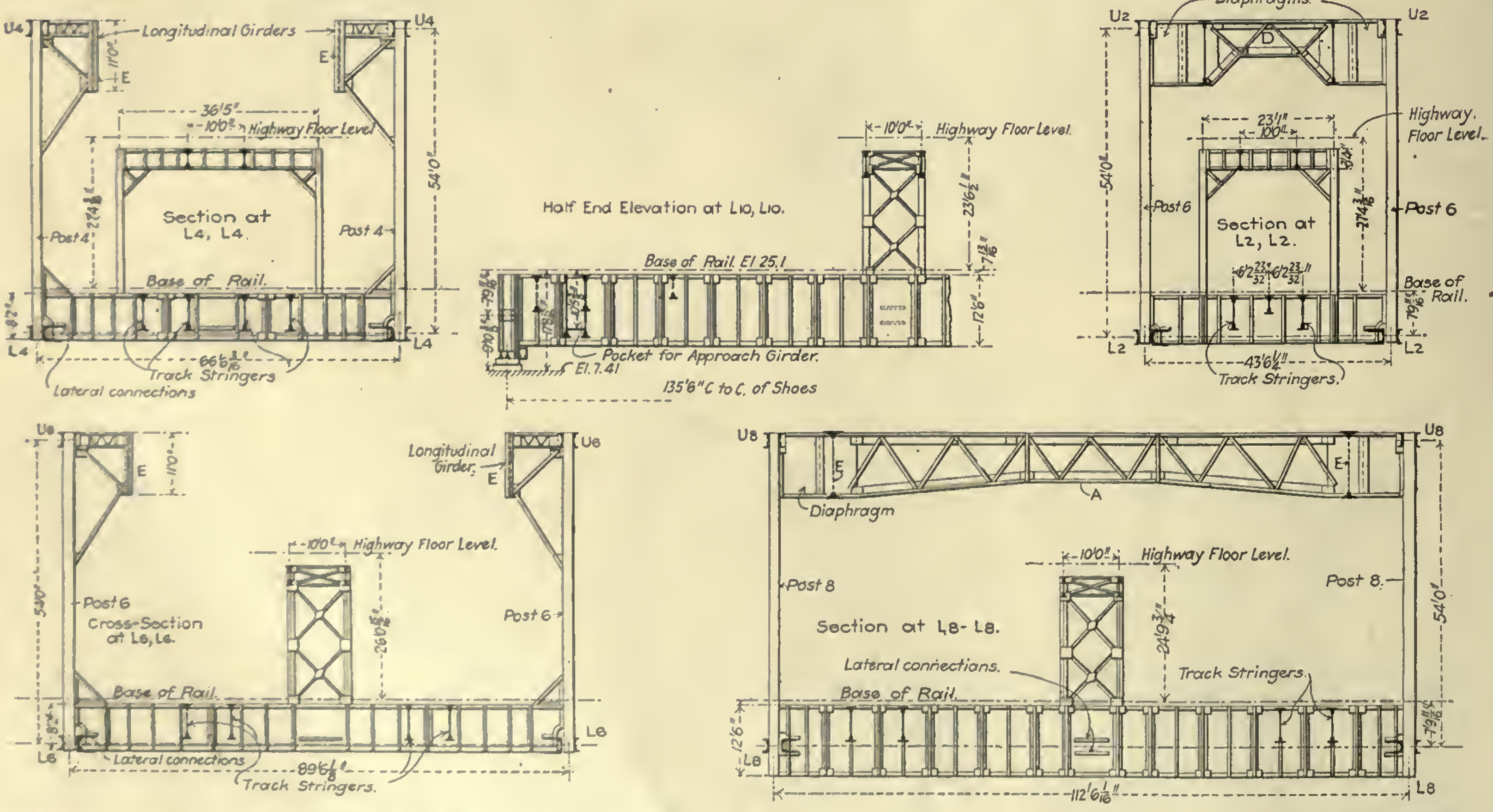
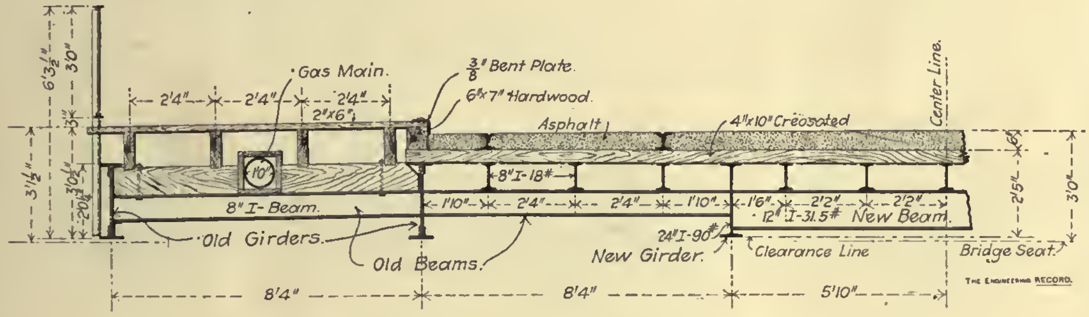


The Engineering Record

FRASER RIVER BRIDGE: TRANSVERSE SECTIONS, TRUSS PEDESTAL AND DOUBLE-WEB FLOORBEAM DETAIL OF SPREAD SPAN.

that it is lighter and does not project below the lower chord. It is made with two built channels having 17-inch webs and 5x3½-inch flange angles. In the lower part of the post the channels have double flanges on the inside to receive the outer vertical rows of rivets in the double-web floor beam. Vertical post L4 U4 is similar to L6 U6, but is still lighter and carries a double-web floor beam 8 feet 2 inches deep and 3 feet wide over all, which has every corner of the web notched to clear the chord pins and has the end sections of the web projecting above the top flanges to lengthen the connection to the vertical post.

The other vertical posts and sub-verticals, the horizontals and the diagonols are of ordinary construction, as indicated in the general elevation. The connections of web members at the center of the middle panel are all mitered and are field-riveted between a pair of 55x¾-inch connection plates 61 inches long that engage both flanges of all intersecting members. The end posts and top chords are of ordinary rectangular through sections with reinforced web plates and double top flange angles and filler plates under the bottom flange angles, as indicated in the detail of the cross-section. The end posts are spliced just below the middle pin, where there are double plates shop-riveted to the webs and flanges of the lower section of the member to form jaws receiving the upper section which is field-riveted to them. The bottom chord is made throughout with two built channels connected on the top and bottom flanges with tie plates and angle-iron lattice bars. The chord is spliced with double web and flange plates shop-riveted to one section and field-riveted to the other.



Half Section.

A Durable Wooden Floor for a Bridge over a Railroad.

The most interesting members in the bridge are the enormous floor beams which support the track stringers from the divergent trusses. Floor beam L11 L10 at the shore end is nearly 134 feet long over all and is essentially a double plate-girder 12½ feet deep, with two 7/16-inch webs 2 feet 7 inches apart on centers. Each girder has two 8x8/16-inch angles in each flange. The top flange has a single full length 48x9/16-inch cover plate field-riveted to both girders. The bottom flanges each have two separate 18-inch cover plates, which extend to within about 10 and 13 feet of the ends. The bottom flanges of the girders are connected by 3x½-inch intersecting lattice-bars and by end tie plates, all field-riveted in place. The webs are made in sections from 84 to 110 inches long, stiffened in the middle with single vertical 5x3x½-inch crimped angles on each side. The ends of the web plates are faced and are spliced by pairs of cover plates and stiffener angles, as shown in the detail. At the upper and lower flanges these splice plates are made longer to contain additional rivets. The splices in the flange angles are staggered and are made with 8x8x½-inch cover angles 4 feet 7 inches long.

The two girders of each floor beam are connected by the top cover plate, bottom latticing and by a pair of vertical transverse diaphragms near each end, as shown in the detail. These diaphragms are in the planes of gusset plates which project from the shore side of the floor beam to form a double web bracket with an I-beam, making a pocket in which the pedestals for the first span of the approach girders are seated, as previously described. This floor-beam was assembled complete in the bridge shop yard and all joints were carefully reamed and match-marked. Afterwards they were taken apart and the flange angles, cover plates and web sections were shipped separately, so that all splices and all flange connections were field-driven, involving a great amount of riveting at the site. This floor beam has a total weight of about 180,000 pounds, and its great dimensions and peculiar construction were very impressive when it was assembled at the shops. The detail given of one end shows the characteristic construction, which corresponds with the rest of the floor beam.

Floor beam L8 L8 resembles L10 L10, but is only about 112 feet long. The ends are notched to clear the lower chords of the trusses, above and below which they are flange-connected to the vertical post. At the ceter there is a connection for the longitudinal plate girder K, in the plane of which there is a diaphragm connecting the webs of both girders. Just below this diaphragm there was a pair of horizontal diaphragms in the planes of the outside connection plates, between which the lower lateral braces are field-riveted. This floor beam was also shipped with the flange plates and angles and the web sections separate, and all field-riveted together in place.

Floor beam L6 L6 is about 86 feet long and 8 feet 4 inches deep over all. It has two webs 2 feet 7 inches apart on centers and is made with 8x8-inch flange angles. Each girder has three 18-inch bottom flange reinforcement plates and the top flanges have three 48-inch cover plates, from 44 to 65 feet long. The bottom flanges are latticed together and the ends of the girders are notched to clear the lower chords, and have their webs extended above the top flanges to give long connections on the vertical posts similar to those in ordinary railroad bridge floor beams. Each girder was made in two sections with web and flanges spliced by field-riveted cover plates and cover angles. The four main pieces and the top flange cover plates were shipped separately, and the total weight of the floor beam was about 110,000 pounds.

Floor beam L4 L4 is about 65 feet long and 8 feet 4 inches deep over all. It is similar to floor beam L6 L6 and has two 7/16-inch webs 23 inches apart on centers. The flanges are made with 6x6x¾-inch angles and are reinforced on the bottom with separate 12½-inch plates and on the top with 36-inch plates riveted to both girders. This girder was shop-riveted throughout, and weighed about 62,000 pounds.

Floor beam L2 L2 is a single-web plate girder about 40 feet 9 inches long with a 98x7/16-inch web and 8x8x¾-inch flange angles reinforced by two 18x11/16-inch top and bottom plates. Pairs of long track stringers which reach from floor beam to floor beam resemble plate-girder spans and have a uniform depth of 71 inches. They are made with the top chord composed of four 6x6-inch angles without cover plates and a bottom chord made with two 6x6-inch angles and two 16-inch cover plates. The details of these girders correspond to those illustrated for the approach spans. They are connected together by sway-brace frames and by zigzag top lateral angles riveted to the lower angles in the top flanges. The main system of bottom lateral diagonals is riveted to the lower flanges of the girders at intersections. The ends of the girders are beveled and are field-riveted through the flanges of their vertical web stiffener angles to the floor beam webs in the usual way.

The bridge was designed and its erection supervised by Messrs. Waddell & Hedrick, Kansas City Mo. The Dominion Bridge Company, Montreal, Mr. Phelps Johnson, manager, was the contractor for its fabrication and erection.

A Durable Wooden Bridge Floor.

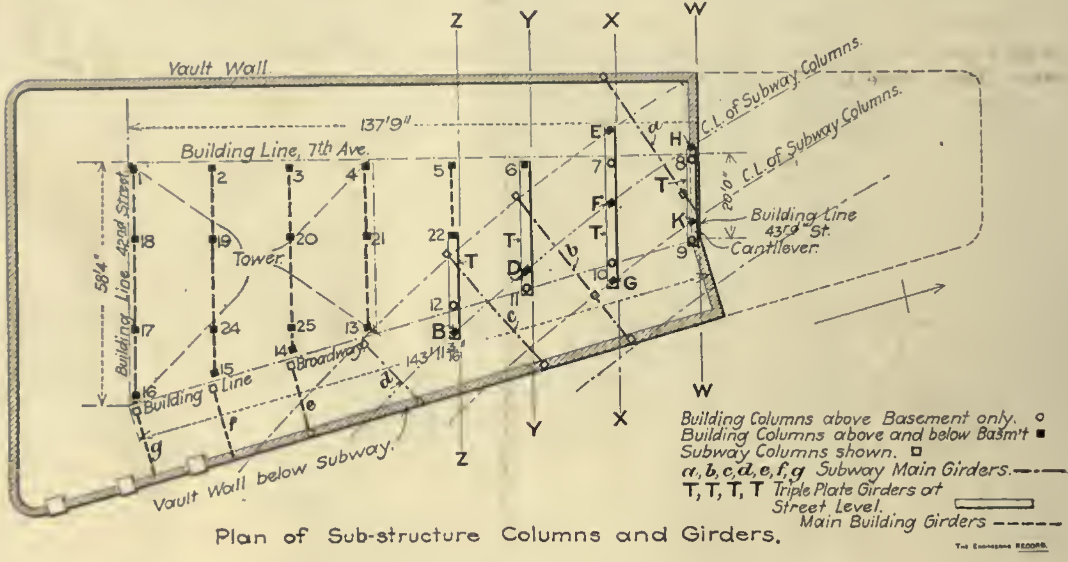
The Clarissa street bridge in Rochester, N. Y., is slightly skewed and carries a highway, two street-car tracks and two sidewalks over the tracks of the Erie Railroad, where switching engines are frequently passing and the structure is exposed to the exhaust and other gases from them. The bridge originally consisted of four 24-inch plate girders 31½ feet long over all supported at both ends on abutment walls 28 feet apart in the clear and carrying 8-inch I-beam floor beams. It was found necessary to reconstruct, enlarge and strengthen it, and the abutments were extended and the old girders were separated, the two each side of the center being moved out equally until each inner girder was 14 feet 2 inches from the center line of the bridge. Two new 24-inch 90-pound I-beams were then placed between the old girders and parallel to them, each being 5 feet 10 inches from the center line. The new girders were connected by 12-inch I-beams about 8 feet apart in line with the old 8-inch I-beams connecting the old girders. This arrangement provided new and heavier supports for the carriage road and street-car tracks and left the old light girders and beams to carry the sidewalk, as indicated in the half cross-section. I-beams from the old structure were also used as longitudinal joists under the roadway and the sidewalks were carried on wooden joists blocked up from the floor beams. The roadway platform was decked with a solid floor of 4x10-inch creosoted pine planks, on which was laid a waterproof course of heavy tar paper and the standard asphalt pavement. This work was done in December, 1897, and a recent letter from Mr. E. A. Fisher, city engineer, to Mr. M. R. Strong, engineer of bridges, Erie Railroad Company, states that the bridge is now in excellent and satisfactory condition, the floor not having been renewed since built.

An Illuminated Map of the United States 40x25 feet in size, forms the central feature of the exhibit of the Electric Storage Battery Company, of Philadelphia. It is intended to show the location of the 1,700 battery installations made by this company. Each one is indicated by a spot of isinglass about 1 inch in diameter. Red lights are for railway plants; blue lights for Edison plants; white lights for telephone and telegraph; green lights for isolated plants.

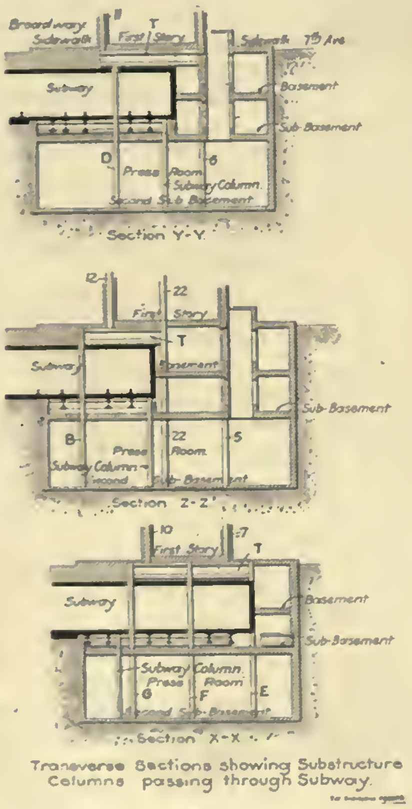
The New York Times Building.

Part II.—General Design of Framework, Loads and Stresses, Relation of Substructure to Subway, Column Grillages and Piers.

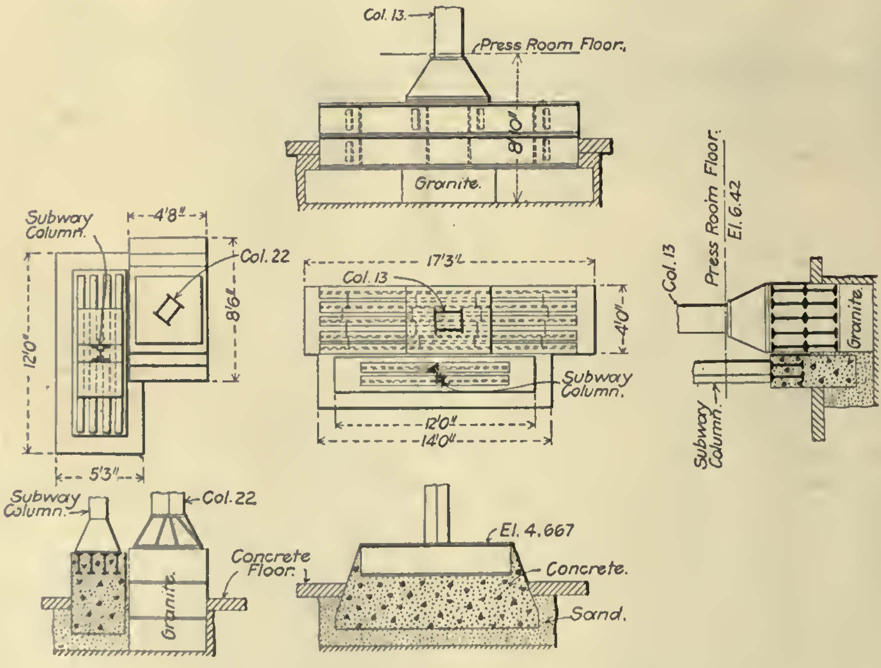
The basement floor is proportioned for a live load of 150 pounds per square foot and the subbasement for 250 pounds. All other floors have 90 pounds live load, and all floors have a dead load of 85 pounds per square foot, except where special provision is made for machinery in the gallery of the 16th-floor composing room and for future loads in the tower, which were assumed to be equal to double the ordinary floor loads. The columns are proportioned as is customary in New York for a full floor load in the upper story and for a diminution of 5 per cent. in each succeeding floor load downward until only 50 per cent. of the maximum lower story loads are considered to be transmitted to the columns from the lowest floors. The total steel weight of the building is about 3,000 tons. The foundation pressures are limited to the maximum load of 275 pounds per square inch allowed on the concrete footings. Wind pressure is calculated at the greatest intensity which it is possible for the building to sustain, that is, it is assumed to be sufficient to just overturn the building by revolution around the lee foundation. This is about equivalent to a uniform pressure of 20 pounds per square foot over the whole of the exposed vertical surface, and thus falls short of the 30 pounds per square foot nominally required by the Building Department, but which it is manifestly impossible to attain in a building of this character. The columns are proportioned for maximum stresses of 11,500 pounds per square inch and 13,000 pounds per square inch in the lower and upper stories, respectively, for dead loads. Unit stresses 50 per cent. greater are allowed for proportioning the additional section required to provide for the vertical components of wind strains. I-beams and riveted girders are proportioned for maximum flange stresses of 16,000 and 14,000 pounds per square inch, respectively.



Plan of Sub-structure Columns and Girders.



Transverse Sections showing Substructure Columns passing through Subway.



Typical Foundations for Subway and Times Columns.

The Times Building, New York; Horizontal Section below Street Level, Sections of Substructure, and Foundations for Columns.

The building has twenty-five lines of main columns, the location of which, above street level, was determined within narrow limits by architectural considerations. The general arrangement is at the intersection of eight transverse and four longitudinal lines, one of the latter extending only across three of the transverse lines at the wide end of the building. One longitudinal line is parallel to Broadway and makes an acute angle with the transverse lines. The other longitudinal lines are parallel and make right angles with the transverse lines. This arrangement provides panels from about 18¼ to 21½ feet long and from 17 to 21¾ feet wide on column centers. From the second to the sixteenth stories, inclusive, the beam plans are very simple, with single 20-inch I-beam transverse girders and 12-inch I-beam longitudinal beams connected to the centers of the column faces and supporting the floor arches. The walls are carried by plate girders and channels at every story, the former being made to form an essential part of the wind bracing. Special construction is, of course, involved in the roof and tower framing and below the street level, where provision had to be made for the subway structure. This passes diagonally through the narrow end of the building, where it extends nearly from the basement ceiling to the subbasement floor, and has four curved tracks with a supreme right of way absolutely prohibiting any obstruction to their alignment.

The subway structure is wide, deep and massive, and is maintained absolutely independent of the framework of the building. No portion of the subway is supported by the building and no portion of the building is supported by or connected to the subway. These conditions made it absolutely impossible to carry all of the columns of the superstructure down to the bottom of the second sub-basement or press room, which was excavated under the subway, the latter passing like an overhead bridge through the lower part of the building. This condition was met by virtually treating the steel framework in two portions, one of them being a substructure reaching from the bottom of the excavation to street level. This substructure was provided in some places with an upper deck of massive girders arranged so that they could receive the sixteen-story columns of the superstructure in intermediate positions, and thus make the location of the latter practically independent of the position of the substructure columns. In this way the columns below street level could be placed so as not to obstruct the tracks of the Rapid Transit Railroad Company or interfere with the construction of its subway and yet allow the columns above street level to conform to the required outlines of the building.

This arrangement was somewhat complicated and, of course, involved considerable extra expense. It was effected by the use of a number of extremely heavy girders of special construction and interesting details. In the wide end of the building the construction is regular throughout and the columns are continuous from the foundations to the roof. In the narrow end of the building where the subway intersects the framework of the building, the former consists of a rectangular steel and concrete tube about 16 feet high and 60 feet wide, supported on a horizontal platform built of massive longitudinal and transverse girders from 4 to 7 feet deep and supported on thirteen columns about 24 feet high within the limits of the Times Building, as described in The Engineering Record of May 7.

The subway girders are connected by massive concrete slabs through which holes were left for the columns of the Times Building in such positions as would clear the traffic through the subway. These were situated on the center lines of the regular rows, but were not in line with the longitudinal rows of columns, and the spaces were limited to a width of about 60 inches. As some of these columns were required to support loads of 2,000,000 pounds, it involved extremely heavy cross-sections and unusual details, which resulted in interesting construction. The columns for the building pass continuously through both floor and roof of the subway and support on their caps four special triple-web transverse girders carrying the columns for the upper seventeen stories. These girders are supported on the columns which are there marked with letters and carry the superstructure columns which are designated by the numbers 8, 9, 7, 10, 6, 23, 11, 22 and 12. The other columns are continuous from foundation to roof and have no special relation to the complications of the subway construction. The arrangement of the columns and the relative position of the subway, together with the space which it occupies within the limits of the Times Building, are clearly shown by the small-scale plan and section diagrams. From these it is seen that in both corners at the north end of the building it was impossible to carry the upper-story columns directly to their foundations. One of them, column 9, and intermediate wall column 11, are carried on the overhanging ends of cantilever girders, and the columns 8, 10, 11, 12 and 23 are carried by the girders at points intermediate between the substructure columns. The subway columns have H-shape cross-sections made with a web, four large flange angles and two cover plates, and have extended caps and bases. The latter are seated on I-beam grillages enclosed in the tops of solid concrete pedestals. In order to prevent the possibility of transmitting vibrations from the subway to the building, these pedestals are seated on cushions of sand 6 inches thick, which is solidly tamped into pockets cut in the solid rock. The top of the sand is covered by a layer of concrete over the bottom of the pit, which seals it and encloses the pedestals. The columns in the Times Building have foundations made with single and double courses of heavy granite blocks set in cement mortar on the solid rock.

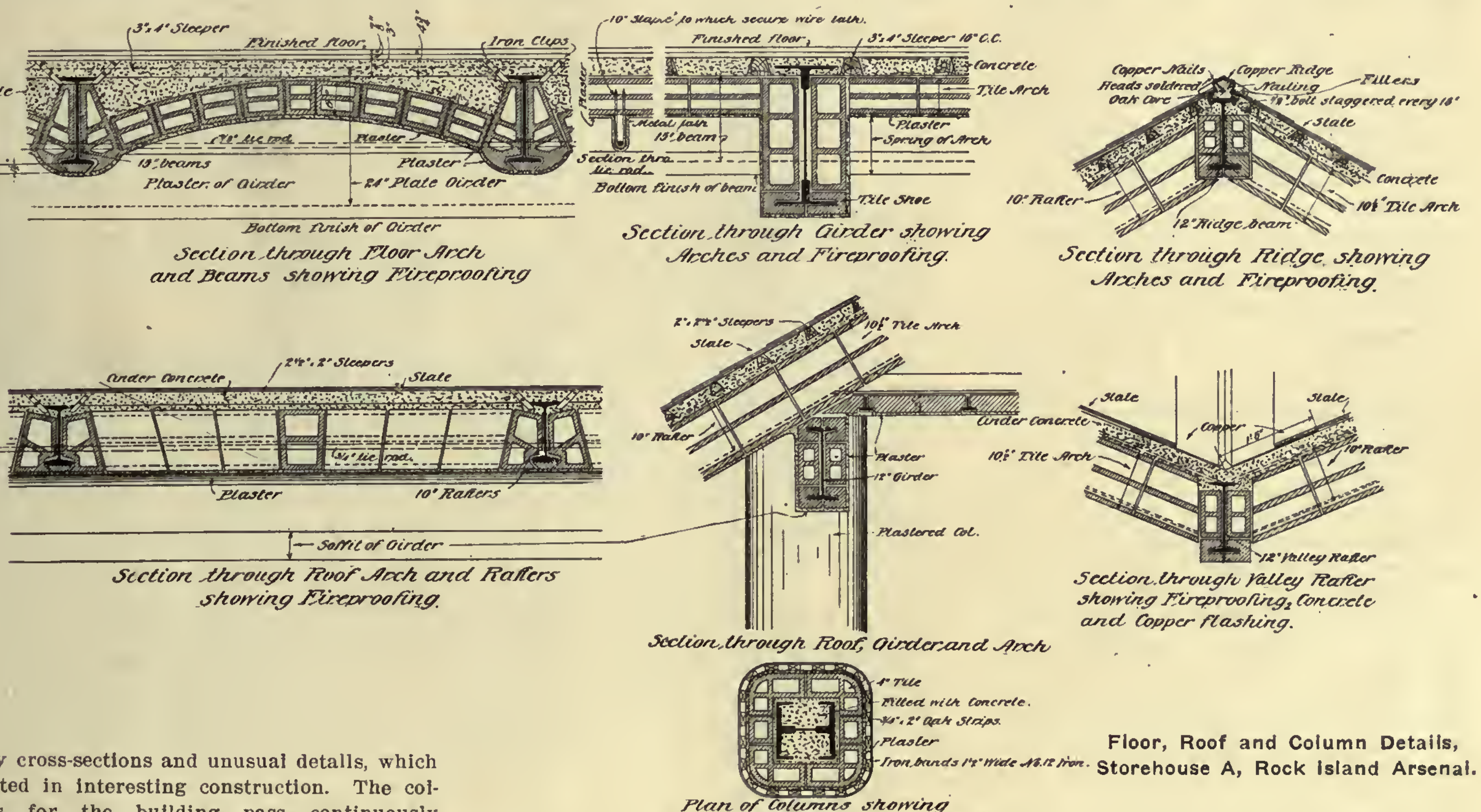
Where the Times columns were very close to those for the Rapid Transit subway, their foundations were made separate, as shown in the detail for pier 22, which is similar to pier G. The special columns which carry the triple girders have their pedestals supported on grillages which distribute the load over the granite pier, the latter being made long and narrow so as to clear the subway pier. This construction is well illustrated in the foundations for column 13 and the adjacent subway column No. 3, both of which are seated on grillages. The subway column grillage consists of a pair of 24-inch I-beams about 9 feet long, which are embedded completely in the concrete pedestal with a 2x12-foot base supported on a sand cushion enclosed by the solid rock and the concrete floor. The Times grillage consists of two tiers, each having five 24-inch I-beams about 15½ feet long bolted together with cast-iron separators and connected by riveted diaphragms at the ends of both tiers and the center of the top pier. The spaces between the beam webs are filled solid with concrete, and concrete is plastered around the outsides to completely encase them and the pedestal they support.

Messrs. Cyrus L. W. Eidlitz and Andrew C. McKenzie are the architects, and Mr. W. B. Bamford and Mr. Paul Gemelin, of their staff, are respectively general superintendent in charge of the building and chief draftsman. The designing of the structural steel was done in the New York office of Purdy & Henderson.

(To be continued.)

A Large United States Brick Store House.

Storehouse A, which is now being built for the United States Government at the Rock Island Arsenal, Ill., is a three-story and attic fireproof brick and steel building with which considerable pains have been taken to secure simplicity, rigidity and durability of construction. It has extreme dimensions of about 90x234 feet, and consists of a 90x60-foot central part and two 60x87-foot symmetrical wings with their longitudinal axis intersecting at right angles the longitudinal axis of the center part which is separated from the wings by solid fire walls in the planes of its outer longitudinal walls, thus making three interior rooms in each story. The self-sustaining outer walls are of red brick with stone and terra cotta trimming, and have interior piers or buttresses bonded into their brick work to inclose the steel wall columns which support the floor and roof loads, and are filled solid with mortar slushed into all interstices. The stories vary from about 11 to 13 feet in height, making the side walls 54 feet high. The roof is pitched both ways from the axis of each part of the building, thus making four gables and four valleys where the wings intersect the main parts.



Section through Floor Arch and Beams showing Fireproofing

Section through Girder showing Arches and Fireproofing.

Section through Ridge showing Arches and Fireproofing.

Section through Roof Arch and Rafters showing Fireproofing.

Section through Roof, Girder and Arch

Section through Valley Rafter showing Fireproofing, Concrete and Copper flashing.

Plan of Columns showing Fireproofing and Wooden Protection

Floor, Roof and Column Details, Storehouse A, Rock Island Arsenal.

The floors and roof are supported on four main rows of columns parallel with the longitudinal axis of the wings. Two of these rows are in the side walls of the wings and there are two more short rows of four columns each, parallel to them in the end walls of the center part of the building. The columns are from about 14 to 19 feet apart longitudinally, making sixteen transverse rows, and the main rows are from about 15 to 20 feet apart. The columns have H-shape cross-sections made with a pair of 10-inch channels connected by a 9-inch web and four 4x3-inch angles in the basement and first story and having the webs and angles omitted in the second and third stories. The columns are spliced 2 feet above the floor line with both web and flange cover-plates, one pair being shop-riveted to one section and field-riveted to the other, and the other pair being field and shop-riveted in the reverse order so as to make double jaw plates. The feet of the columns have flange angles on all sides countersunk-riveted to steel base plates seated on cast-iron pedestals on the foundation piers. The floors are supported on transverse plate girders with 24x½-inch webs and 4x5x9/16-inch flange angles and by 15-inch longitudinal I-beams web-connected to them about 6½ feet apart. At the walls the floor is carried on 15-inch channels independent of the brick work. The pitched roof is carried by 10-inch I-beam rafters about 7 feet apart and has a 12-inch I-beam at the ridge, at each valley and on top of the intermediate rows of columns. The rafters are seated on the horizontal beams with cast-iron beveled pedestals and are connected to the hips with bent web plates. All beams and girders are connected to the columns with vertical web angles and have their lower flanges seated on horizontal 3-inch angle clips.

The interior columns are filled solid with 1:4:7 Portland cement stone concrete. They are plastered outside with cement mortar in which are set 4-inch hollow tile fireproofing blocks with rounded corners. The vertical surfaces of these tiles are plastered and each column is protected to a height of 6 feet above the floor lines by ¾x2-inch vertical oak strips 2 inches apart which are secured by three 1½-inch horizontal bands of No. 12 iron. The floorbeams and channels have their webs protected by hollow brick skewback pieces with extensions to receive the dovetailed horizontal strips protecting the lower flanges. Between the skewbacks there are segmental hollow brick end-construction arches with a uniform rise of 15 inches. The arches are leveled up with 1:3:5 Portland cement cinder concrete in which are embedded 3x4-inch beveled pine nailing strips 16 inches apart to receive the wooden floor surface. The under sides of the floor arches have a plaster finish and one panel of every floor is subjected to a test load of 2,000 pounds per square foot over the entire surface.

The rafters carry flat arches of hollow tile with skewback pieces protecting the rafter beams similar to the detail described for the floor. Cinder concrete 2½ inches thick covers the tops of the arches and the upper flanges of the rafters and forms a bed for the slates which are laid on asphalt building paper weighing 40 pounds per square and are nailed to 2½x2-inch wooden strips bedded in the concrete. The plate-girders, ridge and valley beams and other I-beams, not enclosed by skewback tiles, have their webs and lower flanges protected by rectangular hollow brick or tile and their upper flanges enclosed by cinder concrete.

The ridge is laid with an oak core bolted to the top flange of the ridge beam and having both sides rebated to receive the upper edges of the slates. It is covered with copper flashing secured by copper nails with their heads soldered. Part of the ceiling in the third story consists of 3-inch solid tiles supported on 3x2½-inch horizontal T-bars 18 inches apart and plastered on the under side with cement mortar on expanded metal lathing. The elevator shaft has 6-inch hollow-tile partitions laid in cement mortar and plastered both sides. The door jambs are of 2-inch wood bolted to angle iron frames and covered with No. 26 galvanized iron, which is also used to cover the elevator doors.

The stairs are made with cast-iron risers and treads and have steel I-beam and channel girders and string pieces. In some cases the webs of the latter are protected on the outside with hollow tile and are filled in solid with concrete against the surface of the brick walls. The cornice is made with hollow terra cotta blocks with the ends of their webs built into the wall and anchored to horizontal channels and angles provided for the purpose. At the eaves there is a special cornice construction with the upper course of blocks set out from the wall to leave space for the gutter which is lined with copper laid on a bed of cement mortar pitched to the leader pipes. All of the hollow brick used for arches and for the protection of the steel work is semi-porous tile made from fire clay having 50 per cent. of silica and mixed with coal or sawdust before burning. The exterior and interior webs are ¾-inch and ⅝-inch in thickness and the tiles are tied together where necessary to galvanized iron clamps. The specifications show the principal details of construction and are signed by S. E. Blunt, lieutenant-colonel, Ordnance Department, U. S. A., commanding.

Extensions of the Brooklyn Sewerage System; Sixtieth Street Sewer.

Among the important sewers mentioned in the article printed April 16, in which there was made a brief enumeration of the main trunk sewers in the southerly part of Brooklyn, is the Sixty-fourth Street sewer. A full detailed description of the interesting construction methods used in driving the difficult tunnel for this 15-foot and 14-foot diameter sewer was published in the issues of this journal of November 21 and 28 and December 5, 1903. Like the Ninety-second Street sewer, recently described, the Sixty-fourth Street sewer discharges into the Narrows of New York Bay. This sewer is continued eastward by other sections under different names to a total length of a little more than 7 miles.

The section of this trunk sewer next eastward from the Sixty-fourth Street tunnel is known as the Sixtieth Street sewer and extends through Sixtieth Street from Fourteenth Avenue to Nineteenth Avenue and through Nineteenth Avenue from Sixtieth Street to Fifty-seventh Street. It comprises 15 linear feet of 13½-foot circular brick sewer, connecting to the tunnel, 4,015 feet of 13-foot sewer and 660 feet of 12-foot sewer, besides short pieces of 78-inch, 36-inch and 30-inch brick sewers forming the connections to secondary trunk sewers already built in the streets and avenues crossed by the main sewer. The 36 and 30-inch sewers have egg-shaped cross-sections, but the 78-inch sewer is circular. The grade of the main sewer is at a uniform rate of 0.000565.

The Sixtieth Street sewer is being built wholly in open cut, although the trench is very deep, the maximum depth being about 43 feet and the minimum depth 34 feet. Because of this great depth to the main sewer, short supplementary pipe sewers will be laid above it between the successive manholes so as to receive the house and catch-basin connections. These short pipe sewers will enter the manholes of the main sewer, as shown in the drawing of a manhole reproduced in the issue of May 7. For the most part the work on this section has been easy and straightforward, differing from that for an ordinary small brick sewer principally in magnitude.

All three sizes of the main sewer are made with four rings of brickwork laid in Portland cement mortar, with substantial brick haunch walls carried up plumb on the sides to a level 3 feet above the springing line. The thickness of the brickwork at the springing line is uniformly 24 inches. The haunch walls are each 5 feet thick at the bottom, and the space between them, beneath the outside ring of the brickwork of the sewer barrel, is filled with Portland cement concrete formed into a cradle to fit the outside of the barrel. This concrete has a minimum thickness of 4 inches at the bottom. The sewer is built upon a platform 8 inches thick made of two layers of 4x8-inch spruce planks laid flat, the planks in the lower layer being placed transversely and those in the upper layer longitudinally, close together.

The trench as far as it has been excavated, and 3,300 feet of the total 4,690 feet have already been dug, has cut through the characteristic deposits of this part of Long Island, the upper 12 to 15 feet being ordinarily through coarse gravel and the lower part of the trench through medium to coarse sharp sand. Much of this sand is of good enough quality to be used for the mortar and concrete, so that it has been unnecessary to procure sand for these purposes from any other place.

Work was begun at Sixtieth Street and Fourteenth Avenue in November, 1902, and in order to expedite construction another trench was opened in October, 1903, at the upper end of this section, at Nineteenth Avenue and Fifty-seventh Street. It is expected that the two portions of the sewer will meet about September 1. The excavating is being done with the aid of two Carson-Lidgerwood trench machines of 300 feet span, having 1-cubic-yard steel buckets. Under favorable circumstances each machine, with a gang of about 60 men, has handled 375 cubic yards of earth in a 10-hour day; the average quantity handled has been not far from 250 cubic yards per day. The operations have been so conducted that, as a rule, only one of the 700-foot blocks between two avenues has been closed to travel, but the trench is so wide and the quantity of material to be handled so great that the block in which work is in progress is necessarily pretty completely obstructed so far as vehicular travel is concerned. An accompanying illustration shows the general arrangement of the work.

With the materials and depths of trench obtaining on this section, of course every foot of the trench has to be very carefully and strongly sheeted and braced through its whole depth. For the sheeting three tiers of 2-inch spruce planks in 16-foot lengths are used and are driven back of 4x9-inch rangers spaced 3½ feet apart vertically. The cross braces are 6x8-inch timbers placed one at each end of each pair of rangers and one between the ends, so that they are spaced 8 feet apart. Long practice in this class of trenching has made the men skilful and the sheeting and bracing is so well done that it gives an engineer pleasure to see it. Only ordinary hand methods are employed, but the work is accurately executed. The usual procedure is to open a piece of trench 36 to 40 feet long at a time, carrying down bulkheads or cross sheeting at each end. The sand and gravel is taken out in benches about 12 feet long, being shoveled directly into the buckets of the excavating machine. Of course the bench next to the previously finished portion of the trench is kept the lowest. When the proper depth is reached the bottom is carefully trimmed to the sub-grade for the timber foundation platform.

The sewer is built by successive stages in lengths of 18 to 20 feet. When a portion of the trench has been dug nearly to grade, the bulkhead between it and the finished portion is removed and a section of foundation platform is placed directly on the carefully leveled sand or gravel. On this platform or grillage the two haunch walls are then built, usually the same day that the platform is laid, up to the springing line. The next day a grade spike is driven by the engineer's field party into the forward end of this section of grillage, after it has been under the load of the haunch walls over night at least. A profile board is then set over the spike and the concrete cradle placed and formed ready to receive the brickwork of the invert.

The haunch walls and invert concrete having been built, on succeeding days the bricklayers build the invert up to the springing line and then turn the arch. By following this order of operations the various classes of men are each constantly kept busy and the work moves smoothly and steadily forward by regularly rotating stages. For the barrel of the sewer, mortar made of 1 part Reliance Portland cement and 2 parts sand is used, but for the haunch walls the proportions are 1 to 3. The sides of the haunch walls are built directly against the trench sheeting. All the sheeting and the braces, excepting the lowest brace, which is below the level of the top of the arch, are left in place to within about 2 feet of the street surface. The sheeting and bracing require approximately 2,300,000 feet board measure of lumber and the foundation planking or grillage about 680,000 feet board measure.

Water has caused but little trouble so far in the construction of the Sixtieth Street sewer excepting in the block between Fifteenth and Sixteenth avenues, where a vein of gravel was encountered which yielded water so freely that two 5-inch Cameron steam pumps were required to handle it. In the remaining portion of the trench, up to the date of this writing, there has scarcely been water enough at any point to require even bailing.

In this same block between Fifteenth and Sixteenth avenues the two tracks of the Montauk division of the Long Island Railroad were crossed at an angle of about 30 degrees, the railroad at the place of crossing being on a curve and the trench being 20 feet wide. These tracks carry a heavy freight traffic as well as many passenger trains and required to be very securely supported across the trench. For this purpose the employes of the railroad company placed beneath the tracks three steel plate girders about 5½ feet deep and 57 feet long, spaced 12 feet apart, the two outer girders being about 4 feet outside of the outer rails. It was the intention to support the ends of these girders on pile bents, but the gravel was so hard at this place that it proved impracticable to drive piles at some points and so timber grillages were substituted. On the girders 10x16-inch ties were placed, and every fourth tie was braced. These supports, of course, were placed in advance of the sewer work. Beneath the tracks additional heavy diagonal braces were used in the trench. The crossing was made successfully, without accident and without interruptions to railroad traffic. The settlement of these girders after nine months is 1½ inch.

The connections with the lateral trunk sewers are made in most instances at manholes of the design described and illustrated in the article printed May 7, known as type A, or at manholes of type B. On this section, however, the thickness of the brickwork of some parts of the type A manholes is somewhat less than that shown in the drawings with the article mentioned. The type B manholes are built up from the crown of the sewer arch, with walls 12 inches thick for the lower 10 feet and 8 inches thick above. The top of each type B manhole is circular, 25 inches in diameter inside, and the bottom is elliptical, 4 feet long and 3 feet wide inside.

At Nineteenth Avenue the main sewer turns from Sixtieth Street into the avenue with a 90-degree bend of 100 feet radius, and at this point connection is made with the 78-inch circular brick sewer coming down Sixtieth Street. In order to avoid a thin and consequently weak groin in the masonry, a short bend was made in the 78-inch sewer just before it reached the 13-foot sewer so that the smaller sewer is nearly normal to the outside of the curve of the larger sewer. At the intersection the inverts of the two sewers are at the same elevation. This method affords a much stronger and simpler construction although from the point of view of hydraulic considerations it may not seem so correct a form of junction theoretically. Connections of this type have been made at other places in the Brooklyn sewers and experience has shown that no trouble is caused at such points.

As stated in preceding articles, the work on the extensions of the Brooklyn sewerage system is being done under the general supervision of Mr. Henry R. Asserson, M. Am. Soc. C. E., chief engineer of sewers for the Borough of Brooklyn. Mr. George W. Martin is the division engineer in immediate charge of construction of the Sixtieth Street sewer, and Mr. J. J. Creem, of Brooklyn, is the contractor.

Brooklyn Sewers: Contractor's Plant and Method of Working in Sixtieth Street.

A Difficult Piece of Road Building.

From a report by J. J. Albertson, Atlantic County Engineer, to Henry I. Budd, Road Commissioner of New Jersey.

The old adage, "There is nothing new under the sun," may be true, but there are many new applications of old principles, and we are trying one in building a road across the salt meadows, between the solid land at Pleasantville and the sand bar on which is located America's greatest seaside resort, Atlantic City.

Two generations ago the idea of a highway over these flats was never entertained. The first railroad charter contemplated a terminus at the west edge of the meadows. It was granted for the Camden and Absecon railroad, which was afterward extended over the more solid portion of the meadow surface to the island of Atlantic City. The railroad ties were laid on the stiff, floating sod, with scarcely any ballast. The storm tides were allowed to ebb and flow over the tracks, frequently interfering with travel for days. The increasing weight of modern locomotives and the uncertainty of the storm tides convinced the railroad management that they must dispense with this floating railroad and have a solid foundation. The latter could only be obtained by an earth fill of sufficient size to displace the soft mud under the sod. This has been accomplished within the last few years, at an enormous expense, even to the railroad company, which owns its equipment for transporting the sand. The county, not owning such equipment, had to devise a new application of the old principle of hydraulic dredging, which has been in use near Atlantic City in land development schemes for years, and with very satisfactory results.

Before we could build a road a right of way had to be obtained. Upon this point a lively controversy sprang up. Many years ago there had been built a corduroy road from Pleasantville to Atlantic City. This structure in reality floated upon the mud, which from time to time settled in places. This necessitated the elevation of the road surface by gravel from the mainland. This method was very expensive, and the toll roadbed had a very doubtful existence until the county and State built the magnificent road from Camden to the meadow shore. This brought thousands of conveyances to the toll road, which now began to pay handsomely, the charge for a double team being sixty cents for the round trip. The value of the toll road appreciated rapidly. The owners did not want to sell a good investment for less than the capitalization on its earnings, neither did they want a free State and county road as a competitor until they first disposed of the toll road, which was far below the standard required by the public, being submerged by every storm tide. After much discussion the question was finally disposed of by the sale of the toll road to a trolley company. Then all interests were united in securing a parallel right of way and urging a new boulevard on broader lines than could have been developed had the narrow, old toll road been purchased. Routes were quickly surveyed and the most feasible adopted. We were favored in our location by deciding upon a line to the south of the railroad embankment, thereby securing protection from the northeast storm tides. Much of the right of way was cheerfully donated, but, as is always the case, there were some obstructionists. These were quickly overcome by court proceedings and the public was ceded a right of way 100 feet wide for one of the most important projects ever attempted in our highway building.

Soundings were taken, and we found the mud varied in depth from 6 to 28 feet, the surface of most of which was a floating sod, varying from 2 to 4 feet in thickness, below which was a semi-liquid mud, resting upon hard pan. The latter, in a few places, was only 4 feet thick. Below this was another almost unfathomable stratum of soft mud. We depended upon the first layer of hard pan to support our structure. It was necessary to pile our bridge approaches. These piles were put down with water jet and hammer combined. At the depth of 28 feet the first resistance was met. At 35 feet this was gone, and the pile with weight of hammer sank indefinitely, so we stopped at the depth of about 30 feet. This seemingly bottomless pit extended for only a short distance, and was doubtless the bed of a stream many centuries ago. We usually struck a solid bed of sand, gravel or clay, of various thicknesses, at the depth of from 10 to 20 feet below high tide.

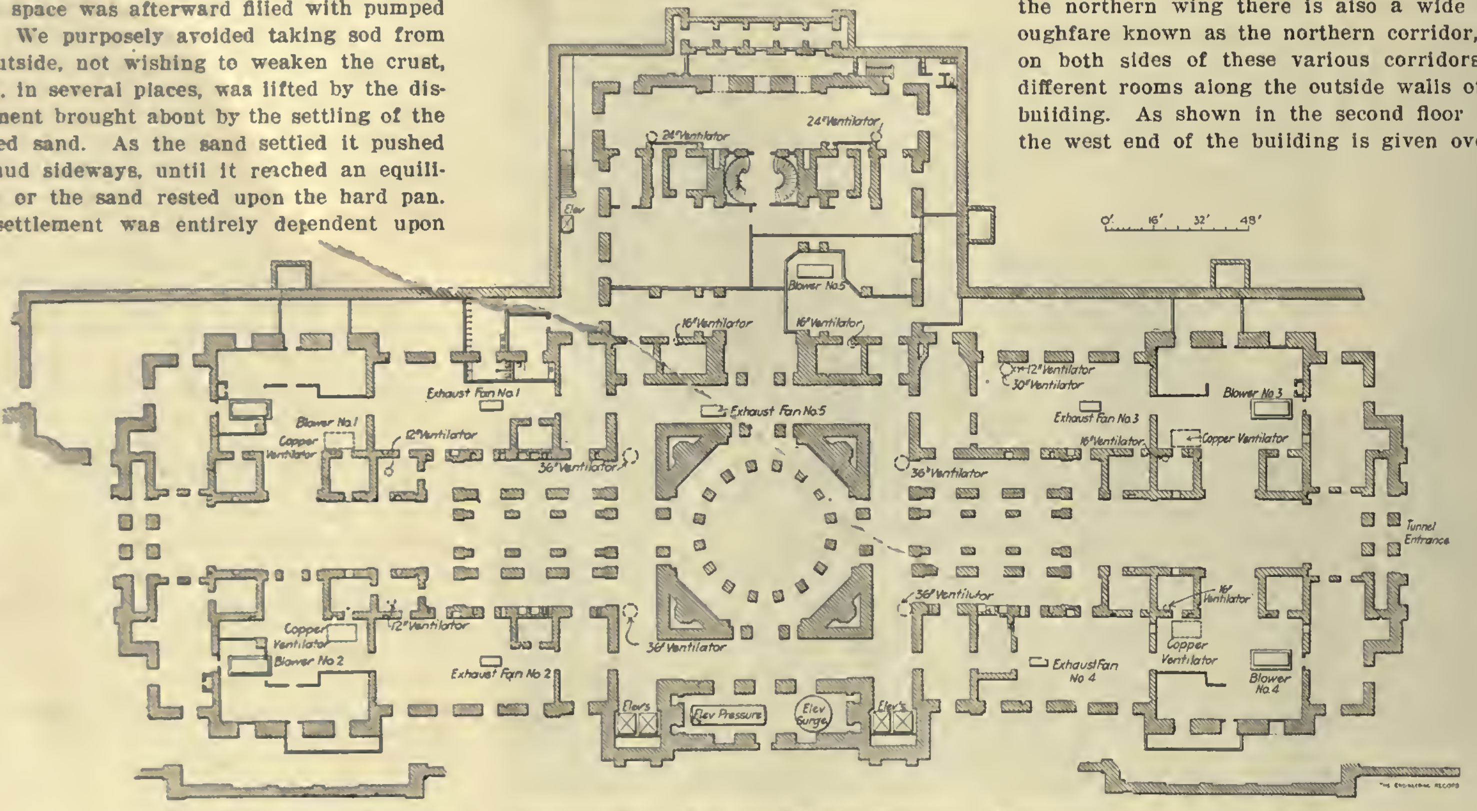
After locating our road line we built sod banks, 5 feet 6 inches high, 12 feet wide at the base and 2 feet wide at the top, with the growing-grass side out. The inside edges of the sod banks are 60 feet apart. We took the sod for this purpose from between the banks. The enclosed space was afterward filled with pumped sand. We purposely avoided taking sod from the outside, not wishing to weaken the crust, which, in several places, was lifted by the displacement brought about by the settling of the pumped sand. As the sand settled it pushed the mud sideways, until it reached an equilibrium or the sand rested upon the hard pan. The settlement was entirely dependent upon the quantity and density of the underlying mud. As the sand was pumped in the settlement continued. When the bed of sand was 6 feet above the level of the meadow the weight was sufficient to displace all the mud, and we had a foundation equal to that of the railroads and at a much less cost. Over the salt ponds, where there was no sod for banks, we substituted hard pine bulkheads, at a cost of $4.50 per linear foot. After the sand fill was made and thoroughly settled the roadway was given the proper curvature and finished with a coating of gravel. It is hoped that later we shall be able to cover it with crushed stone. Both sides of the road are to be protected by a substantial railing.

The sand from the State's riparian lands under the adjoining bay and thoroughfare was pumped through wrought-iron pipes for a distance of one-half mile or more. The sand is mixed with about 90 per cent. of water, which is discharged when required from the end of the pipe, the sand settling and the water running back into the bay.

The agitation at the lower end of the suckers at a depth of about 40 feet is breaking red cedar logs into pieces. These are discharged through the pipe with the water and sand, thus clearly demonstrating that this very land was once above the surface of the ocean, long enough to have produced a forest, and was afterward so quickly submerged that the timber did not have time to decay before it was covered with the best-known wood preserver. This is the last and by far the most expensive link in the great highway across the State from Philadelphia to the sea.

Heating and Ventilating the Minnesota State Capitol.

Warming a building by a supply of air distributed according to the plenum system, has been developed into an interesting plant in the Minnesota State capitol. Here there are 4,000,000 cubic feet which are heated largely by means of the air supply; this is delivered at a rate sufficient to provide ventilation in terms of about four changes hourly, practically the only direct radiation being such as was installed to offset the comparatively large cooling power of the skylights. In connection with the air supply, provision has been made for washing the air by means of water sprays, and for drying it afterward to regulate the degree of humidity, and the system includes a central receiving well and pump, by which the wash water is circulated over and over again. Owing to the fact that the building contains several large rooms where numbers of people congregate, a study of the proportions of the plant will be of interest.



Foundation Plan Showing Location of Blowers and Fans and Relative Position of Roof Ventilators.

It will be recalled that the Minnesota State capitol has already been the subject of an article in The Engineering Record, of April 16. In that connection the power generation and transmission to the Capitol building only were discussed, the power plant being in a detached building connected to the main structure by means of a comparatively long tunnel driven at a considerable depth underground. Among the features of the power equipment, as there described, were the provision and arrangement of mechanical-draft equipment in the boiler room and the method of carrying pipe lines and electric cables in the tunnel. Some photographs covering these points were received too late to appear in the description in question, but as supplementary to the line engravings of the former article, they are herewith reproduced.

The Capitol building is a three-story structure above a basement, which is also given up to various State offices and departments. It extends east and west, with its front facing the south, and at the rear has a large wing, giving the building an extreme depth at the center of 225 feet. The extreme length of the building, from west to east, is 430 feet. Above the center of the building rises a dome covering a rotunda in the center of the building. The general arrangement of the building is indicated in the accompanying part plan for the second floor. This rotunda is surrounded on all four sides at the different stories by the corridor, and on both the east and west sides of it are the main stairways through the building. On the first floor, beyond each of the main stairways, is a corridor, known as the east corridor, in the east end of the building, and as the west corridor in the west end of the building, and in the northern wing there is also a wide thoroughfare known as the northern corridor, and on both sides of these various corridors are different rooms along the outside walls of the building. As shown in the second floor plan, the west end of the building is given over to the Senate Chamber. The northern room is occupied by the House of Representatives, and the east end of the building contains the Supreme Court. All these rooms rise through the third story. The exterior of the Capitol is shown in an accompanying reproduction of a photograph, looking south, with the House of Representatives' wing in the foreground.

For heating the building it was decided to divide the plant into five portions, one for supplying the House of Representatives' wing and four for the main building, two at each end. The four units for the main building are located symmetrically with respect to the building center line, as indicated in one of the diagrams. So far as general design is concerned, all of the blower units are laid out on the same plan. Each has the heaters on the discharge side of the blower, but the air-washing device is placed on the suction side, and a tempering coil has been set up in front of the air-washers, both because the air distributing system includes a run of tempered air ducts, and also to prevent freezing of the washing device. The washing device comprises a group of water sprays and a set of drying tubes laid beyond them, these fitted with helical guides to give the air a rotary motion to separate the water by the action of centrifugal force. In general the tempered air ducts from the blower units are only provided for the larger rooms, such as the Senate Chamber and the House of Representatives, where it is essential that means be at hand for keeping down the temperature of the incoming air. The rest of the rooms, as a rule, receive air that is warmed by the heater. All rooms in the building, except corridors, hallways and the like, are equipped for the automatic control of the temperature by means of thermostats. In the case of the smaller rooms, these thermostats, one for each room, control of the damper of the hot air outlet. In the case of the Senate Chamber there are three thermostats, two on the main floor and one in each gallery, these controlling the air inlet; in the House of Representatives seven thermostats, three on the main floor, one in each side gallery and two in the rear gallery, and in the Supreme Court two thermostats on the main floor. In these, of course, the thermostats control the mixing of the tempered and hot air.

The accompanying detail of the sub-basement shows the arrangement of the ventilating outfit for the north, or House of Representatives' wing. The air enters as shown and passes through the tempering coil. The coil consists of a double group of the ordinary 1-inch steel pipe coils, each group consisting of two 2-row sections and two 4-row sections. They present, all told, about 1,000 square feet of surface, and the total free area through the section was restricted by the specifications to 2,600 square inches, or 5,200 square inches for the double arrangement of the coils.

Minnesota State Capitol with North Wing in the Foreground.

In the spray chamber, immediately beyond the tempering coil, are thirty spray nozzles distributed across the path of the air flow. The spray chamber has a floor of concrete five inches thick, forming a drip pan, which slopes to a return drain. While this same thickness of concrete has been spread over the floors of the suction and fresh air chambers, in the spray chamber it is depressed 8 inches all around. Each of the dry boxes, so-called, contains forty conical tubes 10 feet long, 16 inches in diameter at the spray end, and 14 inches in diameter at the suction end. The helical ribs inside of these tubes are given four complete revolutions in the length of the tube. There are small drip holes on the lower side to allow the separated water to reach the drip pan.

The blower, like those in the four other groups, is a three-quarter housing steel plate blower having a wheel 9 feet in diameter and 44 inches wide at the periphery. They are all of the double-inlet style, and are all built with a single discharge outlet, with the exception of the one in question, which has a double discharge. They were built by the B. F. Sturtevant Company, and each is driven by belt from a 25-horse-power motor. At a speed of 145 revolutions per minute they are calculated to deliver 45,000 cubic feet per minute, and are intended to operate without noise, at a speed of 160 revolutions when necessary.

It will be seen that the normal delivery of the fan corresponds to a velocity of 1,250 feet per minute through the tempering coils, and of 910 feet through the drying tubes, or 1,650 feet per minute if the helical motion is considered. Forty-five cubic feet of air per minute are passed per square foot of the tempering coil surface. Further calculations would indicate that with the given amount of air all passed through the tempering coil and raised to 50 degrees Fahrenheit, some 2,500 British thermal units are transmitted per hour per square foot of the heating surface. It should be stated that where partitions were necessary to enclose the suction chamber, spray chamber and air intake, the expanded metal type of construction on channel iron, with cement coating on both sides, was employed. Doors opening into these are made of pine, but covered on both sides with galvanized iron.

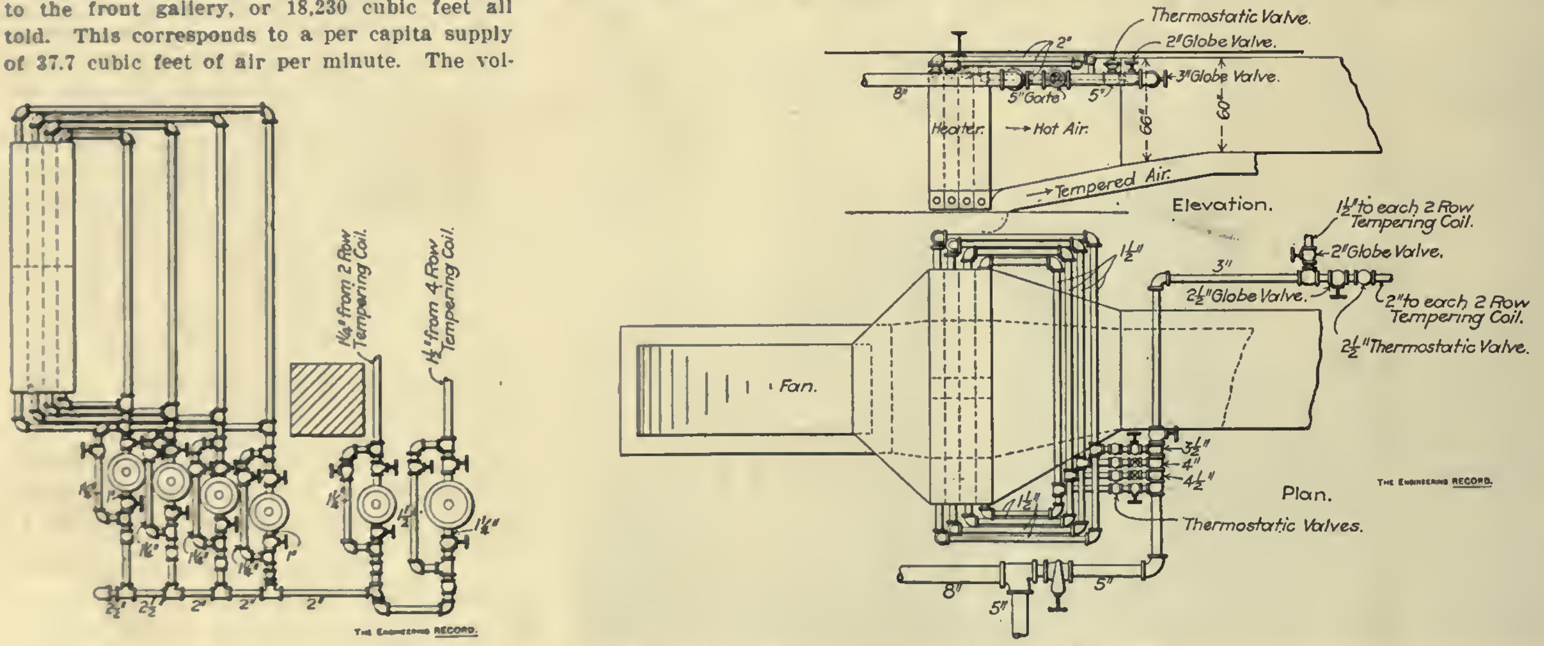
The heater coils are of the same size as the tempering coils, and consist of two double rows of eight sections, four rows deep, giving to each heater a depth of sixteen pipes in the direction of the air flow. Each heater has about 8,000 linear feet of 1-inch pipe, or about 2,660 square feet of surface. The arrangement of connections to and from the heaters is shown in an accompanying drawing. It was felt that provision ought to be made for admitting high-pressure steam into the coils, especially to tide over an unusually heavy drop in the temperature and for other reasons, and the heating apparatus throughout the plant is furnished with steam traps on the return connections. There is one steam trap for each pair of sections, but each trap is provided with a by-pass, which is ordinarily used.

The system employed for distribution of the air is that of carrying ducts in each story over a suspended ceiling in the corridors. The air is largely carried upward through the structure in separate flues for each story, with the flues grouped together in a comparatively large shaft left for that purpose. The location of these flues is indicated on the accompanying drawings for the system supplying the north wing. Each of the other systems supplies a group of flues which are assembled in a shaft located back of the adjacent main stairway. At the ceiling of each story the corresponding flue opens into the suspended ceiling duct, and this is carried in opposite directions in short flues or direct register openings, as the case may be, in the rooms on either side. This method of distribution is indicated on the part plan of the second story. Each of these blower units also supplies a flue which is carried upward in the hollow interior of the piers of the central rotunda. Throughout there are volume dampers where branches leave the main duct, and, as already stated, there is an automatic regulating damper at each hot air outlet into the room, excepting those discharging into the corridors and smaller public places, which are not provided with automatic damper regulation. Ducts more or less exposed are covered with asbestos paper.

The exhaust system is a combination of mechanical and natural ventilation, part of the rooms being exhausted through the medium of fans, while the rest are exhausted through the tendency of the air to rise from its warmth and from the pressure behind it. The exhaust fans, of which there are five, one corresponding to each fresh air blower, mainly connect to rooms on the basement and first stories, and they are located in the basement, so that the air withdrawn from the rooms passes backward to the fans before it is finally delivered into the atmosphere. The four exhaust fans corresponding to the four blowers for the main building, have wheels 4½ feet in diameter, with a 21-inch width at the periphery, while the fifth fan has a wheel five feet in diameter, and a peripheral width of 24 inches. They are motor driven, the four from 7½ horse-power motors, and the fifth from a 7 horse-power motor. They all discharge into the spaces left in the dome structure, which, as already mentioned, is utilized for the carriage of a number of fresh air flues.

At the roof line the discharge from these building flues are collected and passed out through four 36-inch ventilators, one from each of the shafts. The location of these ventilators is shown in an accompanying diagram intended to indicate the general dimensions of the building, and the location of the blowers and fans, this apparatus being in the basement, and also the points of egress for the more or less vitiated air, these located on the roof. All told there are seventeen ventilators scattered over the roof and of these nine discharge air from various toilet rooms, so that these are cared for independently of the rest of the building. Besides the four ventilators mentioned, which pass air from the lower stories of the main building, there are two 16-inch ventilators for the north wing which are connected to the system ventilating rooms underneath the House of Representatives, and there are two 24-inch ventilators which discharge air from the House of Representatives itself. The rest of the air from the main building is allowed to escape into the attic, and thence through four so-called copper ventilators, also indicated in the diagram. Vent flues leading from the upper two stories into the attic are comparatively large in size, and the spaces over suspended corridor ceilings are ample for conducting air from the various rooms to these flues. Of course the larger amount of air is circulated through the Senate chamber, the House and the Court-room. The heat registers in rooms controlled by the automatic regulators are without valves, while the vent registers have a ventilating damper behind. This consists of a series of light rods behind the register face, having a light curtain of No. 12 gossamer hung from them so that the pressure in the room shall cause them to open into the vent flue, but a pressure of cold air from the vent flue shall close them against the register face, as might happen when the blowers are shut down. The ventilating monitors for the outflow of air from the building attic are each designed to give a free area of flow of 40 square feet. Each is built of 16-ounce copper on a wrought-iron frame, has four vertical sides enclosing a space of 5x9 feet in plan, and roofed over with a peak roof. The sides are furnished with louvre openings, protected outside with a wire screen, and behind them is a curtain of gossamer flaps to prevent a backflow.

A few calculations show the following provisions for ventilation. The House of Representatives is arranged for a seating capacity of 169 on the main floor and of 314 in the two galleries, or a total of 483. The system is proportioned for the delivery of 12,600 cubic feet of air per minute on the main floor, and of 3,230 cubic feet to the rear gallery, and 2,400 to the front gallery, or 18,230 cubic feet all told. This corresponds to a per capita supply of 37.7 cubic feet of air per minute. The volume of the hall is approximately 215,000 cubic feet, and the specified delivery of air corresponds to ventilation in the proportion of five changes per hour. The velocity of air on issuing from the different registers averages about 500 feet per minute, assuming an equal distribution and flow of air to the different flues. To study the distribution of air in the House of Representatives in connection with the second-floor plan given among the accompanying drawings, it should be stated that fresh air is admitted into a gallery at either side of the room pointing backward toward the north wall at a point about 22 feet above the main floor, each register 18x24 inches in size. Besides these there are four registers back of the circular gallery, about the same distance above the main floor, these registers in two pairs, and all 12x18 inches. The room has a domed ceiling, and besides the points of egress indicated on the second-floor plan, there are four vent registers in the back part of the circular gallery and four 12x16-inch registers in pairs near each of the 18x24-inch fresh-air registers. In addition to these there is some perforated grillwork in the decoration of the dome ceiling.



Typical Arrangement of Steam and Return Connections to Indirect Radiation.

The Senate has a seating capacity for 76 persons on the main floor and 190 in the galleries, and it is arranged for the delivery of 11,300 cubic feet of air per minute, of which 9,000 is designed to pass through two registers each 9 square feet in area. This indicates that 42 cubic feet of air are supplied per minute per capita, and a calculation shows that the velocities on inflow and outflow are about 500 and 550 feet per minute, respectively. This room is likewise finished with a domed ceiling, and its volume is approximately 140,000 cubic feet, so that ventilation is afforded in terms of nearly five changes per hour.

The steam is received from the power station through a tunnel, as already described. It is largely required by the indirect heaters, but there are some 1,500 square feet of pipe coils for the various skylights and a few direct radiators. These, it may be stated in passing, are provided in the ratio of 2⅔ square feet of glass surface to 1 square foot of heating surface. The main is 12 inches in diameter on its entrance into the building, and the return main carrying the water back to the power house is 6 inches in diameter.

One of the interesting features of the plant is the provision made for circulating the water for cleaning the air. The water from the spray chambers at the five air inlets is all drained to a central point in the sub-basement, where it is delivered into a tank below the floor line. This tank is called the circulating tank, and is shown in the part plan of the sub-basement. It is built of 1¼-inch boiler plate resting on three long brick piers in an excavation having a concrete floor. The tank is 3 feet deep, 7½ feet wide, and 13 feet long. It is open, but surrounded by a railing of wrought-iron pipe. The walls of the pit are of brick, 18 inches wide, and the railing is fixed into a coping of limestone on top of the brick. For delivering the water to the spray nozzles in the five spray chambers there is a duplicate installation of triplex pumps which are motor driven by belt. Each of these pumps, which are located at the tank, has a capacity for delivering 150 gallons of water per minute against about 100 pounds.

The single suction pipe is fitted with a strainer foot valve. As already stated, in each suction chamber there are thirty spray nozzles. These are arranged in five horizontal rows, which are fed by a 1¼-inch pipe, and each group by a 2½-inch pipe. Each of the nozzles is designed to deliver ¾ to 1 gallon of water per minute.

With regard to the electric distribution throughout the building, the feeders for the lighting service and those for the power utilization are carried separately through the tunnel from the power house, as explained in the earlier article. The tunnel reaches the building at the east end and the feeders are carried to independent distribution boards, one for the lights and the other for the power.

The main motors are located in the sub-basement, and the distribution board for power controls directly the feeders to each motor. Besides the motors for the blowers and the exhausters, the motor for the circulating pumps of the air-washing apparatus and two motors for the passenger elevators in the front of the building, are connected to the power distribution system. As was briefly mentioned in the description of the power plant, a hydraulic elevator installation has been made, with the pressure water delivered from motor-driven pumps, as it was desired to use the hydraulic system and yet not considered advisable to run high pressure steam to pumps near the elevators in one case, or to conduct high pressure water all the way from the power house with the elevator pumps located there.

The pumps deliver into a pressure tank 6 feet in diameter and 24 feet long, and the water is returned to a surge tank 12 feet in diameter and 5 feet high. Their position near the elevator wells is indicated in the sub-basement or foundation plan. The pumps are of the triplex type.

The lighting of the building is divided into five different sections, in the same way as the heating and ventilating plant. The light distribution board feeds five mains which are run to distribution boxes underneath the rising points, and from these the cables are continued to panel boxes on each floor. For the main building the rising shafts are the same as those used for the passage of the main flues from the blowers, that is, they are located between the main stairways and the ends of the building. The distribution center for the north wing is carried up a shaft which is given up to a utility room on each floor off of the north dome corridor. Besides supplying the lights for the north wing, it also feeds all the illumination in the rotunda and dome. There are some 7,000 lights all told.

As stated in the earlier article, the Minnesota State Capitol was designed by Mr. Cass Gilbert largely at his St. Paul office. The heating and ventilation were laid out by Mr. Burt S. Harrison, consulting engineer, of New York City.

The Relation of the Engineer to Finance.—I.

An address at the University of Illinois by John W. Alvord, M. Am. Soc. C. E.

In the year 1715, a Scotchman who had obtained the confidence of the ruler of France established in Paris a national bank and proceeded to issue credit money somewhat similar to our United States demand notes. The bank was an immediate success, and encouraged by this first attempt, a company was formed to develop the Mississippi Valley, then the property of France. The prospective business then thought to be very great was estimated, and shares were issued based on the prospective income and readily sold. Additional enterprises in China were added to the company, and new stock based on future expected business was likewise readily sold. Next the company took over the management of the mint and coinage of France, and after a time bought of the Government the right to collect the taxes for a fixed sum. Finally it undertook the refunding of the vast national debt itself, and upon all these later operations large profits were expected and a proportional amount of stock sold, which advanced in value with each new scheme.

In the year 1719, when the securities of the company were selling at forty times their original value, some one who stopped to reflect discovered that the entire income of the company would only pay 5 per cent. on about one-twelfth of the value then existing. This thoughtful person sold his stock and explained the reason to a few intimate friends, who also sold. Then came the crash and the famous Mississippi Bubble of John Law passed into history. This was high finance as it was known about two centuries ago.

The Inflation of 1900-1902.—In the years 1898 to 1902, certain gentlemen of Wall Street, finding that the industries of this country had temporarily more orders than they could fill, purchased many of the mills and united them into a few great concerns with capital greatly exceeding the former aggregate. In return for these services large blocks of stock were retained as promoters' profits. These gentlemen said that consolidation effected important economies, which was no doubt true, but they further excused their immense capitalization by saying that business was rapidly increasing, and the prospective income would pay interest on a much larger capital than had been issued, therefore all these shares would immediately rise in value. The public, seeing that these captains of finance had made large fortunes for themselves, felt that they must necessarily be well posted in such matters, and accepted their advice as valuable.

In due course of time the mills caught up with their orders, and could not obtain more new business, and a man in the street stopped to remember that the lean years would surely come when income would shrink, and could no longer pay interest on inflated value. So he sold his stock and mentioned his reasons to a few friends, and in about nine months three billions of dollars disappeared out of Wall street into thin air.

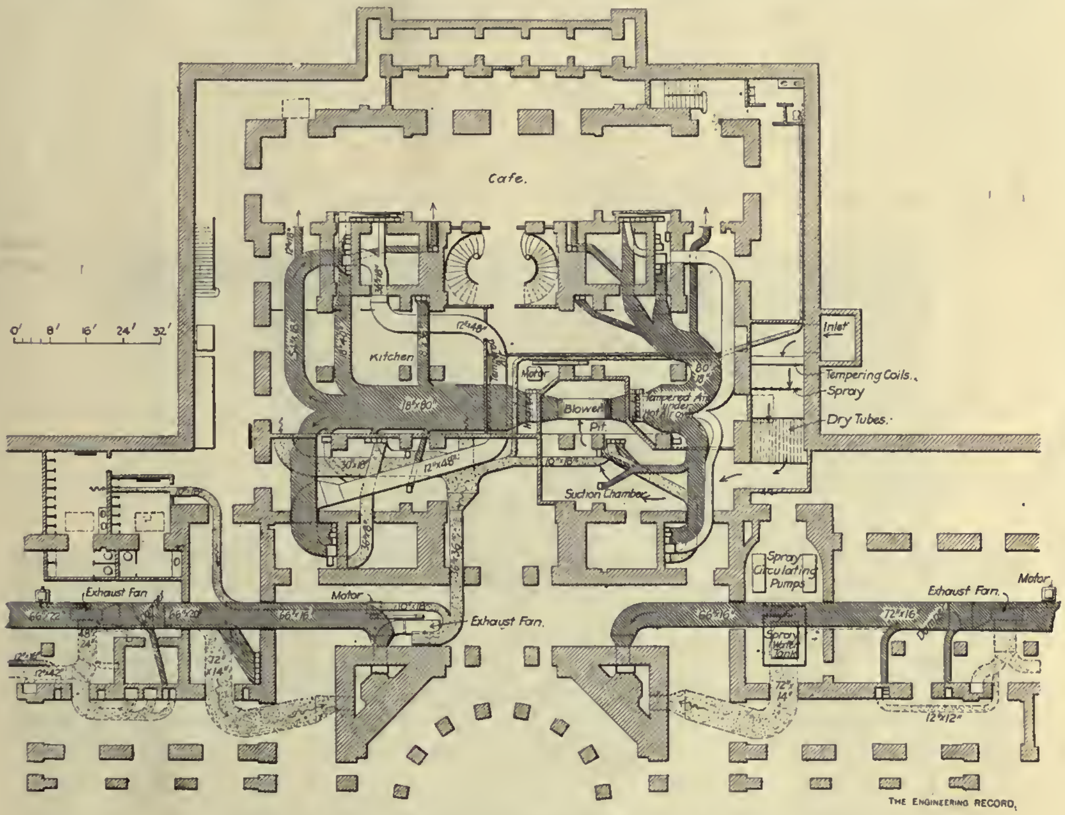
In Paris, after the Mississippi Bubble burst, the street boys sang:—

> "On Monday I bought share on share,
> On Tuesday I was a millionaire,
> On Wednesday I took a great abode,
> On Thursday in my carriage rode,
> On Friday drove to the opera ball,
> On Saturday, came to Pauper's Hall."

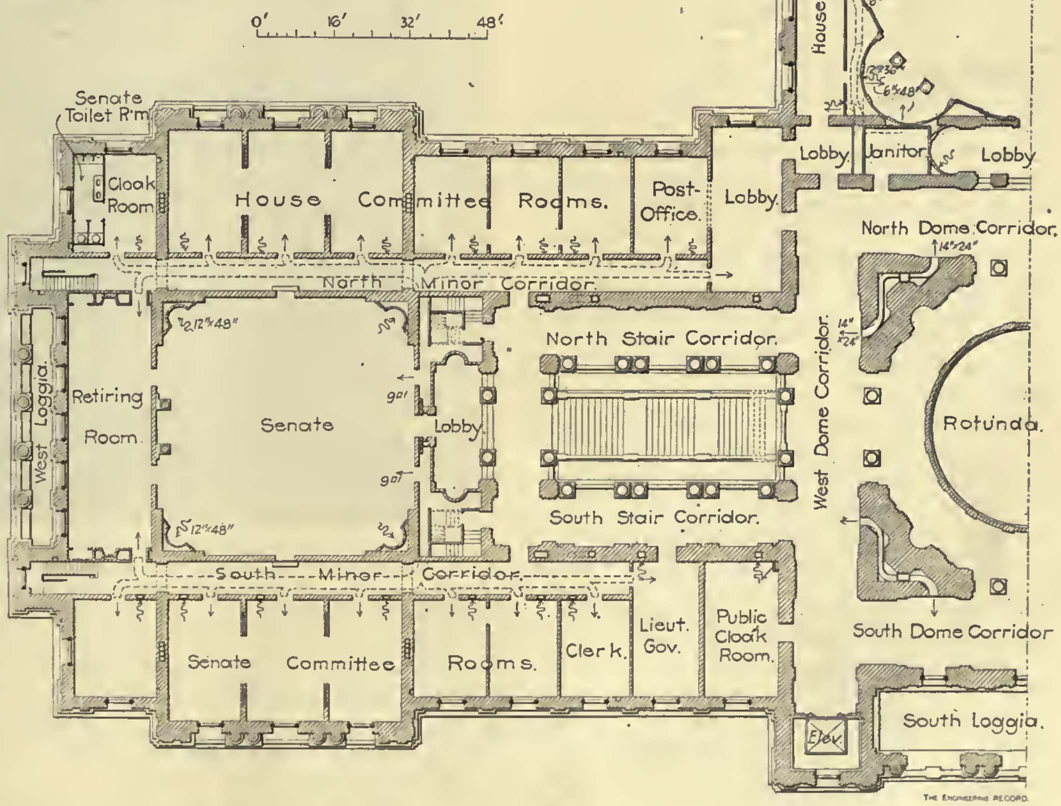
It would appear that this song was not amiss in the year 1903, and thus does history repeat itself.

Popular Notions of Finance.—When we see the giants of the financial world versed in their calling by a life of training, leading well-meaning but dependent minds after them into loss and perhaps ruin, is it any wonder that a civil engineer is timid about studying finance as a science, for fear he is not capable of understanding its mysteries, or appreciating its refinements? Shall we then abandon a field to which the highest attainments of engineering are evidently closely allied, and confess our ignorance to the moneyed men who use our talents in furthering their objects, or is it possible to master essential principles, and take our place as scientific business men as well as engineers? It is the purpose, therefore, of this brief paper to see if we can outline some fundamental ideas on this important subject which will clear away unprofitable awe and stimulate study in a science which is at once so vital and fascinating.

A Definition of Finance.—I would define constructive finance as "the just and orderly con-



Heating and Ventilating Apparatus for the North Wing.



Minnesota State Capitol: Plan of the East Half of the Second Floor.

trol of wealth, so that without waste, it is made completely effective to promote all proper purposes of civilization."

It is evident that many men who control corporations, or who have acquired great personal wealth, have, nevertheless, no clear and reasonable ideas about the principles of such finance as this, but seek success regardless of whether their operations are destructive or constructive, without thought as to what wealth really is, or what are its proper and legitimate uses.

On the other hand, there are men charged with the responsibilities of great personal wealth, or the management of corporate property, who realize how skilfully wealth must be managed in order to prevent waste, and attain the maximum of effectiveness with justice and equity, and, in the last instance, benefit humanity. Such men do not regard their wealth as entirely an individual asset, but rather consider themselves responsible stewards charged with the well-being of the community in which they operate. They do not allow their wealth to be idle or tied up in useless display, but are continually on the alert to keep it at work in the most effective manner, both in increasing established projects and developing new enterprises. Such constructive and conservative management of wealth is a benefit, not only to the owner, but in a far larger and wider degree to all the community who come within reach of his influence.

Waste of Wealth.—A man who dissipates wealth foolishly or extravaganly, who destroys it by deliberate neglect or bad judgment, is ordinarily looked upon as an unfortunate individual, whose actions only injure himself. The science of constructive finance holds that this is not so, and points out that to waste or destroy wealth is a crime against human society, for the loss is not alone personal and individual, but social and racial as well, and the disappearance of an effective and well-directed mass of capital deprives humanity of just that much opportunity for advancement in energy, vitality and uplifting.

Constructive finance even goes further than this, and denounces piratical undertakings which would transfer wealth by the ruin of other wealth, or which tear down and destroy anything which is reasonably useful, in order to reap selfish benefits. Such projects cannot ordinarily be financed in these days by conservative and intelligent bankers, where the avowed object is the wanton destruction of other invested capital.

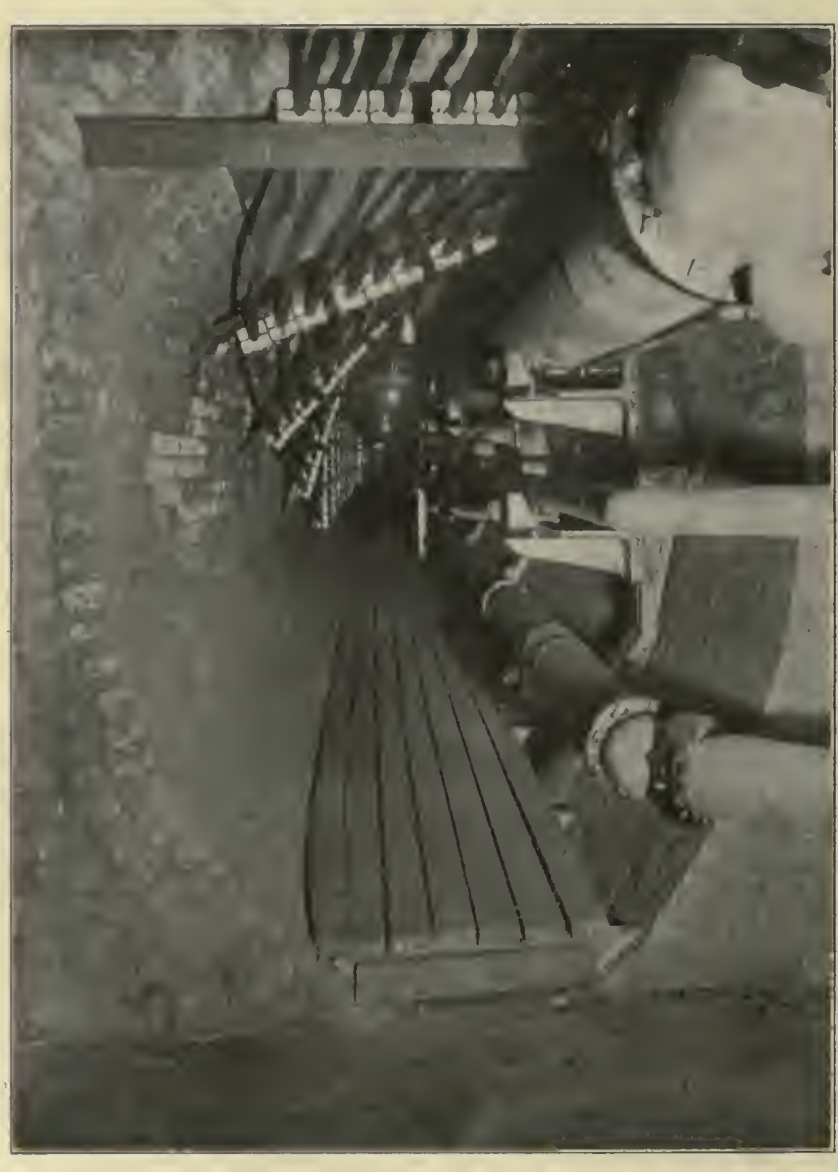
Ruinous competition is also deprecated by constructive finance as a waste of energy, which, when carefully analyzed, is fruitless of real benefit to society, and the phrase, "community of interest," has been adopted as the result of the growing perception that harmony among those who guide and control wealth will allow them to make that wealth more completely effective for all the proper and legitimate purposes of civilization.

Enough has already been said to show that thoughtless speculation, the promotion of excessive capitalization, stock gambling, wealth built up unjustly, illegally, or by methods which are injurious or destructive to other interests, and which do not advance civilization, knowledge and high standards of living, are not constructive finance in the sense that I desire to discuss—the engineer's relation to it and his knowledge of it.

The Relation of the Engineer to Finance.

The engineering student does not generally list constructive finance as one of the requisites of his professional education. Early in life, however, he comes to see that the relation of the engineering side of a project to the financial side is close and important. While he is dealing with the minor economies of large expenditures, he obtains insight into the relation between efficiency and economy. The paradox of the cheapest material often being the dearest, explains itself by practical example, and finally he is taught by embarrassing and unpleasant experiences, that his triangles and logarithms are not the largest factors of the project upon which he is engaged, and conclusions derived solely from them are often overruled.

At this period of life, if an engineer is not broadminded, and gifted with some insight into the root of things, he is a little tempted to whine about the lack of appreciation the public and capitalists have for his work, and complain how underpaid it is compared with its importance. This is a transitional stage for the engineer, when he begins to fit himself into the financial, economic and sociological side of his work, and when he is duly humbled he finds that his peculiar acquirements which have hitherto seemed so important, are in reality only one of the wheels in the procession.



View in Pipe and Wire Tunnel for Minnesota State Capitol.

Several important factors easily take precedence over the engineer in the development of industry and the conservation of wealth.

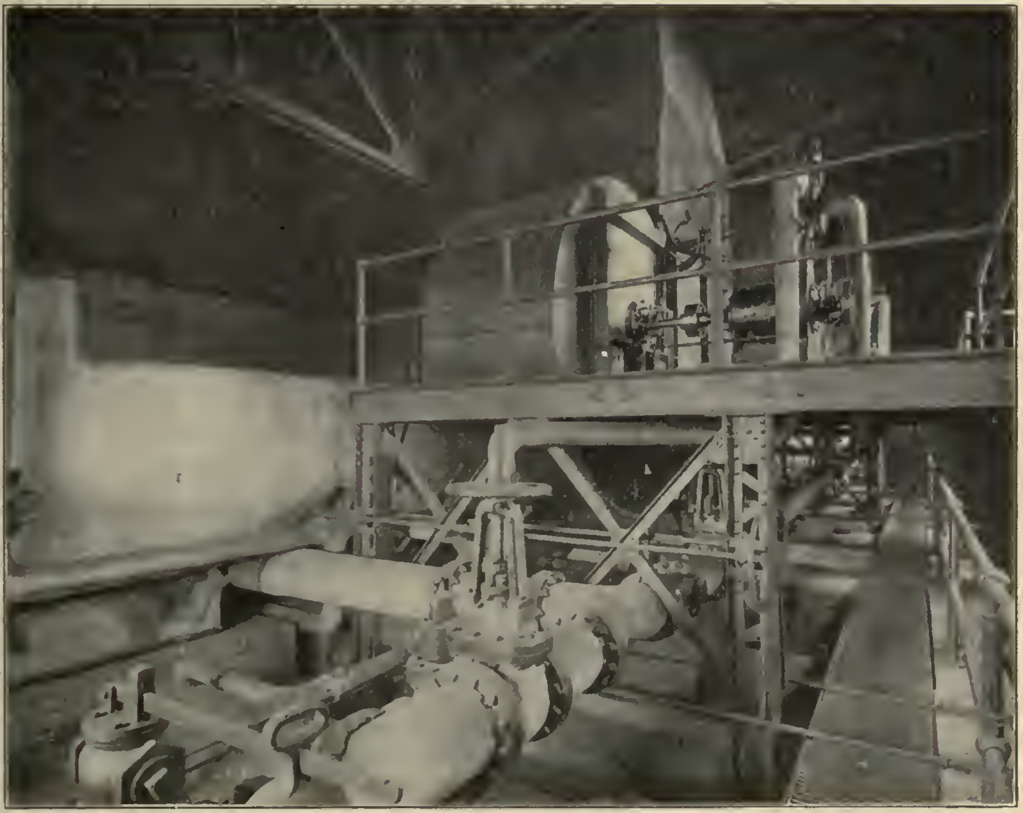
The Promoter.—There is the much maligned promoter, who in reality studies the needs of humanity, often from a selfish point of view, but nevertheless with the innate realization that he cannot help himself without first helping society at large. The promoter is the man who sees opportunities and plans how they may be filled, endeavors to effect economies, harmonizes interests; explores undeveloped territory. He takes risks, fails often, but undaunted, persists to occasional success; always in the present order of society, with self-interest first in view, but always compelled from correct principles of conservative finance, often unexplained even to his own mind, to seek that the public at large shall be benefited in order that he may reap from them a reward.

The Financier.—There comes the financier, who always has his fingers on the pulse of human vitality, and notes the ability of the race to take on new energies, or observes their need to rest up from a temporary overload. Such are the bankers, capitalists, trustees and presidents who control the trust companies, banks, bond houses, and other forms of individual or corporate wealth. It rests with these men to decide on any given project as to its soundness and good sense, and their first inquiry is, "will it pay?" which is only an unthoughtful way of asking if it will serve humanity.

In such analysis no fancies are permitted. Cold, hard facts are alone in demand. The overheated imagination of the promoter does not excite the true financier. No gilded pictures of profits delude him. He is interested only in the truth, and having satisfied himself that he has uncovered it in every part of the project, he proceeds to interpret it in the light of the needs of the time, and asks himself, "Is there idle capital in sufficient amount awaiting for work?" If so, he will undertake to provide that this idle capital and its opportunity shall be brought together. If capital has temporarily exhausted itself in other and more needed directions, or has been so foolish as to enter speculative projects in which it has been dissipated, then the undertaking must wait until financial energy has again recuperated itself, and the times are vital with abundant strength for new enterprises.

With the financier comes the engineer. Often the financier early calls in the engineer to his aid in probing for the truth. Not the engineer whose experience is limited to the transit and the drawing board, but the one whose broad experience and insight into underlying principles of things has given him a large knowledge of finance on its scientific side, as well as an understanding of the broader relations of engineering to human society.

The Engineer.—The engineer of this type is admirably fitted to aid the financier, because, from the very nature of his profession, he has been all his life a seeker after truth and fact, and also because the profession of engineering has very high standards of honor. It is a profession of trust. No higher commission can come to the profession than investigation of the financial status of new projects of magnitude. The interests involved in many cases are vast and far reaching. Security holders in the future are either indebted to his knowledge and care in making life for them higher and better, or are blighted by penury, loss and privation, owing to his poor judgment.



Mechanical Draft Fans and Steam Piping in Boiler Room.

The Designing Engineer.—After the preliminary investigations are finished, and the work is financed, comes the opportunity for the engineer who deals with the design. The design of engineering works affords a most important field for the scientific application of the principles of constructive finance, and while it is only one branch of the financial problem, it is a most important one.

The problem is to expend a given sum of money so as to realize its utmost effectiveness in a physical structure, and at the same time secure only a stability consistent with the use to which it is put, and the length of life which may properly be expected of it.

No engineering design can be said to be intelligent which does not show on its face a clear perception of these principles, and the designer who would fulfil in the highest sense his commission, must know the relative life of a series of structures or parts of structures, the likelihood of change in the arts affecting their usefulness, the financial considerations involved in the value of money invested for the future, and the probable length of time for which it is desirable to attempt to forecast the future in the given business under consideration. All of these items are of first rank, and second to them comes an intimate knowledge of the materials and methods of construction, their relative economy and practicability, their length of life and the life expected of the particular part into which they are fitted.

A young man recently pointed out to the chief engineer of the Pennsylvania Railroad that he was building masonry bridges at immense cost, and substantial steel bridges could be had at much less expense, and the chief engineer very kindly explained that the time had come for the Pennsylvania Railroad when it was proper to look ahead for more than one hundred years and finance its structures accordingly.

The Constructing Engineer.—Nor is the superintending and constructing engineer more free from the principles of finance than the designing engineer. At the very outset of the work he encounters two fundamental difficulties which include nearly all of his others, and which work to prevent his obtaining the highest efficiency.

First. He finds that labor is dissatisfied with its share of the production of human activity, but puts no limits on its demands, while capital has no fixed principles, fundamental in their justice in dealing with labor; hence, organization, strikes and warfare. The solution of these difficulties in their last resort is complex, for the problem involves in its intricacies the whole present day social order. The engineer, therefore, can only view it as a social and economic evolution in which all parties at interest must exercise patience and moderation.

Second. The construction engineer becomes also involved in the law of supply and demand. At times he estimates upon panic prices of materials, at other times upon prosperity values, and always there is constant fluctuation, which is apt to wound his pride in his accuracy.

Political economists say there are times when we suffer from overproduction, and there are other thinkers who choose to believe that we suffer from inability to consume. Certain it is that through lack of scientific and unified control of world resources, we are subjected to periods of inability to properly adjust consumption and production. These are complex questions, and they are not settled offhand. The engineer will need to examine them from all points of view and think over them, for they are the problems the coming generations must solve.

(To be continued.)

A Coal-Testing Plant at St. Louis.

Among the interesting exhibits connected with the Department of Mines and Metallurgy at the Louisiana Purchase Exposition will be a coal-testing plant operated under the direction of the United States Geological Survey. The tests will be conducted not for the purpose of determining the relative value or merit of different coals, but primarily for the purpose of demonstrating the most economical methods for their utilization.

The testing plant will comprise two standard boilers, a gas producer, coke ovens, washery plant, and two or more briquetting plants. In connection with the boilers one Corliss and one steam turbine engine will be operated, and in connection with the gas producing plant one explosive gas engine. The power generated by these plants will be utilized for operating the working exhibits in the Mines Building. The testing plant will be located on the ground reserved for outdoor mining exhibits, at a short distance from the Palace of Mines and Metallurgy. The Director of the Survey has appointed to conduct this work a committee consisting of Messrs. E. W. Parker, J. A. Holmes and M. R. Campbell.

The equipment for carrying on these tests has been loaned by the exhibitors of the machinery, and Congress has appropriated $60,000 to enable the Director of the Geological Survey to make the tests. It is especially provided in the act of Congress making the appropriation, that all the testing machinery and all the coals tested shall be furnished without charge to the government, the expenditure of the appropriation being limited to the absolute cost of assembling the plant so as to make it conveniently available for the work and the expenses necessarily incurred in its operation.

The material to be tested will be collected under the direction of Mr. M. R. Campbell, of the Geological Survey, who will procure the cooperation of the various State geologists. Great care will be exercised to see that the samples sent for testing represent the commercial product of the mines or districts from which the coal is shipped, and are not selected samples. No tests will be made of any coals shipped in less quantity than one good-sized carload, as it will require from eight to twenty tons for each of the different tests to which the coals will be subjected.

The work possesses a peculiar interest from the fact that this government has not heretofore attempted to make any uniform and comprehensive examination of our mineral fuels. The governments of Great Britain, Germany, France, and Belgium have made such examinations and published the results in official reports which are of great value in securing foreign trade.

Types and Details of Bridge Construction; Plate Girders.—I.

By Frank W. Skinner, C. E.

Several months ago there was concluded in this paper a series of articles entitled "Types and Details of Bridge Construction," which dealt with wood, iron and steel arch bridges. A similar treatise on plate-girder bridges is now in course of preparation, and it is the intention to print a few of the chapters in this journal, as convenient opportunities may offer. The purpose of the descriptions and illustrations in the treatise is to record, in a form convenient for reference, classified details, important data and the general features of structures which have actually been erected, so as to indicate progress in design and show present standards. The examples to be presented have been selected because of their interest and not because they are approved as models; the particular structures described may or may not be considered as in accordance with good practice. Criticism, in general, even when obvious, is avoided. The presentation of any detail does not necessarily imply that it meets with approval, but merely that it is considered typical or interesting as an example of actual construction. The descriptions have been prepared with the view of making them specially valuable to bridge designers, draftsmen, city engineers, teachers and students.

Expansion Details.

Sliding Bearings and Pockets.—Expansion ends of plate girders are usually designed to provide for temperature variations and allow small longitudinal movements without permitting transverse or vertical displacement. They are often omitted at both ends of short span girders, but are always provided at one end of single long span girders and at one end of each span or of occasional spans in a structure which consists of a continuous series of spans. Provision is accordingly made for movements of 2 inches or less. This is usually accomplished by letting the end of the girder slide freely on its lower horizontal flange between fixed longitudinal guides, by seating it on rollers, by suspending it from vertical links, by connecting it to a rocker strut or by providing for the movement of a shoe to which it is pin-connected. Another method which has been applied to stringers, but is seldom or never used for girders proper, is to support them by horizontal bolts through slotted holes in the web. A large amount of care and ingenuity has been devoted to the design of expansion connections suited to different conditions and it is an important and often a difficult matter to devise a connection that is efficient, economical, simple, easily constructed in the shop and quickly completed in the field.

Sliding Ends.—In the simplest expansion detail the girder takes bearing on the horizontal under surface of the bottom flange. In light, cheap work the flange angles sometimes rest directly on a bed plate bolted to the masonry and are secured to it by a vertical bolt through a slotted hole on each side. In heavier work there is a sole plate countersunk-riveted to the under side of the end of the flange and planed. It takes bearing on a rolled or cast bed plate, which is planed on the upper surface and is set immovably in cement or on a sheet of lead on the pier masonry. The bed plate may have a plain or ribbed upper surface and lateral displacement may be prevented by anchor bolts through slotted holes in the sole plate and round holes in the bed plate or by a tongue and groove or by outside guide strips on the bed plates.

When the girder is supported on a column cap or seated on top of another girder, the bed plate is generally omitted. When it is supported from transverse girder brackets, pockets and drop ends or some modification of them are generally provided, and when the girders act as stringers to carry the railroad track ties directly on their top flanges it is sometimes difficult to provide a satisfactory detail.

The 67½-foot longitudinal plate girders in the main platforms of the approaches to the Williamsburg bridge, New York, are seated on the long extended caps of the vertical columns between guide plates riveted each side of the girder to engage with a small clearance the edges of the sole plates which are countersunk-riveted to the under side of the girder flanges. At expansion joints, on every alternate column, there is one fixed and one sliding girder end, with a clearance of about 1 inch between them on the center line of the column. The sliding end is bolted to the column cap through slotted holes and supports on its upper flange half of the sole plate of the floorbeam. The sole plate is riveted across the bottom flange of the floorbeam and to the lower edges of a pair of transverse solid-web vertical knee braces, which stiffen it, distribute the floorbeam load on the girders and prevent tipping or longitudinal displacement of the floorbeam. One end of the sole plate or floorbeam pedestal, is field riveted to the top flange of the fixed girder and the other end takes bearing on the top flange of the sliding girder, which thus receives half the load and is free to move back and forth under it.

In the four-track structure of the Atlantic Avenue Improvement viaduct, Brooklyn, N. Y., which was described in The Engineering Record of July 7, 1902, two of the eight lines of longitudinal plate girders are in the planes of the columns and are supported directly on their extended caps. One fixed end and one sliding end girder is seated at each expansion joint with a space of several inches between them, over the center of the column to allow for the continuous web and flanges of the transverse girder of the same depth seated on the same column cap plate, which is reinforced by knee-braces in four directions, in the girder planes. The sliding end is bolted to the cap plate through slotted holes and has slotted holes through the upper part of the web for horizontal bolts in diaphragms riveted to web stiffener angles of the transverse girder. There are also vertical bolts which engage Z-shaped connections at the ends of the top flanges of the longitudinal girders and pass through slotted holes in the top flanges of the transverse girders and so secure the upper parts of both girders.

The other six lines of longitudinal girders are supported directly by the transverse girders. The expansion ends are seated on horizontal bracket shelves riveted to the transverse girder webs. Each shelf has a cover plate on the outstanding flange of a short horizontal angle which is reinforced by two pairs of angles perpendicular to the girder web, which are riveted both sides of the longitudinal flanges of two pairs of vertical angles which distribute the load on the girder web. In order to have room for sufficient rivets in these four vertical rows the shelf has to be near the middle of the height of the girder, and as the bottom flanges of longitudinal and transverse girders are nearly flush the ends of the former are notched to give them seats on the shelves.

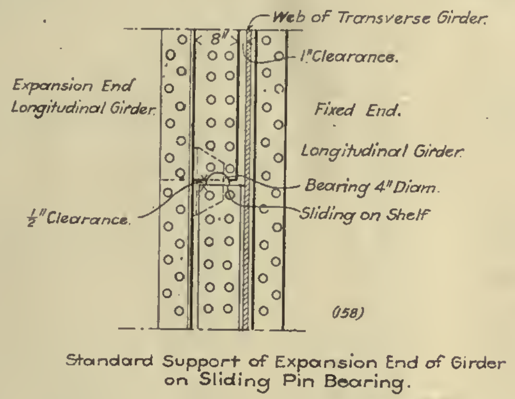
The seat is made with a horizontal transverse angle riveted across the web stiffeners at the notch, and having its outstanding flange reinforced by the milled ends of a pair of vertical angles. These angles have their longitudinal flanges turned toward the transverse girder so as to provide the maximum clearance there and allow the field connection rivets to be driven through the webs of the transverse girders and the fixed ends of the adjacent longitudinal girders, without difficulty, after both fixed and sliding girders are erected. The girders are bolted to the horizontal seats through slotted holes.

The Brooklyn Elevated Railroad spans average about 50 feet, and in general have four lines of longitudinal plate girders supported by transverse plate girders. The early designs were made, as shown, by the standards of 1884-5, with the drop ends of the longitudinal girders seated on the top flanges of the transverse girders, with a butt joint on the center line of the latter. Horizontal bearing angles were riveted to the notched edges of the web plates and were riveted to the top flanges of the transverse girders for the fixed ends, and bolted to them through slotted holes for the sliding ends. The lower flanges of the longitudinal and transverse girders were flush, and those of the former were spliced across the latter by horizontal field-riveted cover plates. Neither fixed nor sliding end girders were connected to the webs of the transverse girders.

In later designs this detail was modified, as shown by the standard for 1886, in which the depth of the longitudinal girder is reduced so that the lower flange is considerably above that of the transverse girder, and its projecting angles are bolted to shelf plates projecting horizontally from the girder webs. Wide seat plates are also bolted across the top flanges of the transverse girders and project beyond them to receive the bearing angle flanges of the drop ends, which are bolted to them with clearance for temperature movements. Both of these types provided conveniently for spacing track ties, but were considered to lack stiffness for lateral and longitudinal stresses, and so were superseded by types with the top flanges of the longitudinal girders dropped to the same level as those of the transverse girders.

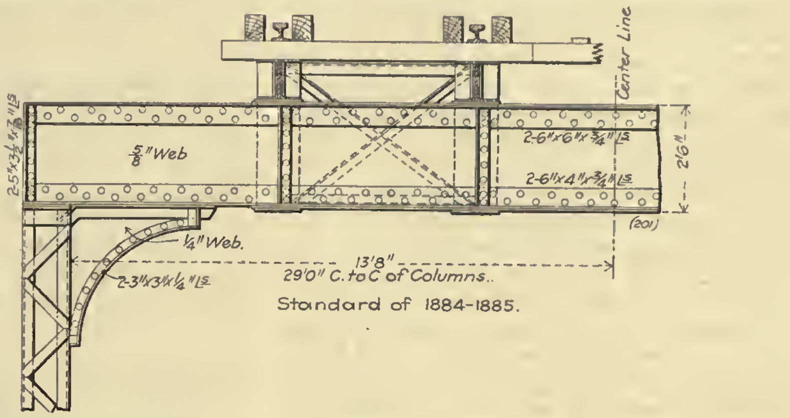
Pocket Connections.—In recent construction pocket seats for the lower flange bearings of the expansion ends of longitudinal girders in viaducts and elevated railroads have been extensively used. These are usually made with pairs of vertical gusset plates perpendicular to the transverse girder web and connected to it by special vertical angles or by the regular web stiffener angles. The bottoms of the gusset plates are connected by horizontal bearing shelves made with bent plates, angles, I-beams or channels, usually riveted to the transverse girder web also, and affording a seat to which the lower flange of the longitudinal girder is usually bolted through slotted holes, although it sometimes merely rests there without any fastening. This type of connection avoids the undesirable features of drop girders, notched ends, or special ends for the longitudinal girders, and can distribute the load uniformly over the web of the transverse girder. It also affords a convenient connection to vertical or batter posts of viaduct bents or towers when it is desired to keep the girders below the tops of the posts.

In the New Kinzua Viaduct the outside lines of the longitudinal girders have their expansion ends seated in pockets made with pairs of gusset plates about 8 feet deep and 15 inches apart. Each plate is connected to the top of the trestle bent by a pair of 6x4-inch vertical angles, and is tapered from both ends to a maximum width of nearly 2 feet near the lower end. At this point the gussets are connected by a pair of horizontal 15-inch channels, back to back, with a pair of 1-inch bearing plates countersunk-riveted to the web of the upper channel. The end of the girder is seated on this plate without bolts, but the top flange is flush with the top flange of the trestle top and is connected to it and to the adjacent fixed girder by a flange plate riveted to the latter and bolted through slotted holes to the sliding girder flange. This connection is virtually made both to the web of the double-web transverse girder and to the top of the battered column which it intersects on the center line.

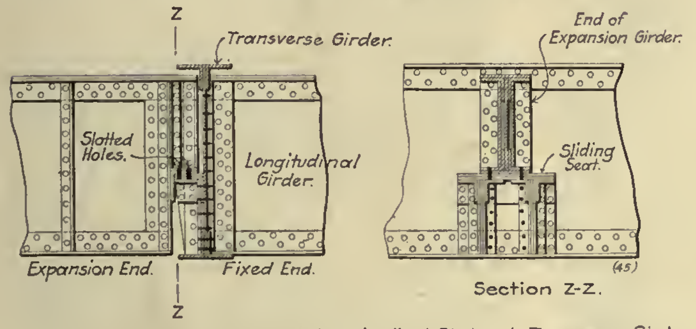


Standard Support of Expansion End of Girder on Sliding Pin Bearing.

New York Rapid Transit Railway.



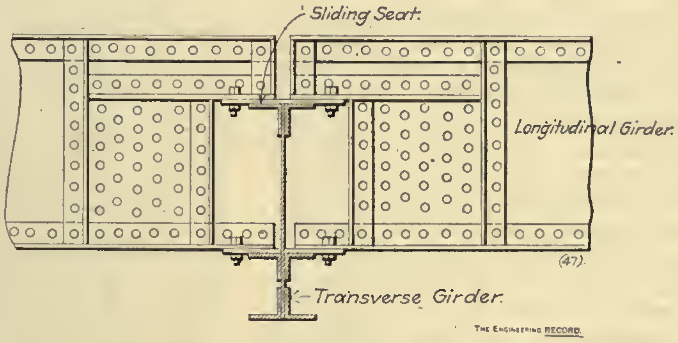
Standard of 1884-1885.



Section Z-Z.

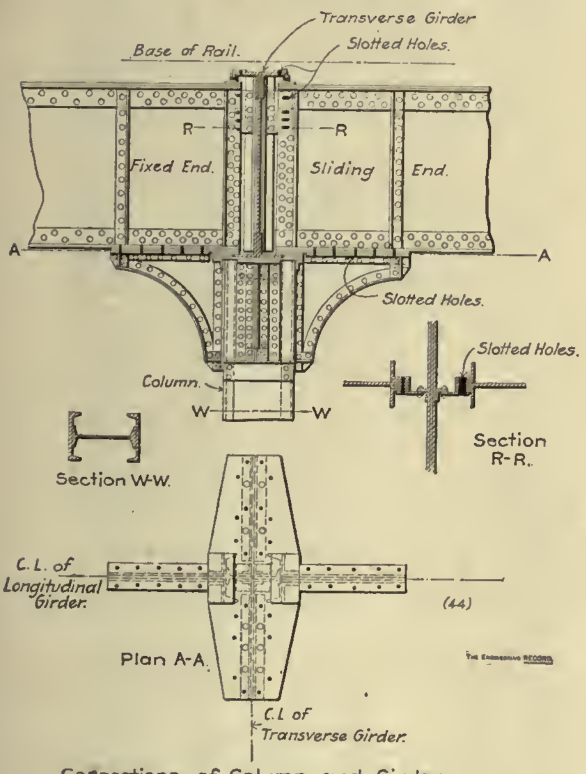
Connection of Intermediate Longitudinal Girders to Transverse Girder.

Atlantic Avenue Viaduct, Brooklyn.



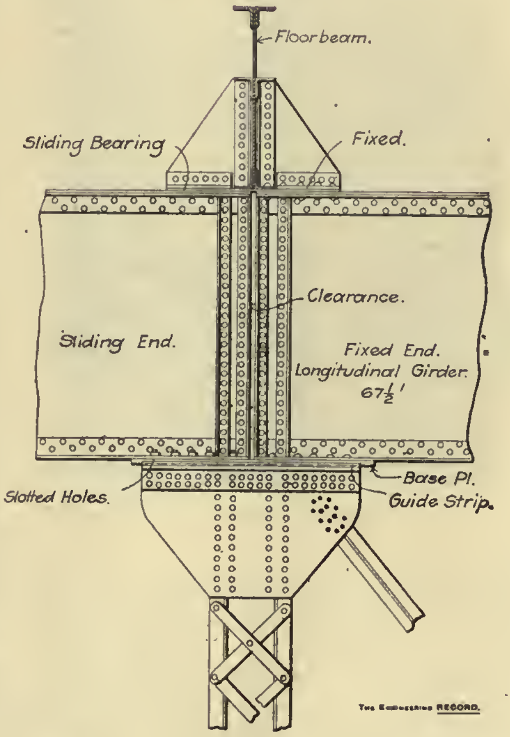
Standard of 1886.

Brooklyn Union Elevated Railroad.



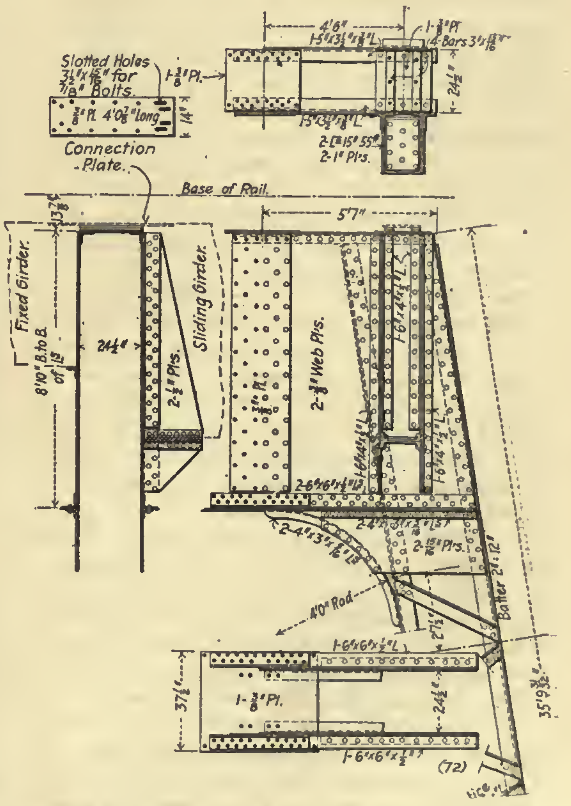
Connections of Column and Girder.

Atlantic Avenue Viaduct, Brooklyn, N. Y.



Expansion End of Main Longitudinal Girders.

Roadway Girders, Williamsburg Bridge.



Seat for Girder, Kinzua Viaduct.

The elevated structure of the New York Rapid Transit Railroad Company was described in The Engineering Record of February 28, 1903. The longitudinal girders are web-connected to the columns and to the transverse girders. Their sliding ends have web reinforcement plates projecting beyond the end vertical web-stiffener angles, with their lower horizontal edges just below the center line of the girder. In the same plane are the reinforced flanges of a pair of vertical web-stiffener angles reaching from the lower flange to the middle of the transverse girder. Their top edges just clear the bottom edges of the projecting plates and support the flat base of a loose semi-cylindrical steel bearing piece about 3 inches long, which is engaged between angle-jaws projecting from the end of the longitudinal girder. The lower edge of the projecting web plate has a half-hole bearing on the semi-cylinder and slides back and forth with it according to temperature movements, while it is also free to deflect on it without perceptibly changing the bearing under deflections. The top flange angles of the longitudinal girders abut on the center line of the transverse girder, and their lower edges just clear its top flange and are engaged between the vertical flanges of two short guide angles riveted across it. The flanges of the fixed girders are riveted and those of the sliding girders are bolted through slotted holes.

(To be continued.)

Alcohol as a Fuel for illuminating and power purposes is extensively used in France and Germany. Germany is the leader in this line using largely spirits extracted from potatoes. Since 1887, when the German government began to encourage the use of alcohol for mechanical purposes by removing imposts, the acreage devoted to potato growing has been increased very largely. From 1887 to 1891, the average annual crop of potatoes was 27,000,000 tons; for the five years 1897 to 1901 inclusive, the crop averaged 40,000,000 tons. During the first four months of 1903, according to "The Engineer," the Society of Alcohol Manufacturers sold considerably over 210,000 gallons.

Future Improvements in Internal Combustion Motors.

The internal combustion motor was the subject of a comprehensive monograph contributed recently by Mr. Dugald Clerk to the Institution of Civil Engineers. A portion of it, on account of its practical bearing on the question of improvements to this class of engines, is printed in the succeeding review, but the rest of it, which was largely given up to the discussion of investigations of the author, can only be referred to in brief. In one particular the work may be said to emphasize the need of co-operation on the part of both the physicist and the chemist with the engineer, pointing out the lines along which scientific investigation is most desired. The present position of the theory of the internal combustion motor is, he said, in the state of that of the steam engine at the time of Watt, before the accurate determination of the properties of steam. As Watt knew of the latent heat of steam, but did not know all its properties accurately through a considerable range of pressures and temperatures, so engineers now know of a similar absorption or suppression of heat existing in gaseous explosions, without knowing accurately its causes or proportions under all the various conditions of practice.

Much difference of opinion still exists on physical and chemical points, but all are agreed, he says, so far as practice is concerned, on certain main features. These leading features are: Initial compression of the working fluid, exposure of the flame to the smallest area of cooling surface for the shortest time, and the use of the lowest flame temperatures consistent with high available pressures. Development has followed two main lines: First, improvements relating to the motor itself, including changes in the thermodynamic cycle; second, improvements in the means of generating the fuel to operate the motor. The former comprehend the modification of admission valves, igniting devices, governing devices and water and air cooling devices. The latter relate to the effective production of ordinary gas, producer gas, the treatment of hydro-carbons, the purification of blast-furnace and coke-oven gas, and the like.

As to the question of the heat efficiency of internal combustion motors, a table was given of heat balance sheets from tests of engines reported by well known engineers from 1882 to 1900. A steady increase of efficiency was noted. In the first test the heat converted into indicated work was only 16 per cent. of the total heat given to the engine, and this rose to 28 per cent. in 1898 and 1900. In the figures for the proportion of heat rejected in the water circulation, the tests of 1882 and 1884 showed 51 and 52 per cent.; the latest tests, 24.2 per cent. An examination of the heat rejected in the exhaust, on the other hand, showed a tendency to increase, ranging from 31 per cent. to 40 per cent., and in one late case 48 per cent.

With regard to the ways in which physicists could be of service, Mr. Clerk presented the following suggestions: The determination of the maximum temperature of gaseous explosions depends, to a large extent, on a knowledge of the chemical actions going on in an explosion. These actions are of a very complicated kind, and more exact knowledge as to their nature will exercise considerable influence upon the future of the internal-combustion motor.

Assuming complete combustion, it is well known that a maximum explosive mixture of hydrogen and oxygen, or carbonic oxide and oxygen, suffers a contraction of one-third in the passage from the uncombined gases to the compounds, steam or carbonic acid. In the use of hydrocarbons such as occur in petroleum and petrol, it is found that instead of contraction, molecular expansions occur. With alcohol, for example, which is now coming into use in these engines, eight volumes of explosive mixture expand to ten volumes on complete combustion. An air mixture with alcohol could easily give an expansion of about 6 per cent. In this respect alone, then, all change of molecular volume between the uncombined gases and the compounds formed after combustion must be carefully examined before the temperature can be estimated, either from an indicator diagram taken from an engine or from the results of an explosion in a closed vessel.

Gas engine constructors have noted that among all uncertainties there emerges one certain fact, that the higher the compression—or, rather, the smaller the compression space relatively to the cylinder volume—the greater the economy to be obtained from the engine. They have seized upon this fact, and the past twenty-five years have shown steadily increasing compression. All internal-combustion motors suffer large heat losses because of the contradictory requirements of the practical cycle. The cycle requires a charge of working fluid first as cold as possible, then the compression of that charge without heat loss or gain, then combustion producing high temperatures, succeeded by expansion, also without heat loss or gain. In the ordinary internal-combustion motor of medium size these opposite conditions follow each other in the same cylinder at intervals of about one-sixth of a second, and in a high-speed petrol motor at from one-twentieth to one-fiftieth of a second.

Concrete-Steel Chimney at Leiter.

With engines of similar proportions, the surface exposed for cooling flame increases as the square, while the capacity of the engine increases as the cube. From this it follows that the larger engines should lose less heat proportionately than the small ones. This is found to be the case, but it is also found that in engines above certain dimensions the reduction of cooling surface can be pushed too far. This is due to the fact that an engine piston has to compress an inflammable mixture to high pressure before ignition occurs at all. If the products of the previous combustion be not entirely removed, then in a large engine the temperature remains so elevated that the initial or suction temperature of the engine is raised, and at high compressions pre-ignitions occur. In small engines pre-ignitions are rare, and are not dangerous; in large engines they are unfortunately somewhat frequent, unless mean pressures be kept down and extensive cooling adopted. Pre-ignitions are due to many causes—sometimes to a small incandescent part of metal within the cylinder, sometimes to a porous surface of metal within the cylinder, sometimes to a hot piston end, sometimes to an overheated exhaust valve, possibly to charred matter of carbon deposited in the cylinder. In all cases it occurs owing to the tendency of these engines to become overheated.

The temperature at which pre-ignition occurs depends on the nature of the gas used; and so the engineer may regulate his compression, rate of cooling, and other circumstances to keep his mixture lower than this point. One of the great limitations imposed on the large engine is due to excessive heat flow through the enclosing walls. This heat flow increases with increase of explosion temperature. In the smaller engines the tendency of recent years has been to increase flame temperatures within the cylinders to the highest safe economical point, because each maker desires to sell an engine giving the greatest power as well as economy for a given price. The problem is, in the end, a commercial one, and the pressure of competition in the end forces the designer to get not only the highest economy, but also the highest safe power limit for compressions and dimensions of the engine.

The question of high mean pressure is a most important one. In many of the large gas engines the mean working pressures are relatively low; in the large continental engines mostly 60 pounds per square inch or under. British built engines usually operate the medium sizes, at pressures as high as 90 pounds and 100 pounds per square inch, and the English engineer at present is by no means satisfied with the average pressures which he can safely employ in existing large gas engines. To obtain high mean pressure is to have an engine of great power for small dimensions, but if flame temperatures be reduced to prevent heat flow difficulties, and save heat in this way, the mean pressure is also reduced. It is very desirable to reduce heat flow, especially in large gas engines.

Some time ago it appeared possible to Mr. Clerk to reduce maximum temperatures while increasing mean pressure by increasing the charge weight per stroke given to an engine. He experimented with two engines, one of 7 inch cylinder, 15 inch stroke, and another of 10 inch cylinder by 18 inch stroke. These engines, which are of the ordinary standard four-cycle type, are allowed to take in the usual charge of gas and air, then at the end of the stroke a further charge of air or other inert fluid is added to increase the pressure in the cylinder to seven pounds or eight pounds per square inch above atmosphere before the return of the piston begins. This has the effect of increasing the charge weight present in the cylinder by about 40 per cent., and of increasing the pressure of compression without, however, increasing the temperature of compression. Indeed, in both experiments, the temperature of compression was diminished. As the charge present is constant so far as gas is concerned, the maximum temperature in the diagrams taken by him from these two engines is about 1,200 degrees centigrade (2,200 degrees Fahr.). Experiments were made, and it was found that the heat flow was reduced to about two-thirds; and, further, that the mean available pressure was increased about 20 per cent.

Two indicator diagrams were shown from the 10x18-inch engine, one from the engine in its ordinary condition of operation, and the other to show the effect of adding air. In the case of the ordinary diagram, the compression was carried to 130 pounds, the maximum pressure to 460 pounds, and the mean pressure was 89 pounds. The amount of gas per indicated horse-power was 16.7 cubic feet, and the thermal efficiency was 27.7 per cent. The other diagram showed a compression of 190 pounds, a maximum pressure of 565 pounds, and a mean pressure of 110 pounds. The amount of gas per indicated horse-power hour was 13.2 cubic feet, and the thermal efficiency 34.4 per cent. This method of increasing practical efficiency has the merit of reducing temperatures all round, and preventing pre-ignitions in two directions, namely, by temperature reduction and also by reducing the average inflammability of the charge so that it is less readily ignited on compressioin.

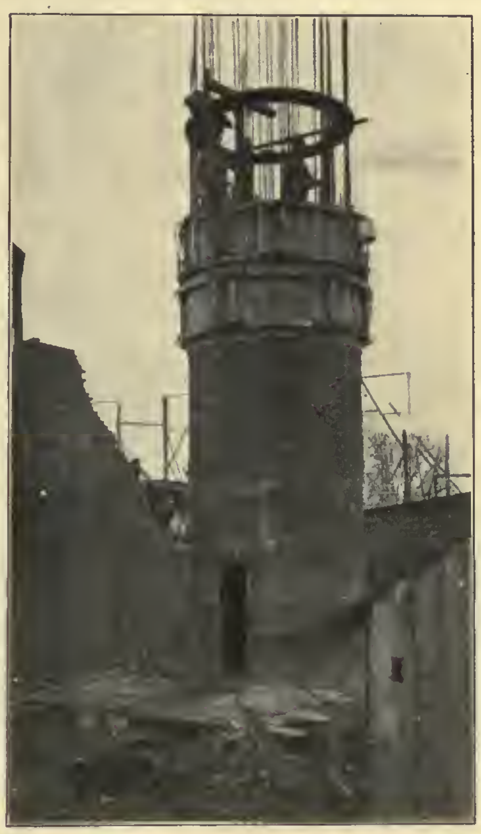
If in large engines just enough heat could be added to the expanding gases to keep the expansion line up to the adiabatic, then greatly increased efficiencies would be obtained, and no increased loss of heat would be suffered by the discharge of the exhaust. From the expansion curves, however, of large engines it is evident that heat is added during the expansion stroke in proportions far greater than is necessary to keep the line up to the adiabatic. More work is done above the adiabatic line, and this at once introduces a cause of loss of efficiency, as is shown clearly by the tables referred to. Further, it also introduces an increased loss by discharge of a certain proportion of heat with the exhaust gases. This loss is increased in large gas engines instead of diminished. Engineers should endeavor to find means of adding the heat required at an early part of the expansion in order to avoid this difficulty. It may very well be that the rate of combustion is too slow to enable all the required heat to be added early in the stroke. In large gas engines it certainly appears as if this were the case, and this peculiarity introduces the possibility of improvement in efficiency by the use of lower speeds giving longer periods for the combustion of each charge. If physicists or chemists could discover means of adding heat early in the stroke greater efficiencies would be at once attained. It might be said that improvement in this respect could be had by expanding to a volume greater than that of the original volume of the gaseous charge before compression. This, no doubt, produces some improvement; but, unfortunately, it greatly increases the weight and dimensions of an engine for a given power. The old idea among gas engineers to increase economy was to increase expansion beyond original charge volume. It has been found, however, that this is much more effectively done by diminishing compression volume. Greater expansion gained in this way is gained under conditions which reduce cooling surface instead of increasing it, and impose no greater strains upon the engine relatively to the volume swept through than in the case of expansion beyond atmosphere.

A Concrete-Steel Chimney Reinforced with T-Bars.

The new Leiter coal mines at Zeigler, Franklin county, Ill., have just completed a concrete-steel chimney 154 feet 10 inches high with a uniform inside diameter of 6 feet. The power house with which this chimney is connected at present contains three Heine safety water-tube boilers of 350 horse-power each, and supplies power to the mines and electric light to the town.

The foundation for the chimney is carried to a depth of 9 feet 6 inches below the new grade and has a bearing 18 feet square. The foundation reinforcing consists of four layers of 1¼x1¼x¼-inch steel T-bars. Two sets lie diagonally with respect to the sides of the foundation and at right angles to each other, and the other two parallel with the foundation sides and also at right angles to each other; the former are spaced 18 inches apart and the latter 12 inches.

The chimney proper is built up around vertical T-rods, 1¼x1¼x¼-inch in size, the bottom ends of which are turned outward and fixed between the layers of the foundation reinforcement bars, to securely anchor the structure. Every 18 inches these vertical rods, which are placed flange out, are banded outside by a T-ring 1x1x⅛-inch placed with the flange inside. The vertical rods are in lengths of 20 to 27 feet, just as they came from the mill, breaking the joints around the chimney and overlapping the ends 30 inches.



Forms for Constructing Chimney.

For 51 feet from the top of the foundation the chimney is built as two, entirely separate, concentric shells. The outer shell, 6 inches thick, takes the wind pressure, and the inner shell, 4 inches thick, allows for expansion changes with the high temperatures of the flue. At the top of the inner shell 2½ inches is left for expansion vertically before contracting the outer shell to the 6-foot diameter. With a thickness of 5 inches, this forms the single shell of the chimney from that point to the top. Between the two shells is left an air space of 4 inches, and about every 18 inches within this air space are blocks, the size of a half brick, projecting from the outer shell to within ½ inch of the inner, to guard against excessive relative displacement. At the bottom of the air space are four openings, each 4x4 inches in size, for allowing a circulation of air, which is quite free to pass into the body of the stack at the expansion joint above, the arrangement tending to keep the soot from settling into the air space. An accompanying photograph indicates the location of the end of the double construction and also the steel-concrete smoke breeching to the power house.

The concreting forms shown in another view consists of two rings of six sections each, 3 feet wide, and fastened together with iron latches. These molds are held only by friction on the concrete and are disconnected before hauling to the next course. The flat top ring is a patent guide-ring to hold the vertical steel rods in alignment through holes in it. This ring is made of two ¾-inch layers of wood and is pushed on up ahead of the concreting. It also carries the beam for the hoist pulley. All material is hoisted inside the chimney.

Egyptian cement was used. The sand is Mississippi River sand, and the proportion 1:3 where high compression exists, and 1:4 toward the top. The mixing was done with shovels on a platform, turned four to five times dry and at least three times wet. The concrete was mixed almost dry and in very small quantities, and used immediately after mixing and tamped very hard. The outside finish is a wash of neat cement applied after the completion of the construction proper.

The total weight of the chimney is 556,000 pounds. Its overturning moment with 40 pounds of wind pressure per square foot is given as 1,442,629 foot-pounds. This brings a maximum compression of 450 pounds per square inch in the concrete. Some 15,760 pounds of steel of an ultimate tensile strength of 80,000 to 90,000 pounds was used, and 251 barrels of cement. The structure was designed by Mr. Carl Weber and erected by the Weber Steel Concrete Chimney Company, of Chicago. Work was begun February 28 and completed May 1. The cost is said to be about the same as that for a steel structure, and the chimney has given satisfaction because of its air-tight monolithic construction and smooth interior service. The actual surface area occupied at the ground is bounded by a circle but 8 feet 4 inches in diameter.

The Ventilation of Sewers by means of a combination of perforated manhole covers and tall shafts connected with the sewers has failed in at least one English town, according to the statement of the borough engineer of Leicester, where such a combination was faithfully tried. "The system of surface grid ventilation has been well tried in Leicester under all conditions, including those most favorable to it, with the result that it has been found a fruitful source of nuisance by reason of the offensive emanations; and strenuous complaints from the public are very common, and of frequent occurrence. This has also been the case in the wide streets of new building estates, where the open grids have been placed throughout at short distances apart, with excellent sewers of the best type which have been regularly flushed. Pipe shafts have been erected at short distances from the grids complained of, and some of the grids left open, but these grids still acted frequently as offensive outlets, which has been proved by the many anemometer tests taken, as well as by the stench arising therefrom. Finally, these grids have had to be closed, which proved the fallacy of the idea that the grids may be relied on to act as inlets only."

The Premier Water Meter.

The Premier water meter is a new device for measuring the flow of water or any other fluid, through a main or conduit, and can be built of any desired size. It is of the proportional, displacement type, and its design is based on hydraulic formulas, the accuracy of which have been established and accepted.

The meter was invented by Mr. Arthur S. Tuttle, M. Am. Soc. C. E., who was formerly connected for many years with the Brooklyn water works.

It consists, first, of a venturi tube, which may be described as a short contracting section of the main, joined to an expanding section by a short cylindrical section. The diameter of the connecting cylinder is the same as that of the smaller end of each of the two cones, while the larger diameter of the cones corresponds with that of the pipe line on which the meter is to be used. These parts are designated respectively as the upstream cone, downstream cone, and throat. The tube is built into and forms a part of the main to be measured.

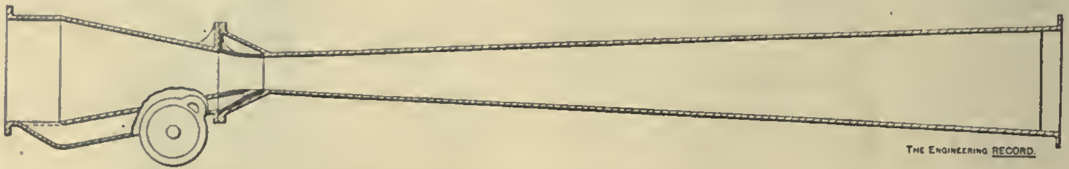
The second part of the apparatus consists of a by-pass leading from the main just above the upstream end of the upstream cone, and again meeting it at the throat, the junction being effected by an acute angle and through a contracting cone and throat. The by-pass, with its cone and throat, are of a much smaller diameter than the main and its similar cone and throat, and each part of the by-pass bears a definite and known relation to the similar parts of the main.

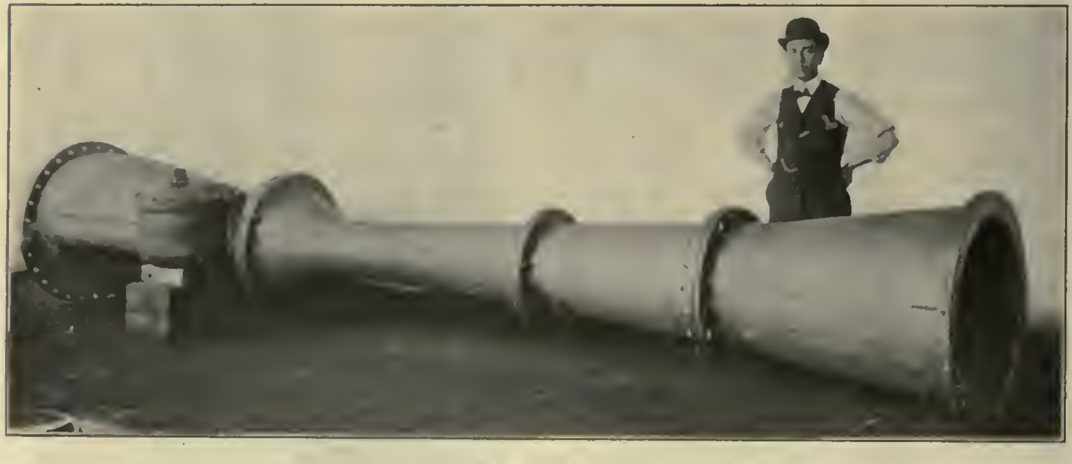
The third part of the meter consists of the recorder, which is a specially designed displacement meter, inserted on the by-pass pipe and so constructed that it registers the entire flow through the main.

As a whole, the meter may be said to consist of a large and a small venturi tube, merging into one at their throats and having a common downstream cone, with a recording apparatus placed on the pipe leading to the smaller venturi but measuring the total flow through both tubes, which is equivalent to that of the main.

From the theory of flow through venturi tubes, as fully explained in text books on hydraulics and as determined by the experiments of Mr. Clemens Herschel, M. Am. Soc. C. E. (Trans. Am. Soc. S. E., vol. 17, page 228), it appears that the temporary loss of head at the throat of tubes of similar design but of different sizes, due to the temporary increase in velocity, is the same in each for any given velocity in the main, from which it follows that when the same temporary losses of head exist at the throats of each of two similar tubes of this character, the velocity in each main must be the same, and that the flow through each must be in direct proportion to their respective areas, this being the principle upon which the meter is based.

The positive and certain action of the apparatus becomes clearer when a specific case is considered. Assume that water is flowing through a main with a velocity of 3 feet per second, corresponding with a velocity head of 0.14 feet. In passing through a meter having a throat area one-ninth that of the main, this velocity becomes 27 feet per second, with a corresponding velocity head of 11.30 feet, so that the pressure head is reduced 11.16 feet at the throat. In the Premier meter, this very appreciable drop in pressure takes place at the common throat and makes itself equally felt in the large and small upstream cones, producing, from the law already explained, a flow in each, the relative volume of which is a constant. The meter is designed to meet given requirements, and so that this positive but temporary loss of head is sufficient to secure the desired effect on the flow through the by-pass. Such effect can only be secured by some form of contraction in the main and the one proposed offers the best advantages.





The Premier Water Meter for Large Mains.

To overcome the slight friction of the recording apparatus, special features of a minor character are introduced in the meter by means of which the velocity of the main is reduced in the by-pass, thus also largely removing danger of the entrance of material floating in the water, which possibility can be made still more remote by placing a screen over the entrance to the by-pass.

The meter will commend itself to water works officials for use on mains for many reasons, among which may be noted the following: It is simple in construction and can be set up without expert supervision, and the recording apparatus not only can be read by an unskilled attendant, but needs no adjustment. It is entirely self-operating, and if not visited regularly, the record is continued for an indefinite time. It may be wholly buried in the ground in like manner to other parts of the pipe line, requiring only a small chamber around the recording apparatus, which latter is in every external respect similar to an ordinary house meter. The constant motion of water through all of its parts reduces the danger of freezing to a minimum, the same being no greater than exists at other points on the main which are similarly exposed; this danger is wholly removed if the meter is placed far enough below the surface. No greater friction loss is produced in the main by this meter than by those of any other type.

Summary of Results of Tests of An Experimental 12 in. Premier Meter, Based on Weir Measurement.

Duration of test.	Velocity. in main.	Ratio of meter record to tank measurement.
30 minutes	0.75 ft. per sec.	95.2 per cent.
30 "	0.80 "	99.7 "
20 "	0.90 "	96.6 "
30 "	1.6 "	97.9 "
10 "	1.1 "	99.2 "
20 "	1.8 "	100.1 "
60 "	2.1 "	100.3 "
10 "	2.3 "	99.8 "
30 "	3.1 "	100.0 "
10 "	3.2 "	100.0 "
70 "	3.3 "	100.6 "

The weir used for these experiments was 2 ft. long and had end contractions.

The Hamilton Smith formula was used for the calculations.

The diameter of the throat of the meter was one-third the diameter of the main.

An automatic recording apparatus is being perfected which will leave a graphic record of the flow through the main at all hours, and in a form which will be appreciated as convenient.

The meter illustrated is for a 30-inch main, and will form a part of the exhibit of The National Meter Company at the Louisiana Purchase Exposition. It is the first one built for actual service, although work is now in progress on two 16-inch meters of the same pattern, with automatic recorders, for Holyoke, Mass.

Summary of Results of Tests of An Experimental 12 in. Premier Meter, Based on Tank Measurement.

Velocity in main.	Tank measurement.	Registered measurement.	Accuracy of meter.
0.95 ft. per sec.	204.75 cu. ft.	200 cu. ft.	97.7%
1.04 "	207.75 "	200 "	96.3 "
1.07 "	101.00 "	100 "	99.0 "
1.15 "	202.50 "	200 "	98.8 "
1.21 "	100.75 "	100 "	99.2 "
1.23 "	206.75 "	200 "	96.7 "
1.25 "	309.00 "	300 "	97.1 "
3.30 "	298.50 "	300 "	100.5 "
3.33 "	201.00 "	200 "	99.5 "
3.34 "	200.00 "	200 "	100.0 "
4.90 "	298.75 "	300 "	100.4 "
4.92 "	499.74 "	500 "	100.1 "
6.38 "	201.00 "	200 "	99.5 "
6.43 "	99.50 "	100 "	100.5 "
6.51 "	200.00 "	200 "	100.0 "
6.53 "	300.74 "	300 "	99.7 "
	3,631.73 "	3,000 "	99.1 "

The diameter of the throat of the meter was one-third the diameter of the main.

The volume of water admitted to the measuring tank was in each case determined by the reading on the meter dial, the supply being cut off when the registration showed that the desired amount had been delivered.

Tests of 12-inch experimental meters of this type have been in progress for nearly four years, and in placing the meter on the market the manufacturers do so with a feeling of certainty as to its merit. These tests have proved abundantly that the meter will at least rank among the most accurate of all devices now known and recognized as suitable for the commercial measurement of water.

To insure absolute certainty of proportions, all meters will be tested by weir or tank measurement, an elaborate plant for weir tests of meters of large size having been provided at the works of the makers, the National Meter Company, for this purpose.

PHOTOGRAPHS OF MECHANICAL ENGINEERING STRUCTURES are desired by the local committee having charge of the headquarters of the American Society of Mechanical Engineers at the Louisiana Purchase Exposition. Manufacturers who can offer such photographs are requested to send full particulars concerning them to the secretary of the committee, Mr. Wm. H. Bryan, Lincoln Trust Building, St. Louis. At the close of the Exposition the collection will be given to the Mechanical Engineering Department of Washington University.

A Heavy Coping and Punching Machine.

The accompanying illustration gives a general idea of a coping and punching machine designed to take beams from 6 to 24 inches in depth. It is shown with double coping tools attached, so that the beam can be fed from either side, and the ends coped without reversing it. The coping is done with four strokes of the slide. The first cuts both corners from the flanges, and the next trims the web. The beam is then turned over and the same operation finishes the process. Cutting both flanges at once brings them into true alignment, and requires no additional gauging or movement.

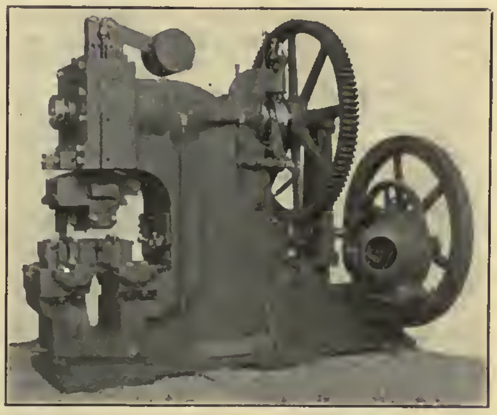
The slide is a steel casting with T slots running from the front to the rear, to facilitate attaching tools for punching the web or flanges. The machines carry punches up to 48 inches center to center of outside holes, and are arranged for punching multiple holes through plates or the webs and flanges of I beams. An automatic stop is provided to bring the slide to rest on the completion of the stroke. The coping tools can be readily removed and shears attached as well as punches, for the machine is intended for general use by the makers, the Long & Allstatter Company, Hamilton, Ohio.

The machine is driven by a Crocker-Wheeler compound-wound semi-inclosed motor, giving 10 horse-power at a speed of 825 revolutions per minute. In some cases it has been found desirable to place tools of this general type on the multiple-voltage system in order to regulate their speed to different classes of work. If a very high speed is provided for light work, when heavy work has to be done, and there is no system of speed control, the operator may not be able to feed his beam rapidly enough for the rate at which the strokes are made, and the tool must be tripped to afford time to get the piece into place. With a variable speed system no such difficulty arises.

Book Notes.

The United States Geological Survey has recently issued its volume of "Contributions to Economic Geology" for 1903, which, like preceding volumes of the series, contains a number of papers of interest to the readers of The Engineering Record. The most important of these relate to the raw materials for cement. Mr. Eugene A. Smith contributes a paper on the cement resources of Alabama. He takes up the distribution of the limestones and clays in the State and gives a number of analyses of them. The extent and character of the deposits are discussed at considerable length, making the report one of much value to those who desire information concerning them. A second paper is by Mr. Edwin C. Eckel, on the cement rock deposits of the Lehigh district of New Jersey and Pennsylvania. It not only gives an outline of these deposits, but also describes briefly the manufacture of cement. A third paper is by Mr. Charles Catlett, on the cement resources of the valley of Virginia. It gives analyses of various deposits and points out their shipping and other advantages. In addition to these papers the volume contains articles on gold, silver, copper, tin, lead, zinc, iron and manganese, coal and peat, petroleum, building stones and other mineral resources of the country.

The Commissioners of Accounts of New York City have issued a report on asphalt paving, prepared by their chief engineer, Mr. Otto H. Klein, and their chemist, Mr. S. F. Peckham. It is divided into four parts. The first is a voluminous discussion of the form of specifications which Messrs. Peckham and Klein consider desirable. This is well known to those interested in the subject, and has been considerably criticised; a large part of this section of the book is a reply to these criticisms. The second and third parts of the volume relate to the work of the Commissioners in the analysis and determination of the character of bituminous minerals, the nomenclature of bitumens, a translation of Boussingault's memoir on the composition of bitumens, and discussions of features of asphalt paving; these parts are by Mr. Peckham. The last section is a compilation of statistics regarding the cost of asphalt pavements in New York from 1898 to 1903, by Mr. W. D. Loudoun, chief examiner to the Commissioners. The book is largely of a controversial nature.



A Heavy Coping and Punching Machine.

The report for 1903 of Mr. O. H. Tittman, superintendent of the United States Coast and Geodetic Survey, is of great interest to all who desire to keep in touch with the precise surveying done by this bureau. The extent and variety of the work are well brought out in the general reports on the field and office duties performed during the year, while the appendices are full of valuable information. Mr. John F. Hayford, the inspector of geodetic work, contributes a monograph on precise leveling in this country during 1900-1903, and gives the results of a readjustment of the level net and the resulting elevations. The data in this monograph will be of much value to engineers, for the large number of Geodetic Survey bench marks which are accurately located will enable the benches of railways and the datum planes of cities to be tied to the permanent national work. Mr. Hayford also contributes a valuable description of the triangulation along the Ninety-eighth meridian in 1902. It gives a description of the instruments employed, the construction of the stations, the methods of carrying on the work and a detailed list of the points established. There are also shorter papers on the magnetic observations made during the year, on a channel sweep for detecting the presence of pinnacles of rock, and on geographic names in Alaska.

There are many engineers who have not been able to keep pace with the rapid development of alternating-current machinery and practice. A book that essays to explain briefly the phenomena, behavior and management of alternating currents, without attempting mathematical analyses or dissecting machines and apparatus to the degree that would meet the wishes of those directly engaged in the industry, has been brought out by Mr. George T. Hanchett. Portions of the book, which is entitled: "Alternating Currents: Their Generation, Distribution and Utilization," are apparently written for the practical engineer, but to one having some knowledge of the subject these parts can be quickly passed over. In this class comes the introductory chapter, which is given up to hydraulic analogies of inductance and capacity combinations which make interesting reading. Following this the principles of alternating currents are taken up, and transformers, phase difference, the summation of vectors, the calculation of copper for polyphase circuits and the measurement of alternating currents are discussed. The remainder of the volume is devoted to the induction motor, the rotary converter, the alternating-current generator, the synchronous motor, and the management of alternating-current machinery, the last occupying three chapters. The matter has been written in a concise style, for one must read with care fully to grasp the argument, but he is thereby saved from reading much that is not directly to the point. It is the type of book that can be consulted whenever it is desired to renew an acquaintance with some feature of alternating-current working. It is published at $1 by John Wiley & Sons, New York, and is 12mo. in size, of 180 pages, profusely illustrated.

The Department of Public Works of the Borough of Manhattan, New York City, has published an interesting report by ex-Commissioner George Livingstone, on a repair plant for asphalt pavements in that borough. He goes farther than most advocates of a municipal repair plant, and recommends "abolishing the guaranty fiction and buying pavements as we do other municipal supplies, for cash, or its equivalent; and taking care of what we get as best we can." The pamphlet also contains a report on the subject by Dr. James C. Bayles, whose investigation has led him to the following conclusion: "If the work was done by the city and under capable management, it should be possible to maintain an honest asphalt pavement in perfect repair for a period of fifteen to twenty years, at an average cost not exceeding two cents per square yard per annum."

Elements of Water Bacteriology. With Special Reference to Sanitary Water Analysis. By Prof. S. C. Prescott and C. E. A. Winslow. New York, John Wiley & Sons; cloth, 5x7½ ins., 162 pages, $1.25.

Though an elementary work, this is the most useful book on the subject in the English language. Water bacteriology is to-day very far from being an exact science, and not only methods of analysis, but more especially the methods of interpretation of results are being constantly modified. The present volume bears evidences that the authors are in close touch with the latest researches and their practical applications. There are ten chapters in the book devoted to the following subjects: Bacteria in natural waters, methods and interpretation of quantitative bacteriological examinations, isolation of pathogenic bacteria from water, methods and interpretation of tests for B. coli, and the general significance and applicability of the bacteriological examination. These subjects are concisely treated in a practical way and a well selected list of references is given for the benefit of those who wish to study the subjects in greater detail. The book is to be commended not only for what it contains, but for what it omits, and the busy engineer who consults it will be spared the necessity of looking over much of the rubbish that accumulated around the science of bacteriology during the years of its infancy, and which is too often reproduced in works of the present day. One topic is treated with less fulness, however, than many practical sanitarians may desire—namely, the viability of the typhoid bacillus in water.

One of the mooted questions in water bacteriology at the present time is the sanitary significance of the presence of B. coli in water. This is discussed at some length and the following principles of interpretation are laid down:

1. Bacteria corresponding in every way to B. coli are by no means confined to animal intestines, but are widely distributed elsewhere in nature.

2. The finding of a few colon bacilli in large samples of water, or its occasional discovery in small samples, does not necessarily have any special significance.

3. The detection of B. coli in a large proportion of small samples (1 c. c. or less) examined is imperatively required as an indication of *recent* sewage pollution.

4. The *number* of colon bacilli in water rather than their *presence* should be used as a criterion of recent sewage pollution.

Ready Reference Tables. Volume I, Conversion Factors. By Carl Hering. New York, John Wiley & Sons; flexible morocco, 7x4¼ ins., 214 pages, $2.50.

At last engineers have an opportunity of obtaining a comprehensive volume of conversion tables, prepared with great care by a man with a high reputation for accuracy in such work. Such books are not often required, but when needed they are worth a great deal, and for this reason it is safe to say that many engineers who do not require tables of this character more than two or three times a year, will secure this book at once. In fact, it is so beautifully printed, so clear and business-like, that few will see a copy and not purchase one. Perhaps such tables are more useful in an editorial office than elsewhere and others may not experience such pleasure in the little volume, but, be that as it may, The Engineering Record feels that in printing this book Mr. Hering has placed it under marked obligations. The labor in compiling and checking the data and the cost of publication in such an attractive form have been too great to meet full reward from the sales, unless they are unexpectedly great.

The book gives conversion factors of every unit or measure in use, including those of length, surface, volume, capacity, weight, weight and length, pressure, weight and volume, weight of water, energy, heat, power, force, inertia, moments, velocity, acceleration, angles, grades, time, electricity, magnetism, electrochemistry, light, temperature, money, money and length, money and weight, numerous compound units, useful functions and numbers, with both their accurate and approximate values, their logarithms, relations, digit conversion tables and explanations of methods of calculation. The data are based on the accurate legal standard values of the United States, and a large part of them were checked, after the type had been electrotyped, by eminent specialists. It is particularly valuable as the first complete collection of all the electric, magnetic and photometric units, and their interrelations.

The book is marked by two distinct novelties. In the first place, the author has broken away in many cases from old methods of arranging his tables, and gives the figures in such usable form as to make older systems seem a hindrance rather than an aid. In the second place, he gives with many of the tables brief but lucid explanations of their purpose and derivation, as well as their relations to other tables. In this way, in one thin volume, the engineer obtains all the fundamental data of his profession, arranged for handy use.

Letters to the Editor.

Water Construction and Meters.

Sir:—I note with interest the article on "Water Consumption at Pittsburg and the Probable Effect of Metering" in your issue of May 14, and it seems to me that there must be some valid reason for such wide variations in the per capita use of metered water, when there are no unusual differences in the climate, industries, general characteristics and population of localities and they are otherwise reasonably comparative.

What is there to make the following great difference between Columbus, Ohio, and Providence, R. I.?

	Population.	Taps Metered.	Daily Consumption.
Columbus 1903.	125,560 (1900)	68%	112*
Providence 1893.	132,146 (1890)	69%	64*

*Gals. per capita.

Why is it that each citizen at Columbus takes 48 gallons a day more than each citizen at Providence?

The probable difference of industrial, sprinkling, use of hard and soft coal, and other legitimate consumption might enter in and account for a small necessary variation, and the longer education to the meter system Providence has had might, under similar conditions, have some effect. It can hardly be said that Columbus is nearly twice as "wealthy and prosperous" as Providence.

Has not the meter rate a decided influence on the consumption, and does not the Columbus rate of six cents a thousand gallons, no minimum, meters furnished and maintained by the water department, as compared with the Providence rate of twenty cents a thousand gallons, $10 annual minimum, meters furnished and maintained by the consumer, account for this variation.

Has the Columbus consumer a great incentive to introduce good plumbing and to exercise the habitual small economies in the use of water costing six cents a thousand gallons? Is it worth while to have a plumber make repairs to the value of say $2.19 when a daily leakage of 100 gallons will cost no more?

The next thought is, do such rates equal the actual cost of the water including due allowance, not only for the ordinary operating and maintenance, but also for all interest, deterioration and other proper charges, for if they do not, then the comparatively few wasteful, extravagant and careless consumers are again making the economical consumer foot an undue share of the loss, and some, at least, of the equity of the meter system is lost.

Noting your editorial comment, is not this question of rates intimately connected with some of the apparent contradictions in the above article and could not some study be profitably spent on the influence and results of the meter rates upon the per capita consumption?

Truly yours, Murray Forbes.

Greensburg, Pa., May 16.

[All that Mr. Forbes suggests is true, and goes some of the way toward explaining the great discrepancies in such an analysis as that in the article referred to. No analysis can be thorough, however, until all the needed data are obtained. The true quantity of water supplied must be determined, and not the estimate based on pump plunger displacement. The number of actual consumers in each town must be ascertained, or failing that, the number of services, for per capita figures are notoriously delusive. The rates must be considered, and, finally, the temper of the people toward meters. There are some cities where meters are so disliked that water would have to be given away in order to persuade consumers to consent to their use. It is probable that the sentiment against meters will steadily decrease, in fact there is no doubt of it.]

Atlantic City Water-works.

Sir:—Referring to your article published May 14th on the water-works of Atlantic City, the following additional notes may be of interest: During the severe storm of October 9th and 10th, in which 9.27 inches of rain fell at our Absecon pumping station in less than 28 hours while a strong northeast wind caused the highest tide in many years, the latter rose 8 inches over the crest of our reservoir dam and flowed freely into our supply canal. Owing to the volume of fresh water coming down we were able to keep the salt water from our distribution system. Since then the canal has been replaced with a 42-inch wood stave conduit, which will protect the water in its flow of two miles to the pumping station.

As to the carbonic acid in our artesian water, this appears to have decreased since first operating them, being 6.6 parts per million in the last sample taken (April 2d). We do not use lead service pipes, tin-lined, galvanized pipe having been introduced a number of years ago.

Yours truly, Kenneth Allen.

Atlantic City, May 16.

Cooling a Store by Means of Ice.

The cooling of a store by means of ice at Paterson, N. J., was studied last summer by M. G. Epprecht of that city, who has invented a cooler for such work. The features of the cooler are not yet to be divulged, it appears, lest complications over patents should arise. The investigation referred to was carried on in a store 30x17 feet in plan and 12 feet high and during a day in which the outside temperature averaged 85 degrees Fahr.; the air within the store was maintained at 70 degrees and 300 pounds of ice were melted in an eight-hour run. The store is separated from an adjoining store on each side by a frame partition, its front is of glass and its rear end opens into a back room. The cooler, located there, employs a blower of 5½ inches outlet diameter, which was run at 1,250 revolutions per minute during the test, discharging air through the cooler and thence into the store. The store was in use, and when the front door was not open, the air was discharged through transoms in the glass front.

On the basis of 142 British thermal units required to melt each pound of ice, and assuming the water is heated, say, to 68 degrees before its final discharge from the apparatus, it will be found that 6,675 thermal units are abstracted per hour by the cooler from the air passing through it. The volume of air within the store is 6,120 cubic feet, and the difference between the amount of heat held by the air within the store when at 85 degrees and that when the air is at 70 degrees is 1,670 thermal units. In other words, the reduction of the temperature of the air throughout the store from 85 to 70 degrees requires the abstraction of 1,670 thermal units. As 6,675 thermal units are carried away hourly by the cooler, it may be assumed that a volume of air four times as great as that contained within the store are passed through it in that time. These figures would allow for four changes of the air per hour. Mr. Epprecht thinks, however, that with his arrangement of inlet and outlet, the four changes of air in a room 12 feet high may be considered as practically equivalent to eight changes in the same room with an imaginary ceiling line 6 feet above the floor, a height corresponding to the breathing line.

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Accounting in Engineering Works.

It goes without saying that the auditing department is the heart of any business undertaking. If it is weak, the whole enterprise is weak, as a good many cities are finding out to their sorrow now that they are becoming acquainted with the true condition of various ventures in municipal trading. It is the same with semi-public companies, and at the recent convention of the National Electric Light Association, Mr. Frank W. Frueauff expressed the opinion that to an incomplete system of records, or to a loose handling of a good system, much of the trouble of management, many of the complaints of consumers and the public, and the failure to secure satisfactory earnings may be traced. This remark refers particularly to electric light and power companies, among which the mortality was very great until within a comparatively few years. It might be added by way of further statement of Mr. Frueauff's views, that he believes in a careful division of the accounts of such companies, so as to give the separate costs of furnishing and delivering arc, power and alternating currents. These costs are also separated into three classes. The first is the fixed charge for station foreman, meter department, shop expenses and the like, which do not vary particularly with an increase or decrease in the business. The second class includes those expenditures which vary directly with the current output, such as fuel, firemen, lamp renewals and carbons. The third class embraces the costs which depend directly on the number of consumers, such as meter repairs, meter-reading expenses and part of the office salaries. When the various expenditures of a lighting company are classified in this manner the course of affairs can be told readily at any time and it will be possible to ascertain in what direction the work of extending business should be pushed. This system of accounting is also necessary for determining the rates to be charged for new business, for the figures will show just what will be the cost of the kind of service the prospective consumer wishes. Under the old system of averaging the cost of current to all consumers, it often happens that new consumers are taken on at rates that are not worth considering while large consumers are kept away and led to put in private plants because the rates offered them are too great.

Mention is made of this particular class of engineering enterprise because it was discussed so thoroughly at the meeting in Boston this week. It is no different, however, from that of every other business, and the lesson ought to be taken to heart by the young men now about to enter work after four years of training in technical schools. The value of their work will be measured in dollars and so will their own value, and the more quickly they learn to apply this measure to everything about them the better they will appreciate their opportunities for success. There are many young men of really brilliant attainments who are working away along lines which are not of enough importance for them to follow. These men should devote themselves to work for which there is more demand, so that they will utilize to the utmost the ability they have. The man who squanders native ability on minor work is as much of a prodigal as one who throws away money on foolish objects. Moreover, if the young man does not learn to measure his capacity for work he will thereby acquire more speedily than in any other way an over-developed appreciation of his own worth. There is nothing like a sound knowledge of what other people can do at any given piece of work to show a young man engaged on such duties how to appraise his own value. This value depends on output, for the quality enters very little into it as a rule; if the quality is not up to the standard of the employer, the later may be trusted to appreciate it more than any one else, while if it is above the standard the time spent in overraising it is thrown away.

These observations are made because a defect of engineering enterprises to-day is the lack of business sense with which much of their technical operations are conducted. Its cure will be found in the general teaching to undergraduate students of the importance of the money aspect of their work, and a better organization of the accounting department of engineering undertakings. Although the average professional man is not able to handle financial affairs satisfactorily without special training, when he masters them his technical knowledge comes into service in a conspicuous manner. For example, in the Denver Gas & Electric Company's offices which Mr. Frueauff describes in his paper, the mark of the engineer is stamped on many of the methods. Adding machines and self-adding paper are used in many accounting offices, but we are told that the slide rule has been introduced here and that the Thacher calculator has been found the greatest labor saver in the office. All costs and receipts are worked out in this office on the basis of current made or sold, and by the use of this device the results are read off as fast as they can be recorded. A tabulating machine, such as a number of railway companies employ, is also used, and there are many other indications about the equipment that the auditing of the company is supervised by some one with engineering training.

The Engineering Record trusts that in making these comments none of its readers will misunderstood their intention. It is no reflection on the members of the profesion to state that, generally speaking, business ability is not their strong characteristic. It would be most strange were it properly developed, for the tendency of precept and practice has been to discourage commercialism and encourage professionalism. Until within a few years the leading members of the profession considered it contrary to a high standard of conduct to take out patents, and even at the present time there are some men who refuse to protect their excellent improvements in this manner. Moreover, employers of engineers looked upon them until recently very much as mere draftsmen or surveyors, able to do certain classes of trained labor satisfactorily, but not for a minute to be entrusted with the responsibility of handling dollars. Consequently the business side of engineering work was in a state of arrested development until a short time ago, and even now it is not appreciated as it should be. While it is true that the technical departments of many works are not conducted in a good manner, it is equally true that the head auditing departments would be much better run if their methods were determined, like those of the Denver company, with a full understanding of the technical features of the manufacturing processes.

History of Civil Engineering.

It is so common to speak of civil engineering as of modern origin, even as the youngest of the profesions, that its real age is recognized by only a few civil engineers. As a matter of fact, it should be regarded as a venerable profesion. The beginnings of civil engineering are lost in pre-historic antiquity. If the engineering works completed in ancient Assyria and Egypt or in the ancient East Indian country could be described and the methods of their construction set forth, engineering literature would be enriched by additions of fascinating interest.

Exact methods of computation, efficient processes of construction and the magnitude of engineering works have been pushed forward with such amazing rapidity during the last half century that the accomplishments of the preceding three or four thousand years are entirely overlooked. Indeed, if one were to confine his attention to the engineering literature produced since the first locomotive was built, the impression would be gained that there was neither engineering science nor engineering construction prior to that period. Relatively speaking, of course, there was so little engineering before the advent of the locomotive that it is not much of an error to ignore it. In spite of that fact, however, there have been periods in the history of the world when really great engineering constructions were successfully designed and completed. This is particularly true of the old Roman period. The Romans were born engineers, although they did not apply that name to their great constructors. The name "architect" included not only those who would be classified under that designation to-day, but also those whom we should call engineers. Vitruvius belonged to that class. His treatise on architecture was largely a work on civil engineering. His book contains admirable advice regarding the design and construction of foundations, harbor works, public water supplies and other similar works. He even set forth some of the fundamental principles of the sanitation of water supplies. While his recognition of the conditions under which wholesome water is found are somewhat quaint, including the observation that the sources of potable water should not be "charged with the exhalations of the fenny animals," it is possible that his quotation indicates an obscure appreciation of the influence of pathogenic bacteria. Again he states, refering to the means of judging water: "If it be of an open and running stream before we lay it on, the shape of the limbs of the inhabitants of the neighborhood should be looked to, and considered. If they are strongly formed, of fresh color, with sound legs and without blear eyes, the supply is of good quality." Such a method of determining the character of a proposed water supply would scarcely be considered conclusive at the present time, yet the distinction between good and bad water was recognized with absolute clearness, and the Romans established that distinction by means of the best lights at their command. The great masonry aqueducts, roads and other engineering works are well known to all intelligent and well-read people. In a general way their engineering knowledge has been disclosed to us, but their methods of design and the details of the considerations on which their designs were based are practically lost, although we know absolutely that their modes of design must have been guided largely by quantitative considerations.

It is practically certain that the Romans did not establish out of hand the great body of engineering knowledge which they possessed, although there is little doubt that they greatly enlarged and developed whatever they may have acquired from others. Long before the Romans were engaged in any engineering construction of magnitude remarkable public works were serving the industrial operations of the teeming population which occupied the valleys of the Tigris and Euphrates. The full extent of these public works can never be known, but the ruins of the network of canals and their appurtenences demonstrate conclusively that the ancient Assyrians had developed water transportation to a remarkable extent. They were clearly familiar with the control of water in rivers and canals for useful purposes. It is equally clear that the construction of the arch as well as the construction of great buildings must have been known to them little or no less than 4,000 years before the Christian era. When these facts are coupled with the further knowledge of their extensive commerce at the same time with the coasts of Southern Asia, it is unquestionable that they had reached a high degree of excellence in a considerable field of engineering construction, even though they knew practically nothing of real engineering science.

The ruins of ancient Egypt, dating possibly as far back as 2,500 or 3,000 years before the Christian era, together with what is positively known regarding the ancient irrigation works in the valley of the Nile, demonstrate with equal certainty that the Egyptians were also at least fairly good engineers in their day. Tunneling, quarrying, river diversion by means of dams and auxiliary works and the construction of great masses of masonry were included among their successful engineering operations, nor is it all improbable that other lines of engineering practice existed.

Mr. J. A. L. Waddell has made a strong plea for the study of engineering history in technical schools, and the plea is rational. There is a body of engineering history, if it were put in useful shape, which would be of at least much indirect value to the engineering student. While he would gain no additional knowledge of engineering science, he would find ancient experiences stimulating and broadening in their influences upon his professional judgment and cultivation. It is a field in which little has been done, but which if properly developed would round out in a most valuable manner the study of the great engineering advances of modern times.

The National Electric Light Association.

About eight hundred people were in attendance at the convention of the National Electric Light Asociation this week in Boston. This fact is particularly impressive as an indication of what special organizations of this character can accomplish when all concerned in their management work together for their success. The convention is merely another instance which proves that the strictly engineering societies cannot fill all the requirements of those who are engaged in many branches of engineering work. The National Electric Light Association, the American Railway Engineering & Maintenance of Way Association, the American Society for Testing Materials, the American Water-Works Association and others which it is needless to mention have a field of great importance, in which the purely engineering features can be discussed in the light of commercial and operating conditions that have no place in strictly professional proceedings.

The success of these organizations is always found to depend primarily on two things, the earnest work of the officers responsible for the meetings and the absence of a preponderating highly scientific tone in the papers. If they are to be successful the managing officers and the operating staff who attend must not be bored with calculus or wearied with discussions of the respective merits of mechanical appliances whose salesmen haunt their offices day by day. Moderation and variety in the discussions must be secured. The meetings should be the great clearing houses of practical information, at which men from all over the country tell what they have found best to do under given conditions. In some societies it has been found most satisfactory to secure this information by having committees gather the data before the meetings and present them in reports, while other societies, whose members are more ready for oral discussion, do not need this stimulus to start the debates. Each society must solve the problem for itself, but there is none which should find it incapable of solution. The dreary gloom which follows the presentation of many papers before the dignified national associations of engineers should not be regarded as a model for the proceedings of these special societies, organized for the consideration of live subjects of immediate practical importance.

Elsewhere in this issue there is a short abstract of a few of the most important of the papers of the National Electric Light Association. There were many others just as good, although most of them were not so directly in the field of this journal. Gas engines, steam turbines, mechanical stokers and an important test of a 5,500-horse-power vertical engine served for the power specialists; the electrical engineers had papers on standard instruments for operating companies, a three-wire 500-volt transmission line, and the remote control of electric apparatus; while the managers' side of the association's work was represented by papers on economy in minor supplies, the organization of an arc light department, office methods and accounting, purchased electric power in factories, and lost and unaccounted-for current. Then there were a number of papers on miscellaneous topics, such as a review of the progress of electric lighting, combined ice and electric plants, district heating from electric central stations, not to mention a 106-page pamphlet of "wrinkles" of all sorts, obtained from the members in different parts of the country.

This brief summary of the papers indicates well how thoroughly the field of the Association's work was covered, but it does not bring out one important feature of such a well-arranged program. While much can be learned by listening to papers and discusions, The Engineering Record is convinced from the testimony of many men that the informal conferences which takes place at these conventions are of equal value to those on the program. The discussions bring up certain subjects which some of those present are able to talk over among themselves in greater detail during the spare time on their hands. It is the recognition of the value of this informal conference which has led the most wide-awake organizations to escape the criticism of overdoing their meetings. Instead of continuing professional and business sessions at all available hours, there are enough half days for excursions and similar functions to permit this highly important part of the conventions to exist side by side with the scheduled meetings.

Requirements for Graduation from Technical Schools.

Th committee of the Society for the Promotion of Engineering Education is now at work on the subject of the ground to be covered by students before receiving their general science degree or their first professional degree in engineering. In order to ascertain the prevailing opinion on this subject of men engaged in active work, they are sending blanks to our oldest and ablest engineers asking them to state their views. These blanks are very complete, and copies can doubtless be obtained from the chairman of the committee, Prof. Wm. G. Raymond, of the Rensselaer Polytechnic Institute, Troy, N. Y. It is greatly to be desired that those asked to aid the committee by filling the blanks will do so, for it is only in this way that a really comprehensive understanding of present opinion can be obtained. The work is most timely, for engineering education is now in a critical condition owing to the many attacks on its character. The extent to which these attacks are backed by the views of those whose opinion should carry most weight can only be ascertained by such a census, and it is by no means unlikely that some of the critics who have been making most noise will find themselves their own audience as well as orchestra.

One great fault found with schools is that they do not complete the undergraduate course by giving the student the wisdom that only comes with ripe experience and the caution that must generally be learned by expensive failure. Just as every reader of a paper can edit it better than those who are in charge of the journal, so every alumnus believes he can introduce great improvements in the curriculum. The limitations under which schools labor do not appear before him. He forgets that the students are young and that finances are limited in amount; that teaching offers little attraction to most men, and those who are most successful in it make a serious sacrifice of income with each year they stay at the teachers' desks. Everything considered, our technical schools are doing and have done grand work with limited facilities and with poorly prepared raw material to work on. Most of the criticism against them is not worthy of consideration, because it is based on the assumption that there is some subtle virtue in pure and applied science which makes the student of it more mature and cautious in his judgment than the student of liberal arts and the classics.

That there are justifiable differences of opinion on the subject of such schooling is shown by the appointment of this committee and the broad nature of its investigation. The Engineering Record's opinions have not changed for a number of years, although it is ready to alter them at any moment when the evidence justifies such a shifting. It believes that undergraduate work should be confined so far as possible to fundamental subjects, leaving the specialties for postgraduate courses. If this plan is carried to its logical conclusion it may mean a reduction of the general course to three years, but it will surely mean a thorough inculcation of those elements of science on which sound engineering practice must always rest. These can be taught to the young student as well as to one of more advanced years, and after they are learned thoroughly the student will be in a position to choose his specialty wisely and to grasp the details of that specialty with understanding.

This journal is further convinced that not enough attention is paid to the manner in which classroom work and written exercises are carried on. What value is it for the president of a school to tell his pupils that good English speech is necessary, if a large part of the faculty have a diction that should bring disgrace to a truck driver? In what respect will the average undergraduate look upon a course in a modern language when not more than two or three of the professors with whom he comes in touch speak of the language save as a joke? The trouble with the average technical school to-day is that the trustees are not doing their duty. They do not give the attention to the schools which they should and they allow a lack of united purpose to develop that would wreck a business. One of the most encouraging aspects of technical education to-day is the great work being done in a famous school by an honored alumnus who is now its president. As an engineer and a business man he achieved great distinction, and now he is gaining new laurels as a pedagogical iconoclast. He began his work by educating the faculty, so that every one of them represents something more to the students than a fount of specialized wisdom. He had an excellent faculty to work with, and after the first severe shaking-up affairs have gone on with increasing smoothness. To-day there is no school in the country which gives its undergraduates such sound business training along with technical information, because there is none in which every classroom is in some degree a school for the teaching of business principles. The faculty are at one in teaching at all times the value of the language studies, the mathematical branches and other courses that are too often spoken of with some contempt. Not only are they working in harmony, but every classroom has become a room for instruction in language, and the training in mathematics only begins in the mathematical courses, being supplemented by the work of other departments. This is as it should be, with the faculty striving to help the student and not to give courses of a complexity that may add to the individual reputations of some teachers, but most result in the overbalancing of the general training of those who take them. It is the business of the trustees of each school to see that such sanity marks the work of its faculty, yet in how many schools have the trustees paid the slightest attention to the subject?

The New Electric Light.

A few weeks ago a statement, to which some esteemed critics took exception, appeared in this paper to the effect that a large part of the best scientific work in the country was now carried on by men in the employ of manufacturing corporations. While the work was acknowledged to be for business ends ultimately, it was claimed by these correspondents that the commercial aspect was an incidental matter and that scientific investigation was the real kernel. It was strongly urged that science was the pioneer and that finance followed, grasping most of the rewards of useful inventions at little risk to itself. It so happens that the last of these communications was received on the same day as an issue of the "Electrical World and Engineer," in which Mr. C. P. Steinmetz described the new magnetite arc lamp. The history of this interesting novelty is a good demonstration of the fact that it is business which furnishes much of the incentive for valuable scientific research, and not science which stumbles on a good thing for money to develop.

The arc light is not an efficient apparatus, for of the energy supplied to it only a small percentage is developed in the form of illumination. The light is due to the incandescent carbon crater, only very little coming from the arc itself. Certain calcium compounds have sometimes been added to the carbon so that their evaporation in the arc may increase its luminosity, but their use is accompanied by difficulties due to dust or smoke. This makes it impracticable to enclose such carbons, and they are of corresponding short life. There being an evident need of improvement in this well-known apparatus, a program for a thorough scientific investigation of the subject was laid down. What was wanted commercially was an electrode fulfilling four conditions: (*a*) it must be a good conductor when solid and its vapors must be conductors of the arc; (*b*) it must be incombustible, so as to give a long-burning arc; (*c*) it must give a spectrum of high brilliancy, or, in other words, an arc of high efficiency; (*d*) the light must be distributed with approximate uniformity over the whole spectrum, so as to be white.

This problem was turned over to the electrochemical laboratory of the General Electric Co. Very extensive investigations were conducted to determine all the phenomena of illumination by the arc method, and experiments were made to ascertain the availability of different materials for electrodes. These investigations showed that the positive carbon burned away more quickly than the other because it was unable to conduct quickly enough the heat due to the blast from the negative terminal. It is consumed more rapidly than the other on this account and not because it feeds the arc, as is commonly stated. It is only necessary to make it large enough and a good enough conductor to keep it from wearing away. This fact once established, it was merely a logical series of deductions from theory and experiment to the positive terminal of copper, which is a permanent part of the new lamp. It was found, however, that it could be made too good a conductor, for if it was not heated to a certain temperature the material from the other terminal would be deposited on it instead of being volatilized.

The experiments in the laboratory finally showed that magnetite possessed the four qualifications, previously enumerated, for a successful negative terminal. In its pure state its efficiency is only about twice that of the carbon arc and there is a tendency to flicker. It was an eminently satisfactory carrier of the arc flame, however, and the mixture with it of small quantities of other substances was found to remedy its defects and also reduce the rate of combustion. The best method of using the material seems to be to compres it in the form of an impalpable powder in a thin iron tube, sealed over by the arc. Such an electrode eight inches long has a life of 150 to 200 hours without any loss of efficiency, while with a little sacrifice of its efficiency Mr. Steinmetz gives its life as 500 to 600 hours, a statement which surely needs the backing of some such eminent authority to receive more than passing consideration, such a great change does it signify in arc lighting.

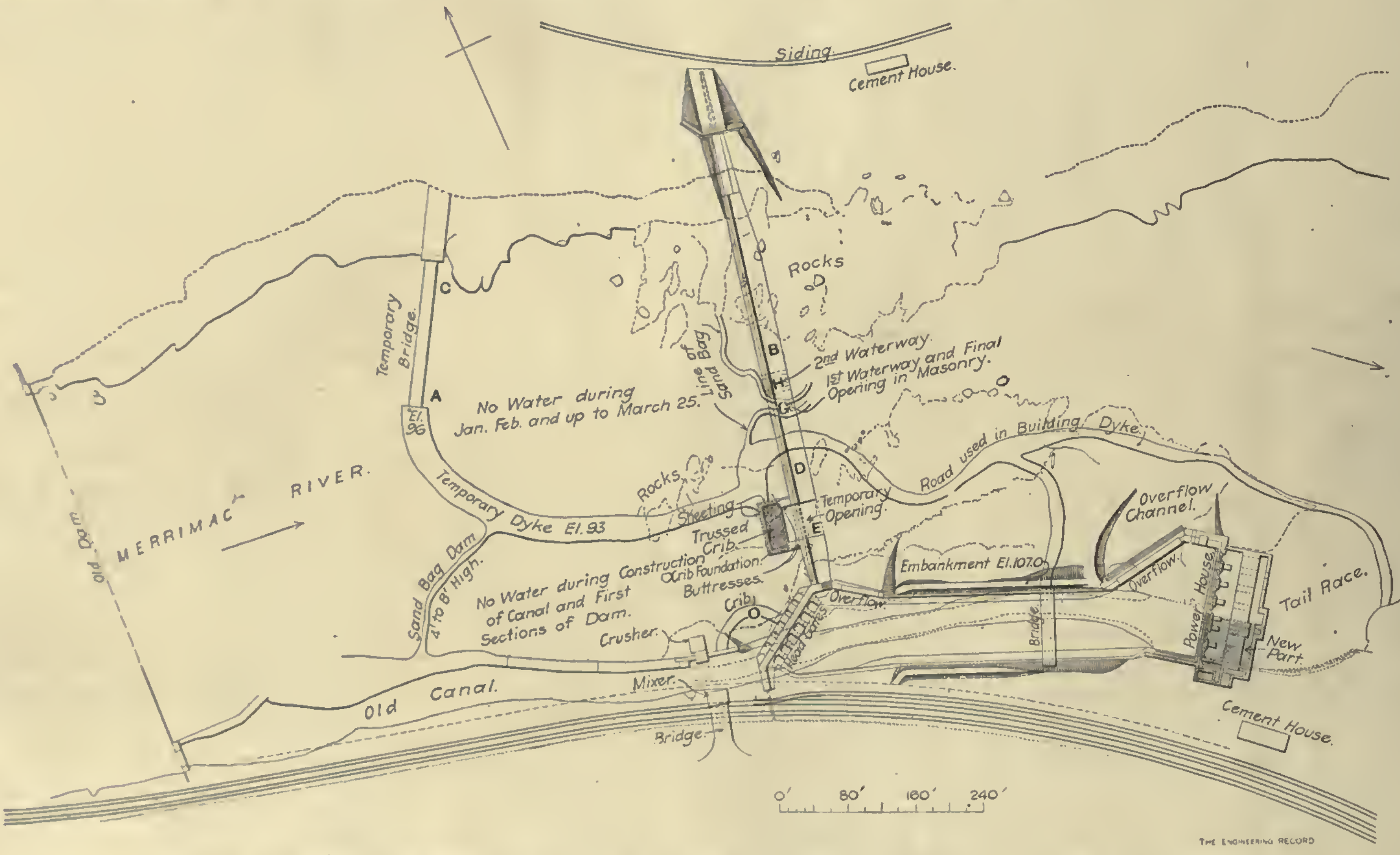
The two terminals for the new lamp being provided, it became necessary to supply a new feeding mechanism. The magnetite lamp furnishes light from the arc and not from the crater, in which respect it is vitally different from the carbon lamp. It is therefore necessary for the terminals to be farther apart than when carbons are used, and, moreover, this distance must be kept constant. Hence the feeding mechanism is new. While the entire apparatus, suspended above a street, would attract no attention at all on account of any variation from the appearance of the familiar carbon lamp, yet it is novel in every feature.

This lamp is a good sample of applied science and it teaches the lesson mentioned at the outset of this article. The General Electric Company recognized the commercial value of an improved arc lamp and conducted the scientific investigations and practical experiments to bring out this invention, and it now has to sell it. All three branches of its work are equally important, if the greatest good to the public and itself is to result. It cannot be maintained that equally desirable results could follow the tedious course of private research, the long delay while some business man was becoming acquainted with such research, and the ultimate organization of a company to perfect and manufacture such an apparatus. The fact that the experiments were made under the financial wing of a manufacturing corporation in no way lessens their manifest value from the point of view of pure science, while it does add materially to their value to the community at large.

The Insulating Supports of a Storage Battery were described at the meeting in Boston of the National Electric Light Association by Mr. Walter I. Barnes. A double tier of porcelain insulators is used. The first tier is mounted on brick piers, which are capped with a hard pressed tile impregnated by boiling in paraffin. The insulators are of the triple-petticoat pattern and rest on the tiles. There are two for the support of each side of the cell and on each pair there is a hard-pine stick, 4x4¾ inches in size, painted with an acid-proof paint. On each of these are three tiles, carrying the second tier of insulators, six in all for the one cell, or ten insulators, including both tiers. The second tier supports the cell and the distance from the floor to the bottom of the tank is 20.75 inches.

The Garvin's Falls Dam and Canal.

Work is approaching completion on a plant at Bow, N. H., which is designed to develop about 6,000 horse-power in the Merrimac River. The plant is being constructed for the Manchester Traction, Light and Power Company, which furnishes light and power and operates the street railways in and about Manchester, N. H. There has been a dam near this point since 1859, but it has never before developed the full available water power. The present plant includes the dam, canal, power house and auxiliaries, and will be completed during the current year. Work was commenced in May, 1901, on the power house, one section of which was built and operated by water derived from the old dam and canal, the plans being so prepared that this building and its equipment would form part of the final structure. A description of it was published in The Engineering Record of January 24, 1903. The completed power house corresponds to this portion, and the description already published applies to it as far as it goes. The completion of the plant beyond the point described in the previous article consists of the extension of the power house and the construction of a new dam, head gates, canal and overflow and the improvements of the tail-race. It was commenced in the spring of 1903.



General Plan of Garvin's Falls Water Power Development, Showing Location of Construction Plant.

The new dam is located about 800 feet below the site of the old dam and crosses the full width of the channel at a point where the low-water flow is about 1,000 cubic feet per second. It is estimated that it will develop power varying from a minimum of 2,500 horse-power in extreme low water to a maximum of 6,000 for about nine months of the year. The dam is about 550 feet long and 22 feet high above the original bed of the river. It is built of stone with foundations on the solid rock, which is excavated in some places to a maximum depth of 11 feet. For all except 75 feet of its length, the dam has a base about 32 feet wide and is made with a partly curved and partly straight outline on the crest and down-stream face. The remainder of its length is built up to an elevation 2 feet higher and has a different cross-section with horizontal crest and a straight incline on the down-stream face. At each end of the dam there are rubble concrete masonry abutments at right angles to its axis. At the north end these abutments are comparatively thin walls reinforced with earth slopes. At the south end the abutments are continuous with the head gates and side wall of the canal.

The canal is about 500 feet long, more than 62 feet wide at the bottom, more than 74 feet wide on water line and has a maximum depth of about 17 feet. It is designed for an ordinary depth of water 12 feet and velocity of 3.55 feet per second. The bottom slopes about 1 in 400 and the sides are battered 1 foot in 2 feet. It is nearly parallel to the tracks of the Boston and Maine Railroad and follows approximately the course of the old canal, of which it is really an enlargement. At the lower end its width is increased to about 135 feet to correspond with the forebay wall of the power house in which there are six large and one small openings to the turbines. Adjacent to the power house there is a masonry overflow about 90 feet long, and below it the rock is excavated to elevation 65, 35 feet below the crest of the dam, to make a tail-race about 200 feet long, which delivers the water into the main channel of the river. Both sections of the dam have the battered up-stream face built of granite rubble with large rectangular stones, at least one-quarter of which are headers, and have joints not exceeding 2 inches thick. The crest of the low section is made of cut granite not less than 2½ feet thick with rough-pointed upper surface and joints ½ inch wide for a depth of 3 inches. The down-stream face is built of ashlar masonry having an average thickness of 30 inches and made partly with radial joints and with special large stones at the toe.

All of the face stone is laid in 2:1 Portland cement mortar, and the cap-stones on the crest are secured to one another by dogs, the 1¼-inch bolts shown on the plan being omitted. The body of the dam is built of rubble stone masonry laid in 2½:1 Portland cement mortar. All cement used in the work was of the Lehigh brand and was thoroughly tested by samples from every fifteenth barrel, which developed an average strength of about 268 pounds in 3:1 briquettes 28 days old. Regular coursing was avoided and the stones were used as large as was consistent with obtaining full beds and water-tight joints. Special care was taken to bond them well with the ashlar facings and their dimensions were varied to improve the bonds. Each stone was washed and the irregular projections and feather edges hammered off before it was laid in a thick bed of mortar and thin spalls. The side and end joints were made large enough, wherever required, for small stones to be packed in them, and all of the cut-stone work was grouted. The masonry in the high crest section corresponds substantially with that above described, except that the joints in the down-stream face are all parallel. The cap-stones only are pointed; they are secured together by 1¼-inch galvanized-iron dogs 14 inches long with upset ends.

The south abutment is made with 1:2½:4½ concrete with 2-inch broken stone and containing large stones of various sizes bedded in the concrete at least 10 inches from the finished surface, which was washed with Portland cement grout. The top of it is 8 feet wide and serves as a walk which is protected on the river side and at the high part on the canal side by an iron hand rail. The north abutment has a rubble concrete face wall and an earth embankment 30 feet wide on top with 2:1 slopes riprapped on the up-stream side, and a concrete core wall 3 feet wide on top with both sides battered 1:12 and extending down to foundations in sound rock. The space enclosed by these walls is filled with earth and the embankment is composed of earth rammed in 4-inch layers.

The canal is excavated in earth and rock on both sides of the old canal. In all cases the sides have a batter of 1:2, and in earth they are faced with dry rubble made with large stones having the bed joints normal to the slope and backed with spalls sufficient to protect the earth. Between elevations 97 and 105 the joints are pointed with cement mortar. The face walls are battered 1:3 on the back side, are 3 feet wide at the top at elevation 105 and 6 feet wide at the bottom in the deepest places. Above the tops of the face walls the fill has a slope of 1:1 and is carried up where necessary to elevation 107 so as to prevent any possibility of overflow, the normal height of water in the canal being elevation 100 and the bottom of the canal varying from 87 to 88, and in the forebay from 88 to 83.

The head gates are set in six arched openings 10 feet wide and 12 feet high in a rubble concrete wall which crosses the upper end of the canal. It is about 145 feet long over all and 29½ feet high above the canal bottom. It is made with 1:2½:4½ Portland cement concrete and has a floor about 2 feet thick below the canal bottom, in which the piers extend to a depth of 1 foot. At the upper end the foundation was trenched to a depth of about 5 feet and below it the surface was stepped off in short saw-tooth planes so as to provide abundant resistance to sliding. The piers are 5 feet wide and extend about 8 feet up-stream from the face of the wall. They have rounded ends and are grooved to receive the gates and stop planks. The wall and piers are made of solid concrete to a point 3 feet above the crown of the arches, above which large rubble stones are bedded in it. At the upper end of the canal there is an overflow 45 feet long with a crest at elevation 103, which is built of 1:2½:4½ rubble concrete similar to that used in the abutments and head-gate wall. At the lower end there is another overflow about 90 feet long with a crest at elevation 102, which is built of rubble masonry.

Partially Completed Main Dam at Garvin's Falls during a Flood; Masonry in Downstream Face of Dam.

Work on the canal was commenced June 8, 1903. The earth was stripped by hand and the rock was blasted in the usual way and handled by numerous guyed derricks on both banks. The tops of the masts were connected by horizontal, longitudinal and transverse ropes and were braced by inclined guys clearing the adjacent railroad tracks. Work on the canal was arranged so as to interfere as little as possible with the delivery of water to the existing portion of the power house, and part of the stone excavated from it was used for the hearting of the walls. While the canal work was in progress, operations were commenced on the main dam. The river bed was approximately level and consisted of irregular strata of naked rock with some projecting points. The water was unusually low throughout the season and the maximum depth and velocity rarely exceeded 3 feet and 2 miles an hour, respectively, on the center line of the dam.

An L-shaped cofferdam about 600 feet long was built in the bed of the river from a point about 110 feet from the south end of the dam to the north shore, on the up-stream side, in water from 4 to 8 feet deep. It was 50 feet wide at the base and an opening of 150 feet was left near the north end of it for the passage of the water, which was thus confined to the main channel. It was essentially a dike made by dumping in a line of broken stone to break the current and then filling in front of it with dirt, which stopped the cracks and made a structure that was nearly water-tight under the heads encountered. The materials were all supplied from the excavation of the canal. A supplementary sand-bag dam was built across the side channel to connect this dam with the south bank of the river.

While the water was confined to the north channel, the foundations were excavated for the south end of the dam and about 150 feet of it was built to the full height, except for a length of 60 feet at E, where an opening was left down to the toe stones. Simultaneously the head gates at the south end of the dam were constructed. Care was taken to excavate all loose and unsound rock down to hard solid strata, precautions being observed to prevent shattering sound stone. The holes were drilled at an angle so as to level the ledge surface, as shown in the cross-section. The loose pieces were carefully removed by baring and wedging, and a minimum amount of explosive was employed. All cracks and seams were thoroughly filled with a grout of neat Portland cement. All springs were piped to a height above their source and were grouted after the masonry had been built to the corresponding elevation. No masonry or concrete was laid under water and the water was not permitted to rise on any masonry until the mortar or concrete had set at least 24 hours. Particular care was taken to make a good joint between the masonry and the ledge so that there should be no leakage under the dam.

All of the work on the canals, head gates, forebay walls and power-house foundations was completed and the water from the old canal was admitted through three of the new head gates to the new canal November 19th. It then became necessary to take the entire flow of the river through the new canal and through the 60-foot opening E, which together had a capacity proportioned to the whole low-water discharge. A temporary crib dam O, 14 feet wide filled with stone was built to connect the old canal and the head gates. It was made of railroad ties 8 feet long drift-bolted together and faced on the inside with 2-inch matched plank, battened. When it was completed the opening AC in the dike was closed with stone and tightened with earth, brush and hay, great difficulty being experienced on account of the severity of the weather, which froze the materials very hard. By January 6, the dam was tight enough to exclude nearly all the flow and work was begun in excavating the foundations for the 136-foot section BD in the middle of the channel.

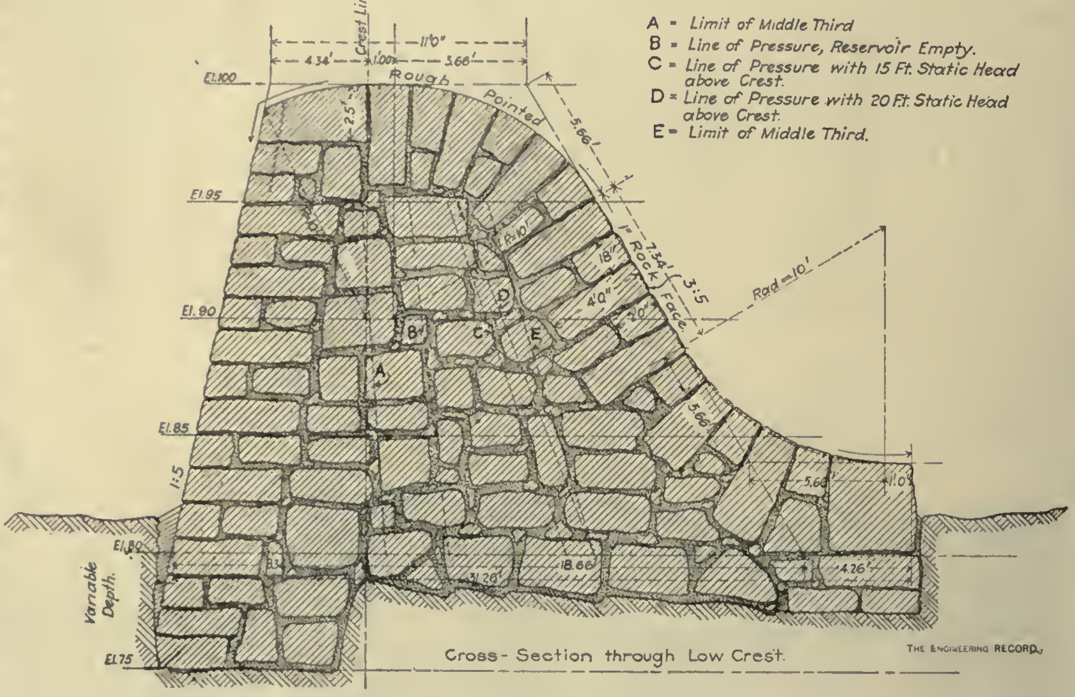
The rock on the upstream side of the dam was at a higher level than that on the downstream side, and the small amount of seepage water was collected there by temporary lines of sand bags and concentrated to point G, where a temporary sluice was placed to carry the water to the downstream side of the dam. The foundations ED and DB were then excavated to grade about 5 feet below the sluice G and the masonry was laid up to the level of the bottom of the toe stones. The sand bags were then shifted so as to deflect the water to the point H, where it was discharged over the masonry, thus freeing the sluice G and allowing the masonry to be built up at that point. The water was again deflected through an opening in the dam located at the same place as the first by-pass G. The masonry was completed to the crest line as fast as convenient and the section E was built up to elevation 84 to provide a channel for the flow while the section GH was built up to elevation 93, where work was stopped on account of high water. The work was pushed as fast as possible during January and February so as to carry it above danger from spring floods and ice which were expected to come about March 1.

As it was seen to be impossible to complete the dam before this date, the masonry at GH, the last section, was built to elevation 93, in order to divert the entire normal low-water flow through opening E, thus doing away with the necessity of rebuilding the cofferdam should it be damaged by high water and permitting work to be resumed very soon after freshets. The river, while it has not reached low stage, has lowered sufficiently to permit work upon the dam to be resumed at the north end of GH, behind a low sand-bag dam, placed at the upstream face of the masonry.

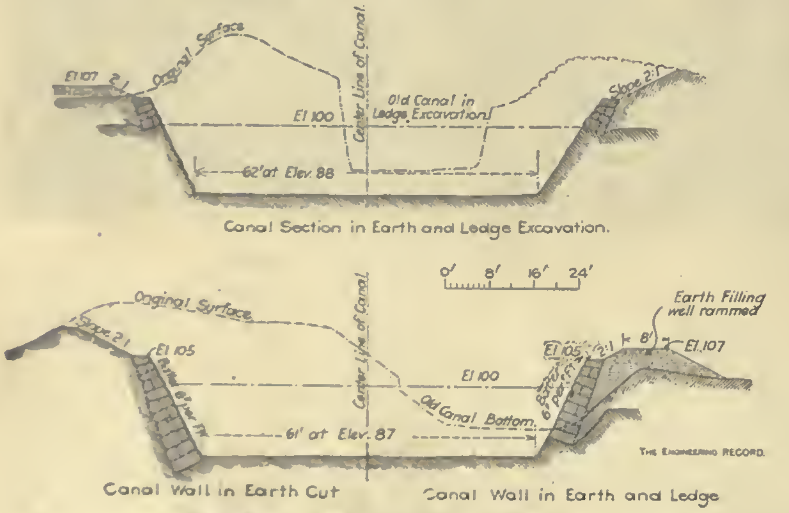
It is intended to build the upper part of the masonry in section E under the protection of a crib cofferdam, for which provision has already been made. Two heavy masonry buttresses 15 feet wide have been built on the upper side of the dam to receive the ends of the crib. A foundation for the latter has been prepared by excavating in the line of its outer face a U-shaped trench about 3 feet wide, which extends down to solid rock and is filled with concrete. This will form a foundation for the crib, which will have several panels of horizontal diagonal bracing designed to form heavy timber trusses spanning the opening between the buttresses and thus enabling the unsupported side of the crib to resist the heavy hydrostatic pressure. The outer face of the crib will be sheeted with 4-inch or 6-inch grooved and splined plank.

The work was prosecuted vigorously throughout the past winter, although the conditions were exceedingly severe on account of the low temperature, which averaged about 16 degrees and fell as low as 35 degrees below zero. This extreme cold was accompanied by snow and high winds, which made the work very difficult and uncomfortable and necessitated special precautions for laying the masonry. The mortar was mixed with hot water and the stones were heated by steam and covered with tarpaulins, under which steam pipes were carried along the face of the work.

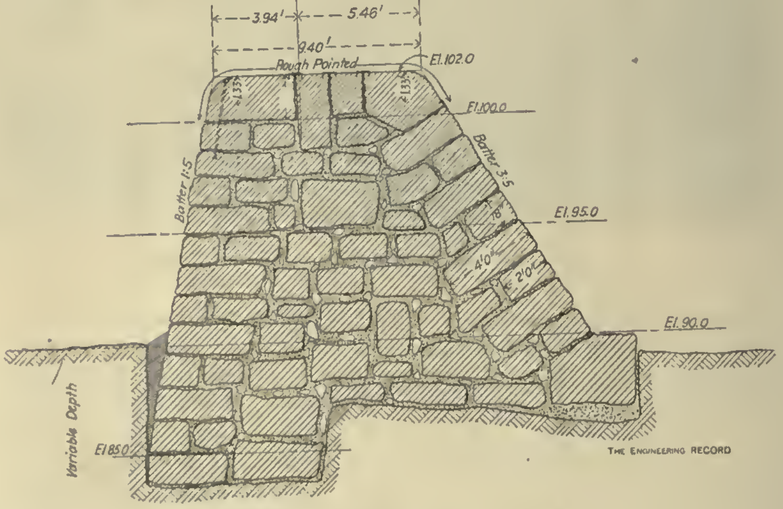
The principal quantities involved in the work here described included about 19,000 cubic yards of earth excavation, 21,000 cubic yards of rock excavation, 4,100 yards of concrete and 16,000 yards of masonry of all kinds. The principal items of the plant installed were fourteen derricks, each provided with a Lidgerwood or Lambert double-drum steam hoisting engine and swinging gear; sixteen Ingersoll-Sergeant steam rock drills; one Farrell rock crusher; one Carlin's 5-foot concrete mixer and several 10-inch centrifugal and 5-inch Cameron pumps and 4-inch pulsometers. There was an average force of about 300 men working single 10-hour shifts.


Crest Line
11'0"
4.34'
1.00'
3.66'
El.100
Rough Pointed
2.5'
5.66'
El.95
R=10'
18"
7.34'
1" Rock Face
3:5
Rad=10'
4'0"
2'0"
D
B
C
E
A
El.90
El.85
1:5
5.66'
5.66'
1.0'
El.80
Variable Depth.
31.28'
18.66'
4.26'
El.75
A = Limit of Middle Third
B = Line of Pressure, Reservoir Empty.
C = Line of Pressure with 15 Ft. Static Head above Crest.
D = Line of Pressure with 20 Ft. Static Head above Crest.
E = Limit of Middle Third.
Cross-Section through Low Crest.
The Engineering Record.

Low-Crest Portion of Main Dam.



Enlarged Canal to Head Gates.



High-Crest Portion of Main Dam.

Cross-Sections of Garvin's Falls Dam and Canal Showing Character of Construction.

The work was designed and its construction was supervised by Messrs. Hollis French & Allen Hubbard, consulting engineers, Boston. Mr. George G. Shedd was the resident engineer and Messrs. Holbrook, Cabot & Hollins were contractors. Mr. J. B. Haviland was resident superintendent for the contractors and [illegible]s, Jr., of that firm, frequently designed many of the con-

excava-
of 11 feet.
the dam has a
made with a partly
outline on the crest and down-stream

Reinforced Concrete in Building Construction.

Condensed from a paper read by Mr. Emile G. Perrot before the School of Architecture, University of Pennsylvania.

Generally speaking, what has been accomplished with the steel skeleton construction is possible in reinforced concrete. For business buildings and factories there seems to be no good reason why the exterior walls and ornamentation such as is used for these structures should not be built of reinforced concrete, our main difficulty at the present being the impossibility of securing workmen who are familiar enough with this material to make a satisfactory finish.

In considering the advantages and disadvantages of reinforced concrete, the architect is confronted with many important questions which must be answered aright before any definite plans can be drawn: (1) Is reinforced concrete "reliable"? Will it stand up? (2) Does its added weight work to its disadvantage? (3) Can it be erected with sufficient speed and in weather of varying degrees of temperature? (4) Does the stony and monolithic character of the construction render the building less adaptable for the introducing of overhead shafting, fixtures, etc.? (5) Is it fireproof?

The answer to the first question depends on certain factors, the most important of which embodies the personal element. In other words, reinforced concrete, in the hands of thorough and conscientious workers, will be just as safe as any other form of construction, while the reverse is true if the designing and execution is left to inexperienced persons.

The question of its added weight can be passed by as one of little moment when we consider the saving of cost effected by its use over other fireproof methods of construction. Furthermore, when a building is to be erected on a compressible soil this system can be used to good advantage by designing the building with a solid bottom running from wall to wall, omitting the independent footings.

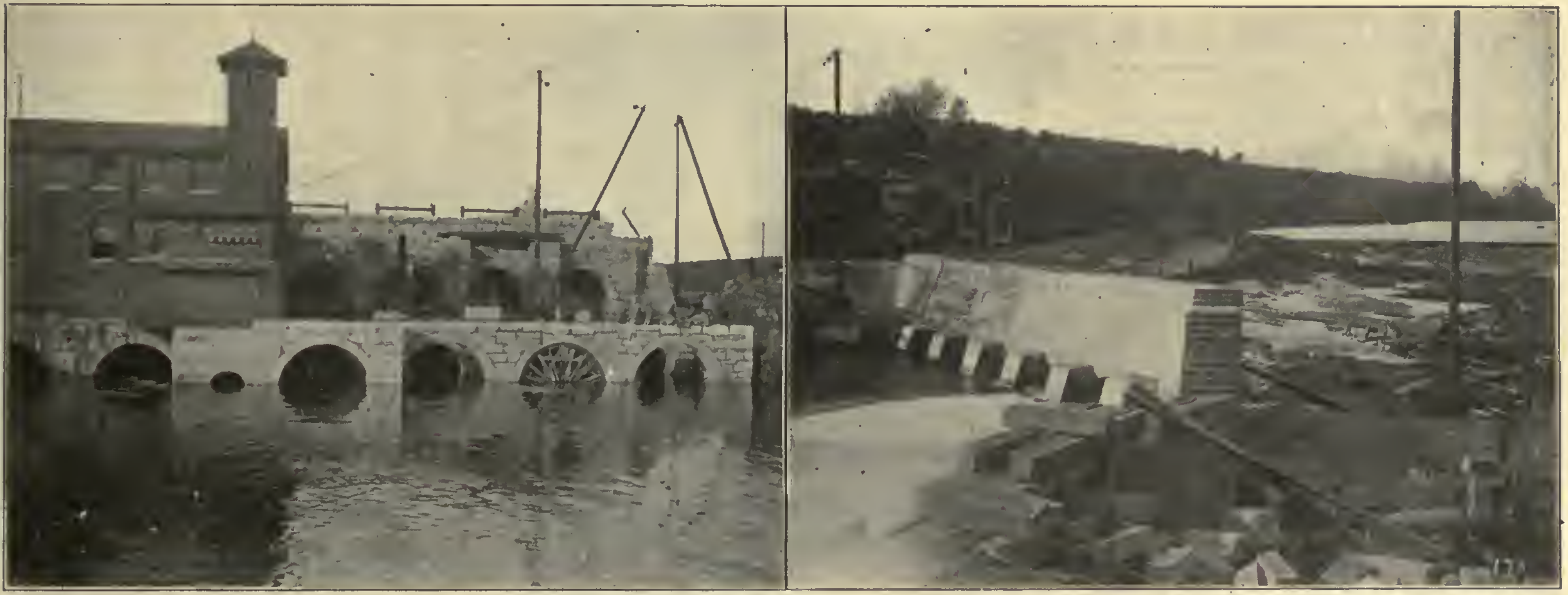
Can it be erected with sufficient speed and in weather of varying degrees of temperature? The first part of this question I will answer by giving the record of the reconstruction of the Forrest laundry last year. This building is a four-story and basement structure 50 feet wide by 160 feet long. The entire structure was finished on December 12, 1903. On November 26 all the plastering was finished; the concrete construction of the entire building, except the roof on top of the tank tower, was completed on October 29. As the work was given out on July 25, this shows a very rapid progress for the work. Since the work of erecting the staging for the concrete construction started on August 5, the time occupied for putting in the concrete construction was, therefore, twelve weeks. As this involved the laying of about 35,000 square feet of floor and roof, this is remarkably rapid progress.

As to laying reinforced concrete in freezing weather, I might say that it is not impracticable to do so, provided the temperature does not fall below about 26 degrees Fahr., but the precaution of leaving the forms or centering in position until the concrete has thoroughly set and hardened after the thawing process is absolutely necessary.

The stony and monolithic character of reinforced concrete is somewhat of an objection for buildings in which the location of the shafting and gas fixtures is not predetermined, unless some means are adopted by which the shafting hangers, etc., can be located at any point.

The fireproof quality of reinforced concrete has been established beyond a doubt, not only by actual conflagrations, as instanced in the Baltimore fire, but also by experimental fire tests made under the direction of the Philadelphia Bureau of Building Inspection and the New York Building Bureau.

The test made by the City of Philadelphia took place on a specially constructed test house or furnace with roof constructed of reinforced concrete, size 8x18 feet inside measurement, supported upon four 16-inch square columns. There were two girders, 8x14-inch, reinforced by four steel rods 1 inch in diameter, with 5/16-inch stirrups. The floor slab was 5 inches thick, with a layer of 5/16-inch rods at the bottom 8 inches on centers, and another layer running from bottom at the center to the top at the outer edge, for the purpose of strengthening the overhang of 14 inches of the floor. Columns, beams and floor were built continuously in one solid mass. The walls of the test house were of brick with buck staves. The proportions of the concrete were one part of Alpha Portland cement, three parts of gravel and five parts of trap rock. The age was two months. The floor was loaded with a uniform distributed load of 150 pounds per square foot.



Upstream Side of Old and New Portions of Garvin's Falls Power House; Head Gates during Construction.

The fire test lasted for four hours, after which water from a hose was turned on the test house under 65 pounds presure.

The mean average temperature of the fire was 1,776 degrees Fahr. The total deflection under fire and water was 2 5/12 inches. The next day the deflection was 1 5/12 inch less, showing that the floor had recovered this amount in cooling. The inside surface of the concrete showed a slight superficial crack near the front end. The northeast column showed a shearing break across one corner; other parts in splendid condition. Additional pig iron was loaded on the slab until the load was increased to 602 pounds per square foot. The northwest column showed a perpendicular crack through the center. The maximum deflection under a load of 602 pounds was about a half inch more than under the load of 150 pounds. The back columns showed a buckle of $\frac{5}{8}$ of an inch.

One other important feature which is interesting to the architect and engineer, inasmuch as it affects the pecuniary interest of the client, is the rate of insurance. Making the comparison with similar buildings of the slow-burning type, everything else being equal, the rate on the reinforced concrete type is considerably lower than on the slow-burning type; this is seen in the case of the Bilgram machine shop, where the rate is only twenty cents per hundred, while on the slow-burning type the rate would be more than double.

The rate on the Forrest laundry is thirty-five cents per hundred, while on a laundry building of the slow-burning type the rate would be seventy cents per hundred. I understand from the insurance agent that the rate on this particular building is cheaper than any other laundry rate in the United States. Furthermore, the same owner, while in temporary quarters after the destruction of the building by fire (the building being of slow-burning mill construction, sprinkled), paid $1.57 per hundred insurance. This gives some idea of the saving effected by using this system of construction.

The cost of reinforced concrete, as compared to the slow-burning type on the one hand and steel frame fireproofed with terra cotta on the other, reveals some interesting figures. The data I give you is from actual estimates received on buildings designed by our firm.

The bids of the Forrest laundry for the slow-burning type figured out $1.07 per square foot of floor area; for the reinforced concrete, $1.45 per square foot; for steel floors and roof construction fireproofed the cost would have been $1.85 per square foot. This is for the entire building finished, exclusive of elevators, power, heat and light.

The bids on the Union Mission Hospital do not show the same variation, as, the construction being lighter, the cost was not affected as much as with a heavy construction. The actual bids on this building were $2.45 per square foot for reinforced concrete and $2.54 per square foot for steel construction fireproofed, making a total difference between the two systems of almost $3,000 in favor of the concrete.

The patented systems of concrete-steel construction may be divided into three classes—those using "deformed" bars, those using "plain" bars and those using a "webbing." In the first class are the Ransome, which uses a square, twisted bar; the Kahn, which uses a square bar with side wings bent upward to form stirrups; the Thacher bar, which is a round, rolled bar with flattened sections; the Johnson bar, which is square in section and has ridges on the four sides. In the second class there are the Hennebique and De Valliere, in which half the number of bars are bent, the stirrups in the two systems being the points of difference. The Cummings combines the rod and stirrup in one bar. The Columbian uses a specially rolled bar similar to a double cross in section and support it at the ends on steel beams or walls. In the third class are expanded metal, Roebling, International and other types which employ a netting or sheeting in the concrete slab, in some instances strengthened with rods or cables.

The usual theory of the resistance of materials based on the following hypothesis, that a section plane before bending remains sensibly plane after bending, while it is not held by all engineers as being absolutely exact, is, however, sufficiently so for all practical considerations when applied to simple flexure; and this hypothesis forms the basis of all the formulas used in the writer's calculations. Such French engineers as Considère and Christophe and American engineers as Thacher hold to the above tenets, and I do not see any good reason why the theory of reinforced concrete beams should be so refined as to reduce the calculations to an exactness which is undoubtedly rendered null by the inequalities almost sure to exist in the concrete mixture and irregular workmanship.

On this assumption, then, that within the elastic limit the stresses are uniformly varying across the section, the fundamental formula for the flexure of beams may be reduced to the following for reinforced concrete beams of rectangular section with reinforcement in the bottom only, neglecting the effect of the concrete in tension:

$M = 0.33\ p\ a^2e + t\ s\ b$, in which M is the bending moment in inch-pounds, a is the distance from the neutral axis to the most remote fiber in compression, p is the unit compressive strain on the concrete, e is the width of beam, t is the unit tensile strain on the steel, s is the area of the steel, and b is the distance from the neutral axis to the center of action of the steel.

The determination of the neutral axis is, therefore, the key to the solution of the equation. If we represent the height of the beam by h, then the fraction a/h (which we shall call x in the next formula) represents the fractional part of the height of the beam in compression: likewise, the fraction s/eh (which we shall call y) is the percentage of the metal in relation to the total sectional area of the beam. By assuming the coefficient of elasticity of steel as being twenty times that of concrete, we deduce the following formula, which defines the position of the neutral axis in fractions according to the percentage, or

$$x = 20y\left(-1 + \sqrt{1 + \frac{1}{12}y}\right)$$

This formula is based upon the steel reinforcement being located at five-sixths of the depth of the beams from the top.

In calculating the strength of beams with floor slab united thereto the beams and slabs are considered a T section and the beam figured accordingly. Of course, should the neutral axis fail in the slab, the formula used for rectangular beams will hold good for these T sections, since we neglect the consideration of the concrete in tension and are only concerned with that in compression.

The formula for T sections, then, when the neutral axis falls below the slab becomes

$$M = p/6a\,[a^2w\,(3h' - a) - (a - g)^2\,(w - e)\,(3h' - a - 2g)]$$

In which p, a, e have the same meaning as before, and w is the width of the slab, h' is the distance from the top of the slab to the center of action of the reinforcement, and g is the thickness of slab. The position of the neutral axis from the top of the beam is found to be equal to the fraction h'/2.6 when p = 500 and t = 16,000 pounds.

The working stresses of the concrete we have assumed as 500 pounds per square inch, and that of the steel as 16,000 pounds per square inch, these values being established by the Philadelphia Bureau of Building Inspection.

The approximate formula for finding the area of the steel in the bottom of a beam of T section is as follows:

$$S = M \div 16{,}000\,(h' - g/2)$$

This formula is very convenient for checking up beams that have been designed by the correct formula, but it does not determine any dimensions for the concrete.

The effect of shear upon a beam seems to be very little considered in the early study of reinforced concrete, but since data obtained by practical tests seem to indicate that beams designed without the use of steel to take up the shearing strains fail by the cracking of the concrete, several systems have been devised to meet this objection. The De Valliere has a very good form of twisted stirrup, which is built in the beam and unites the steel rods of the beams to the reinforcement of the slab. The Kahn system employs a square bar with side wings bent up at an incline, the stirrup in this case being originally part of the bar and cut away, leaving just enough material to unite the two securely together. The Hennebique system uses stirrups bent in the form of a U-shaped loop extending under the tension rods and running up through the beam projecting into the slab.

The unit shear at the plane of the reinforcement equals $q = K/Ie \times m\,b\,s$, in which q is the unit shear sought, K is the vertical shear at the section considered, I is the moment of inertia of the section, m is the ratio of the coefficient of elasticity of steel to that of concrete, = 20, and b, e, s have the same meaning as before.

For T sections the formula becomes

$$q = \frac{K}{e\,(h' - a/3)}$$

The usual methods of reinforcing columns is to place vertical rods in the corners, strapped or laced together at frequent intervals. In order to have the two materials act together the deformation of the concrete and steel must be equal. We have then the condition:

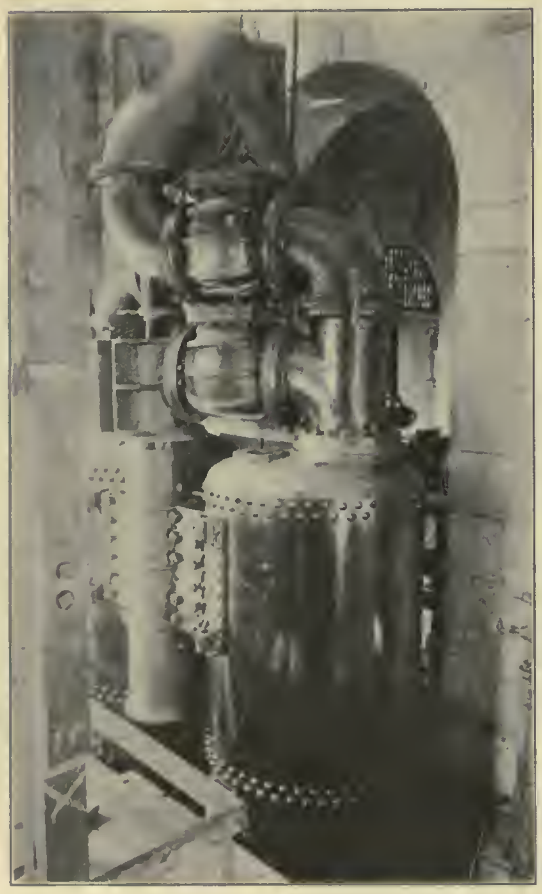
$$\frac{P}{E_c} = \frac{t}{E_t} \text{ or } t = \frac{P\,E_t}{E_c}$$

If we assume 500 pounds as the safe unit stress on the concrete the value of t becomes 500 × 28,000,000 ÷ 1,400,000 = 10,000 pounds. This is lower than the safe unit stress of steel, but is the proper value to use if we allow 500 pounds on the concrete.

For square columns longer than 10 diameters the safe unit stress should be reduced by the following formula;

$$P = p \div \left(1 + 0.0005\,\frac{l^2}{e^2}\right)$$

in which P is the allowable unit stress, p is the unit stress allowed on short columns, e is the side of column in inches, and l is the length of column in inches.



Pair of Air-Lift Pump Tanks.

Another method of reinforcing columns is by running, in addition to the vertical rods, spiral hoops close together around the column. This method is new, and as the experiments recently conducted on columns of this form are in somewhat an incomplete state it is best not to allow any higher unit stress on columns than given by the above formula.

A test of the protection afforded steel or iron embedded in concrete was made by our firm. A concrete prism 6x6x8 inches long, with four 5/16-inch rods, was placed in brine for six months in order to determine the effect of this solution on the embedded steel. When the block was broken open the rods showed no trace of rust and were as bright as the day they were embedded in the concrete. All the rods were placed within one inch of the face of the prism and the ends of same were as close as ⅜ inch to the outside of the prism.

We also had tests made to determine the adhesion of plain steel rods to concrete. The tests were made on a 1:3:5 mixture of concrete seven months old. The rods were ¼, 5/16, 9/16 and ¾ inch. The first three rods were rusted; the ¾-inch rod was entirely free from rust. The average pressure for release was 210 pounds per square inch of surface in contact, while the friction pressure after the adhesion was destroyed averaged 122¾ pounds per square inch. The rusted rods showed that the adhesion was equally as great as with the clean rod.

These values are somewhat low, as compared with other tests, but they indicate that the adhesion of the concrete to the steel rod continues until the steel is stretched to its elastic limit.

Air-Lift Pumping Machinery at the Inverted Siphon of the New Croton Aqueduct, New York City.

The new Croton aqueduct, which conveys water from the Croton Reservoir to New York City, crosses the Harlem River between the Borough of the Bronx and Manhattan Island by means of an inverted siphon 10½ feet in diameter inside, 1,266 feet long and about 311 feet below high-water level in the river. This siphon and its shafts were described in The Engineering Record, October 12, 1895. Shaft No. 25, near the corner of 179th Street and Amsterdam Avenue, Manhattan, from which the tunnel was driven beneath the river, was excavated to a depth of 426.5 feet and to a cross-section of 16½x33 feet in the clear of timbers and rock.

In this shaft there were constructed two wells 12 feet 3 inches in diameter, one forming a part of the aqueduct in which the water rises and the other serving as a pump well for emptying the siphon. There is a connection between the two wells at the bottom, controlled by a 20x30-inch sluice gate. The pump well is lined with cast-iron hub and spigot rings 3 feet in length and 1¼ inches thick, backed by a 2-foot ring of brickwork, with the space between the bricks and the sides of the excavation filled with rubble masonry. The cast-iron rings extend from the bottom of the shaft to the lower of two brick diaphragms, 378 feet above the bottom. Each of these diaphragms is a 4-foot inverted brick arch enclosed in additional brickwork making the total thickness 9 feet, and was built across the shaft to resist the upward pressure of the water. Through each diaphragm there is a manhole with cast-iron frames and covers; the manhole covers are 16 feet apart vertically. At a height of 337 feet above the bottom of the shaft the water in the pump well can overflow through a 48-inch blow-off pipe into the Harlem River, while in the adjoining well the water flowing in the aqueduct rises to an elevation 123 feet above the overflow pipe.

A stone building was erected over this shaft and a plant installed for unwatering the wells and siphon, whenever it might become necessary for inspection and repairs. The floor of the engine room is 424.25 feet above the extreme bottom of the shaft. The plant installed in 1889 and used until about two years ago for emptying the siphon consisted of a pair of 1,390-gallon bailing buckets 14 feet deep and 4 feet in diameter, lowered and raised by an engine and steel wire cables passing through large overhead sheaves. A flap valve in the bottom of each bucket opened as the bucket was lowered, but closed when the bucket was raised. A sliding gate in the side of each bucket at the bottom was provided for discharging it, being opened above river level by means of a tripping post near the top of the shaft. These buckets were operated by a high-pressure hoisting engine with 25-inch cylinders and 60-inch stroke. With this installation it required about 73 hours, as a maximum, to empty the siphon.

For several reasons this arrangement was considered very unsatisfactory, and many plans were studied for improving it. It was finally decided that in calling for bids for a new equipment the bidder should simply be required to guarantee that the machinery which was offered would have a capacity of 2,500,000 gallons in twelve hours, with a lift of 337 feet, and that complete plans of the proposed plant should be submitted with each bid, together with a statement of the power that would be required to operate it. The contract was awarded to the Pneumatic Engineering Company, of New York, April 21, 1902. This company offered a plant consisting of compound direct air-pressure pumps based on the design of Prof. Elmo G. Harris, of the School of Mines, University of Missouri, Rollo, Mo. The theory of this type of pump was explained briefly in this journal October 8, 1898. Whatever difference of opinion may be held as to the advisability of adopting this type of apparatus for deep shaft pumping under the peculiar conditions existing at this place, the numerous difficulties ingeniously overcome in the design and erection of the plant make a description of it particularly interesting.

Head-House over Manhattan Shaft of Harlem River Siphon, New Croton Aqueduct, Highbridge Pumping Station at Left.

During the installation of the pumping apparatus a number of modifications were made in the preliminary designs in order to meet the existing conditions to better advantage. When the contract was awarded, it was the intention to bail out the pump well and then assemble the tanks and other submerged parts of the pumps and their connections in place at the bottom of the shaft, erecting the rising air and discharge pipes upon them from the bottom upward.

The equipment as built includes the following principal parts: Four steel tanks, at the bottom of the pump well connected in two pairs; two 15-inch outside diameter (14.1-inch inside diameter) pump columns, for discharge rising pipes, joined at the top of the shaft by a Y-branch into one 21-inch goose-neck discharging into a cast-iron box, from which the water flows into the 48-inch blow-off pipe leading to the Harlem River; four 5-inch air pipes rising from the tanks to manifolds just below the engine-room floor; and, in the engine room, a heavy Rand-Corliss air compressor of the Comstock type, a 42-inch diameter by 10-foot steel-tank air receiver, an after-cooler, a special switching device for controlling automatically the flow of air to and from the tanks, a small Rand auxiliary air compressor to supply the necessary and accidental losses from the system, and an Otis hydraulic lift cylinder.

The preliminary plan contemplated a single 21-inch discharge pipe for all four tanks, and in some other respects the piping differed slightly from that finally built. Developments during erection made it desirable and necessary to change several features, although some of the parts had already been made. Steam for the compressors is brought through an 8-inch main underground from the 179th Street, or High Bridge pumping station, about 300 feet distant. Almost all the steam and other piping is beneath the engine-room floor.

Before removing the old apparatus it was employed to empty the water from the pump well, with the hope that the well could be kept sufficiently clear of water by means of small pumps to permit the men to work on the tanks and connections; but when the well was emptied it was found that the water leaked in from the aqueduct and from the ground at a rate of from 1,200 to 1,500 gallons per minute. To handle such a quantity of water against the existing head would have required a pumping outfit of so large size that room could not have been spared for it in the restricted space, and it would have been costly to install and operate. Furthermore, it was considered unsafe for the aqueduct well to have the pump well empty for so long a time as would be required for the erection of the machinery, on account of the great pressure on the aqueduct. At best, it would have been so wet and dark and the ventilation so poor, and the small space would have been so crowded with the tanks and piping that it would have been almost, if not quite, impossible for the mechanics to work. Consequently, the pump well was allowed to fill again.

The contractor was, therefore, asked to so modify the designs as to make it possible to assemble in the engine room and in the upper part of the shaft above water, the parts of the apparatus to be put into the lower part of the shaft, to lower them into position through the two elliptical manholes in the brick diaphragms previously mentioned and to provide means for lifting these parts of the apparatus to the top of the shaft for inspection and repairs, if it should ever become necessary to do so. One brick diaphragm is 39 feet and the other 55 feet below the engine-room floor. Exact templates were made of each of the manholes, which are 4 feet 6 inches by 5 feet 4 inches, and by the aid of these templates the designs were so rearranged that a tank with its lugs and other connecting parts attached could just be gotten through one of the manholes when turned in a particular way. A clearance of only ⅜ to ½ inch was allowed over the rivet-heads and other extreme points when the tank was turned in the right position.

Heavy cast-steel brackets, of such shape and size as to leave just the absolutely necessary clearance for a pair of tanks when assembled, were tap-bolted to the cast-iron lining of the shaft at a level about 95 feet below the engine-room-floor, to support a temporary erecting platform. These brackets were arranged as shown on one side of the drawings, one pair being at the extremities of the diameter between, and at right angles to, the axis of the two manholes. Each bracket of this pair had five 1¼-inch tap bolts and two 1-inch steel dowel pins, and the others, having less load, each had three bolts of the same size and two dowel pins. On the pair of heavy brackets was placed a 15-inch 42-pound I-beam, and the other brackets were set with their tops on a level with the top of the I-beam. A 10x12-inch hard pine stick cut to exact length was laid with one end on a bracket and the other on the I-beam, there being eight sticks in all. Across these timbers the floor of 3-inch planks was laid, but not spiked. The platform was so arranged that either half could be removed independently of the other.

On this platform first one pair of tanks was assembled with the pipe connections on top and tested to 200 pounds per square inch pressure, and lowered to the bottom of the shaft, and then the other pair of tanks was likewise assembled, tested and lowered. Each pair of tanks with its fittings is so put together that all the weight, including that of all the rising pipes, is carried down through the tanks to their bottoms, which rest on the bottom of the shaft. To lower the tanks the erectors made use of the hydraulic cylinder and the two 1½-inch galvanized plow steel cables engaging pairs of steel channels supporting long bolt rods, which in turn engaged lugs on the tanks.

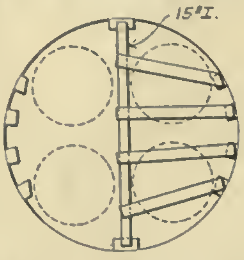
The hydraulic cylinder is a 14½-inch by 23½-foot elevator cylinder fitted with a balanced elevator valve and supplied with water by a Deane pressure pump. It was designed to handle safely a load of 40 tons. The total weight of the pair of tanks with all the attached piping is about 38 tons, to which, of course, the weight of the cables must be added. The cylinder has two piston rods connected to a cross-head carrying a pair of short I-beams, to which the cables could be attached by means of eye-bolts seated in a swivel. The combination is arranged to swivel on the crosshead so as to adjust itself automatically under its load to compensate for any unavoidable slight inequalities in the lengths of the cables. This cylinder was made by the Otis Elevator Company and was mounted on a trestle 6 feet high built of heavy timbers and set on the floor of the square pit at the top of the shaft. The building over the shaft has a tower tall enough to accommodate the old bailing apparatus, so that there was plenty of headroom for the cylinder beneath the large sheaves of the old hoist.

The cables were made by the John A. Roebling Sons' Company and were guaranteed to have a breaking strength of not less than 100 tons each. Six 20-foot lengths and twenty 60-foot lengths, fitted with pin couplings at each end guaranteed to be stronger than the cable, were furnished. On top of the upper brick diaphragm a tower about 9 feet high was built of 10x10-inch yellow pine timber, and on it was set a pair of 10-inch steel I-beams, connected by bearing plates, so arranged as to pass the cables, but engage the coupling at the end of a length of cable and support the total load while a shift of the cables was being made and the piston of the hydraulic cylinder returned for another down stroke, and then, by unbolting and spreading the beams, pass the coupling when desired in order to lower the tanks.

The tanks of each pair were connected together near the top and bottom on opposite sides by four sets of steel connecting plates and angles and special steel castings, as shown in the drawings, riveted to both tanks. The four steel castings in the upper pair of connections directly riveted to the tanks each have two lugs with a hole through which a 2-inch steel bolt could pass. The four bolts are 12 feet long and extend from the bottoms of the lower lugs through the spaces betweeen two pairs of 12-inch steel channels back to back above the cross-pipe connections on top of the tanks. The lower ends of these bolts have round forged heads, and the bolts are kept from dropping, when there is no lifting stress on them, by small guard plates close under their heads, bolted to the lug plates. The upper ends of the bolts are upset and threaded and the nuts bear on plates across the top flanges of the channels. Steel-plate clamps attached to each channel and passing over the top of each bolt prevent the channel from dropping down along the bolts when no lift is exerted, or when the tanks rest on the bottom of the well. At a point in each pair of channels, so chosen that the pair of tanks with its fittings would balance and hang in the desired position when suspended at these two places, the pin couplings for the two cables were attached.

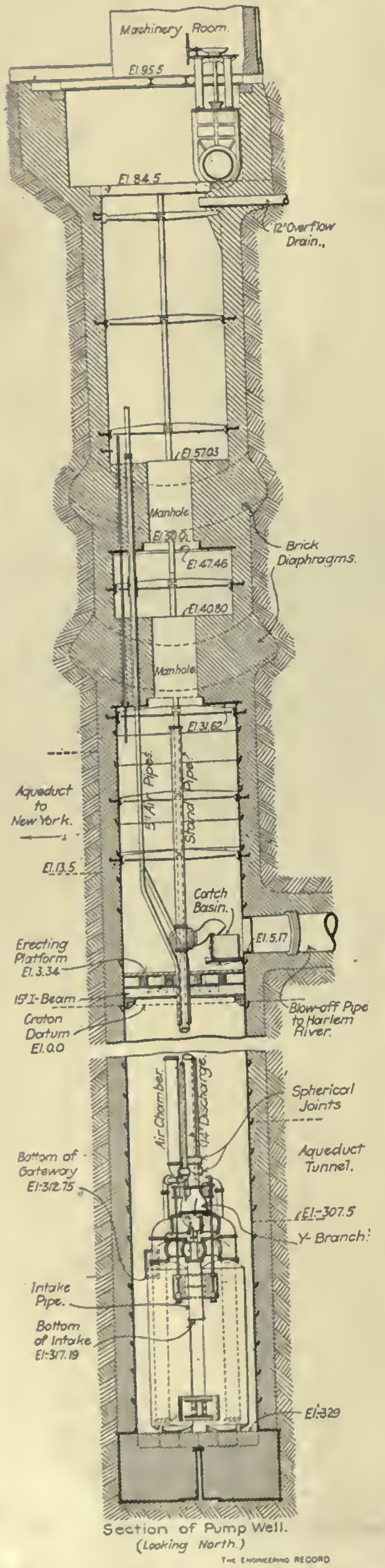
When the parts were all assembled ready for lowering, the distance from the pair of couplings just above the tanks to those on the cylinder crosshead, with the piston at the upper end of its stroke, was 60 feet 6 inches. The stroke of the piston was 21 feet, but it could travel an inch or so above the nominal upper limit of the stroke. First a pair of 60-foot lengths of cable was connected to the crosshead and to the couplings on the channels at the top of the tanks. The piston was lifted slightly so as to raise the tanks just clear of the platform, half of which was then removed. Then the piston was allowed to take a full stroke downward, bringing the couplings at the upper ends of the cables to bear on the I-beams on the wooden tower standing on the upper diaphragm. The piston was then returned, a pair of 20-foot lengths of cable attached and 20-foot sections of pipes bolted to the riser connection on the tanks.

A second tower of 10x10-inch yellow pine braced with 3x10-inch planks, 23 feet 3¾ inches high and carrying a pair of I-beams and bearing plates similar to those on the upper tower, was erected on the working platform. Its height was such that the distance from a cable coupling resting on its I-beams to the corresponding coupling on the piston crosshead in its highest position was 60 feet. With this tower in position the piston made a second and then a third stroke downward, 20-foot cables and sections of pipes being connected on at the end of each stroke. The tanks were then suspended from the top of the lower tower and a second pair of 60-foot cables substituted for the two pairs of 20-foot lengths. The operations were then repeated until the two pairs of 20-foot cables were again in place, when another pair of 60-foot cables were substituted, and so on until five pairs of 60-foot cables had been used and the tanks were seated on the bottom of the shaft. Of course, during this lowering process the position of the center of gravity of the tanks and pipes were changed somewhat as the sections of pipes were added, but this had been anticipated and provided for in determining the points of suspension. The cables were left in place after the tanks were in their final position so as to be ready for use if it should ever become necessary to raise the tanks. This process was repeated for the second pair of tanks.



Section of Well showing Temporary Platform Timbers and Brackets.

The Engineering Record.



Section of Pump Well. (Looking North.)

The Engineering Record

Harlem River Siphon Shaft with Air-Lift Pumps in Place.

There was reason to believe that the bottom of the pump well was not clean and level, tools having been dropped into it which were never recovered and more or less sediment deposited. Preliminary knowledge of its "topography" was, therefore, necessary in order that the tanks might be properly set.

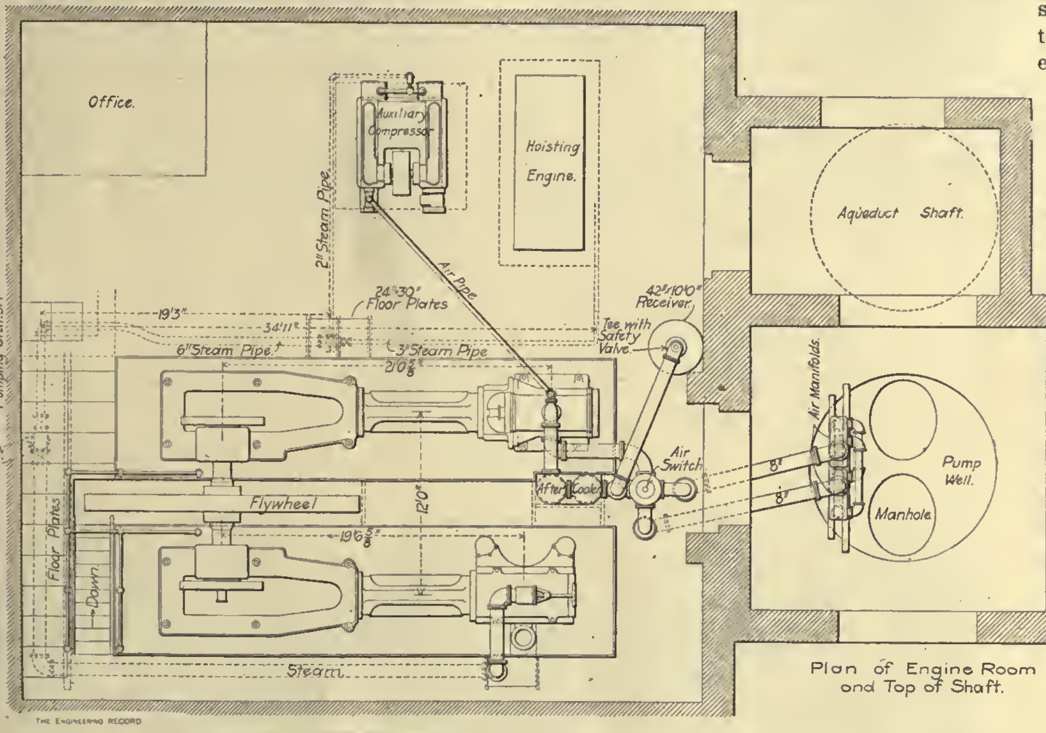
A sufficiently accurate survey was made by means of a flat-bottomed conical piece of lead weighing about eight pounds, attached to a long wire fastened to the end of a steel tape. Soundings were taken at located points and the depth measured from the water surface. It was thus learned that there was an extreme difference of level in the bottom of 8 inches. An attempt was made to level the bottom and cover any pools or similar hard objects by carefully depositing sand and fine gravel through the water. Some improvement was made in this way, but a level bottom could not be obtained, because there seemed to be sufficient movement in the water near the gate between the pump well and the aqueduct shaft to carry the sand somewhat away from this point.

Since it was impossible to make sure that the tanks could be seated so as to stand plumb and since even a comparatively small inequality in the footing would have caused serious deflections in the very tall rising pipes and have jeopardized the joints, it was decided to insert a spherical joint in each vertical pipe just above the tank connection. An accompanying drawing shows the design of the swivel joints for the 15-inch pipes; those for the 5-inch pipes are similar. In the 15-inch joint, to save height, the spherical surfaces of the "ball" were brought nearer together than they would have been on a sphere of the radius used, just as if a thick slice had been cut from the sphere at its equator and the remaining portions brought together. To compensate for the lateral movement caused by this deformation of the sphere, the upper bearing on the ball is a sliding ring whose upper surface is flat and travels on the bottom of the flange above, as shown. In the 5-inch joints the balls are true spheres, and not reduced in height, consequently the sliding bearing is not needed. These joints were tested under 150 pounds pressure per square inch and found tight. The friction on the bearing surfaces was made such that a man pulling or pushing at the other end of the 20-foot length of pipe could readily deflect it and yet the pipe would remain in position without support.

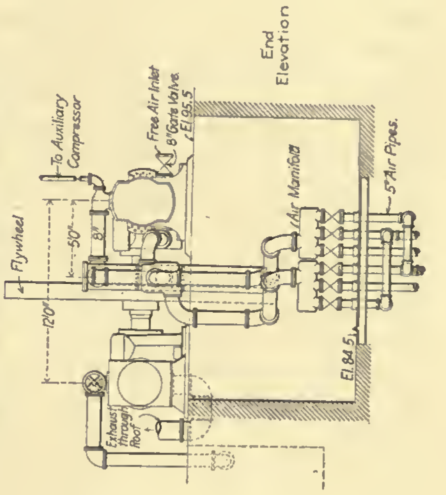
The work at shaft No. 25, as on other parts of the new Croton aqueduct, is in charge of the Aqueduct Commissioners, for whom Mr. J.

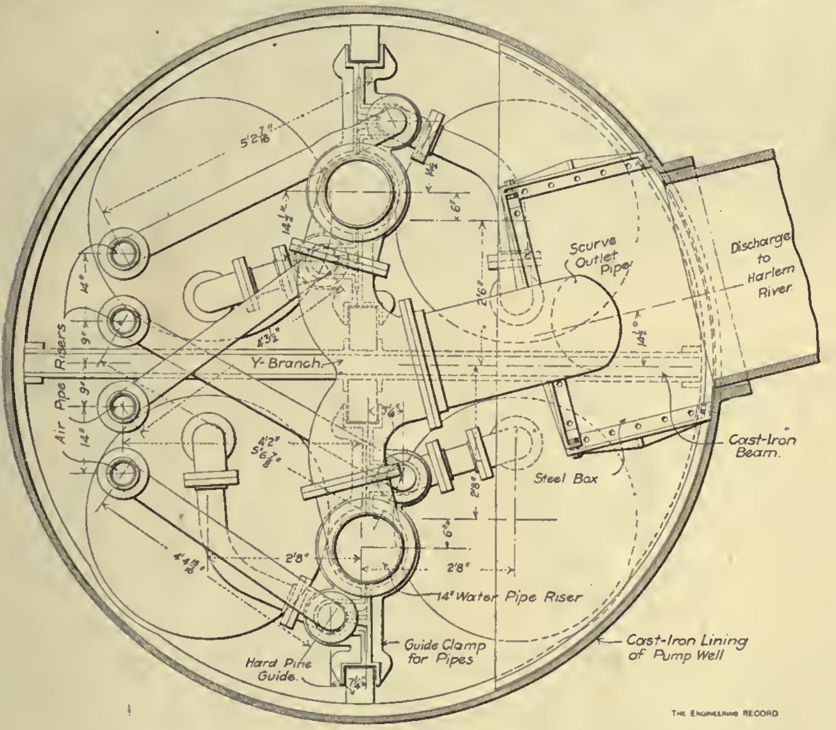
Waldo Smith is chief engineer, Mr. F. S. Cook, assistant engineer, and Major F. W. Watkins, the division engineer in local charge. The pumping apparatus was designed and installed by the Pneumatic Engineering Company, of New York, for which Mr. E. L. Mills is the designing and erecting engineer. In the efficiency test of the apparatus Mr. Will J. Sando was the expert representing the Commissioners.

(To be continued.)

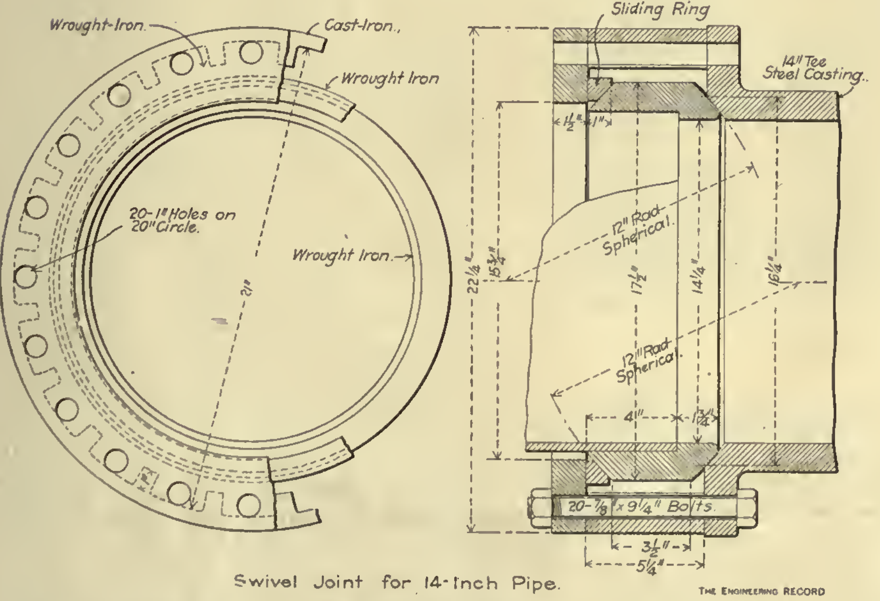


Plan of Engine Room and Top of Shaft.

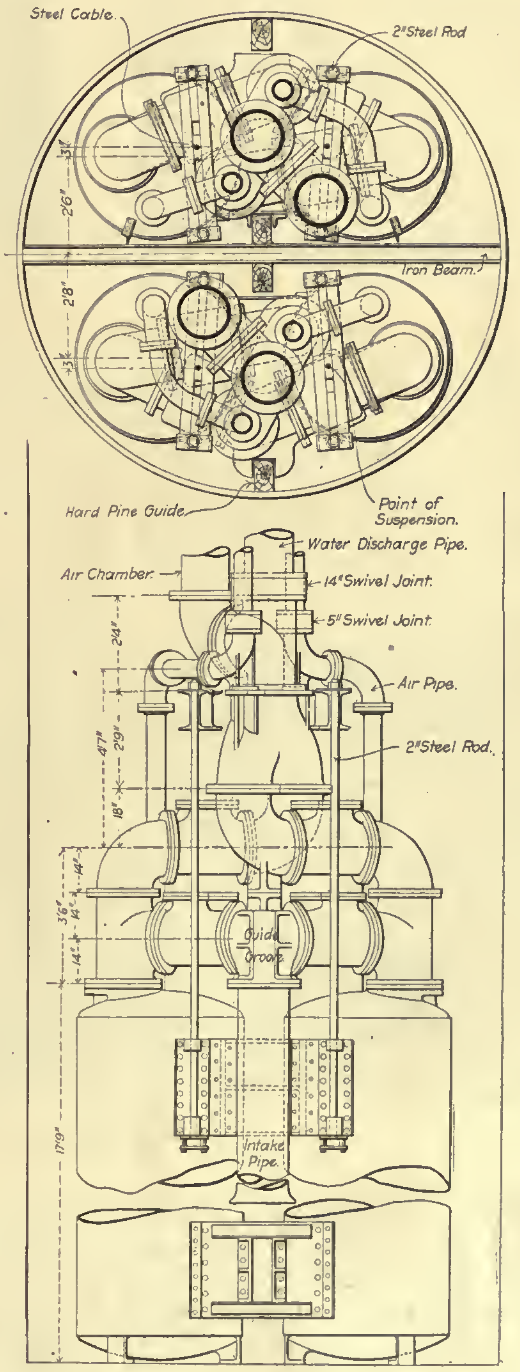




Plan at Top of Well showing Pipe connections



Swivel Joint for 14-Inch Pipe.



Plan and Elevation of Tanks and Pipes at Bottom of Pump Well

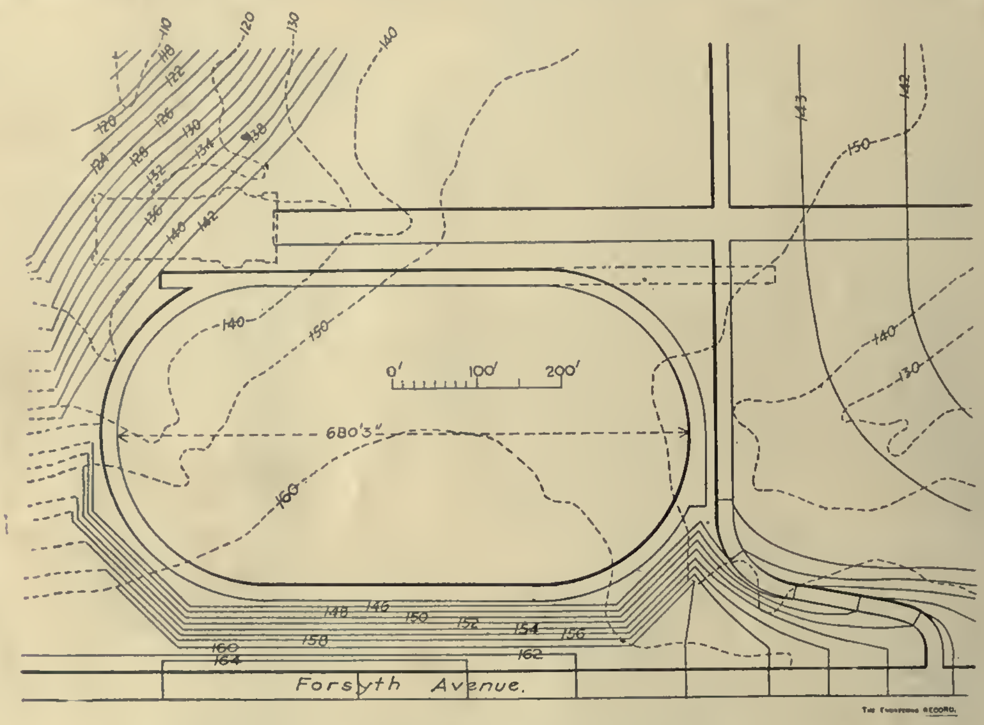
AIR-LIFT PUMPS AT HARLEM RIVER SIPHON: ARRANGEMENT AND DETAILS OF MACHINERY, TANKS AND PIPES.

An All-Concrete Grand-Stand.

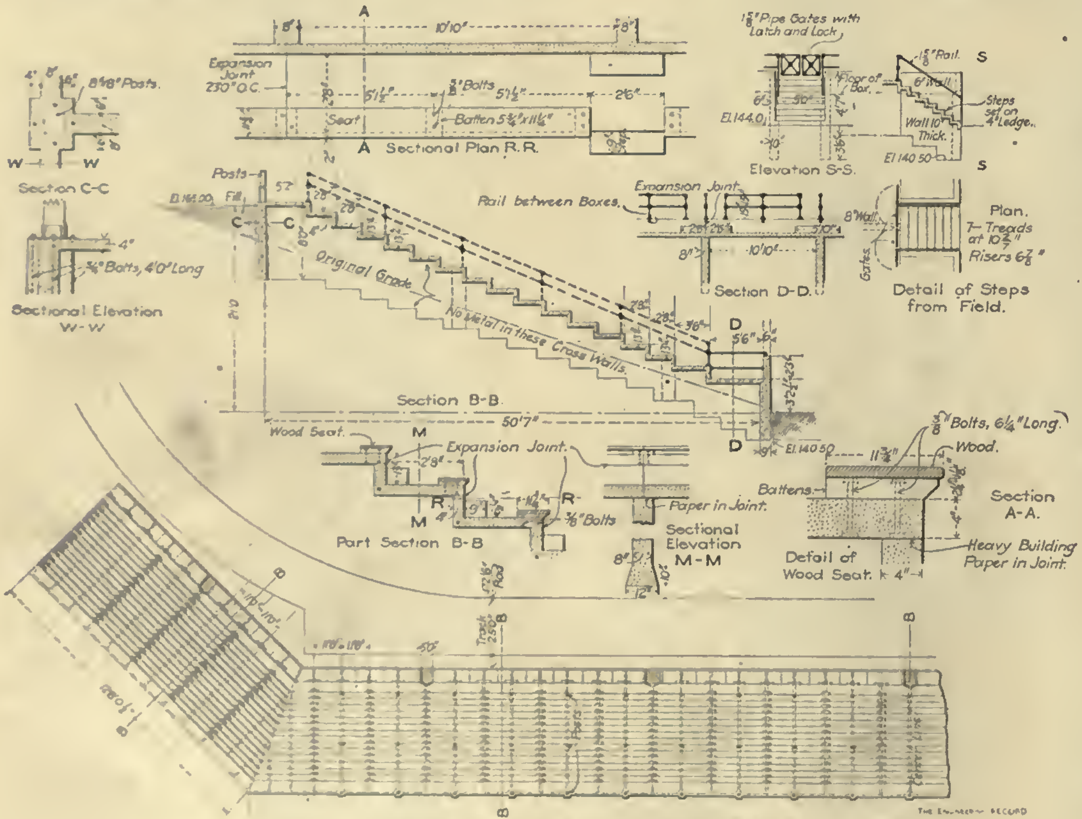
By J. L. Van Ornum.

Washington University has just completed a grand-stand for its athletic field, which will receive its inaugural through the famous "Olympic Games," which will be held here during the summer in connection with the Louisiana Purchase Exposition. As will be seen from the plan, the stadium occupies an area of about 450x750 feet, the circuit of the track being one-third of a mile. The site of the stadium is high, but in its preparation the earth was excavated to a depth of from 10 to 20 feet below the original surface. In doing this a sloping embankment was left on the south side of this field, and it is upon this sloping bank that the grand-stand has been built, with a seating capacity of about 9,000.

This structure is entirely of concrete, except for the reinforcing steel bars embedded in the seats and in the front and rear walls. It will be seen from the plan of the grand-stand that the cross walls to support the seats are spaced 11 feet 6 inches on centers in the main portion of the structure and 11 feet on centers in the wings. These cross walls are 8 inches thick at the top, 12 inches thick at the base, and vary in height from 4 to 10 feet, or from below frost to the required seat levels; the walls are also stepped at their base to better resist the superimposed weight and at the top to receive the seats.



Plan of Concrete Stadium, Washington University, St. Louis.



Structural Details of the Concrete Stadium.

The seats and risers spanning the supporting walls just mentioned are of concrete 4 inches in thickness, and embedded near the bottom of each riser are two ⅝-inch round steel rods, spaced 2 inches apart, the outer one being 1½ inches from the rear surface of the riser. The length of each rod is about equal to the span of the seat; it is bent to a vertical position for a length of 3 inches at each end and curves downward at the middle to within 1½ inches of the bottom of the seat at its center. Before constructing the seats sheets of heavy building paper were laid on top of the supporting cross walls to break here the continuity of the concrete construction, and expansion joints of about ¼ inch (the width depending upon the temperature prevailing at the time the work was done) were left at the end of each section or above the center of each cross-wall. The seats are 2 feet 8 inches wide and the risers are 13 inches high.

The lower tier, next the field, is 5 feet 6 inches wide to accommodate the boxes, and the upper tier 5 feet 2 inches wide. The front and rear (longitudinal) walls vary from 6 to 12 inches in thickness and also carry embedded steel rods to prevent unsightly cracks, in addition to expansion joints every 23 feet of length. The concrete used in the seats and risers consists of a mixture of one part of Portland cement, two parts of Mississippi River sand, five parts crushed granite not exceeding the ¾-inch size. The exposed surfaces are finished in the way usual in granitoid construction, the upper ¾ inch of the concrete slab being of one part Portland cement to one part of granite siftings. The concrete for the walls is like the first-mentioned mixture except that the broken stone is limestone and its maximum size is double that above given.

The writer made several tests of seat units (consisting of a full size seat slab and its two adjacent risers) with various sizes, shapes and distribution of the reinforcing steel before the system above described was finally adopted. In the tests the full size of the seat (11½x2 2/3 feet) was uniformly loaded. In the system as adopted the deflection at the center reached ¼ inch under a uniform load of 500 pounds per square foot with no weakness appearing in any way. The first hair cracks appeared at a load of 550 pounds per square foot. Under a uniform load of 725 pounds per square foot, the maximum practicable, these cracks on the under side near the center of the span were still hardly perceptible and extended upward from the bottom less than an inch and constituted the only weakness apparent, while the center deflection under this maximum load was 0.44 inch.

After the supporting walls were constructed the seats and risers were built upon them in alternate sections, as indicated in the view of the western end during construction. This view also shows the false work in position in certain sections (which was removed through temporary openings left in the rear wall and used again), the embedded bolts for attaching the cypress battens and seats, the finishing of the surfaces and other details of methods of construction. At the top of each riser is seen the expansion joint, permitting a transverse expansion, formed by a layer of heavy building paper placed between it and the seat slab resting upon it.

The tops of the seats, shown in the other view, slope toward the front at a rate of ⅛ inch per foot, and a small gutter runs longitudinally just back of the front wall, connecting with weep holes through the front wall. Especial care was taken for thorough drainage to keep water from entering underneath the structure.

The details of the more temporary portions of the structure, such as the wooden seats, the pipe railing about the boxes, the posts for supporting the roof and the iron gates at the seven entrances to the grand-stand from the field are shown in the drawings. The architects were Messrs. Cope & Stewardson, of St. Louis and Philadelphia, and the contractors were the

James H. Bright Contracting & Building Company, of St. Louis. The total cost was about $32,000.

The Forms for the Steps of the Stadium.

The Finished Concrete Steps.

The Relation of the Engineer to Finance.—II.

An address at the University of Illinois by John W. Alvord, M. Am. Soc. C. E.

The Financing of Engineering Projects.

The financing of engineering projects may, for the purposes of this discussion, be divided into three groups, somewhat in the order of their complexity.

First—Investments by the public bringing indirect returns.

Second—Private investments for public purposes, bringing both direct and indirect returns.

Third—Private investments for general purposes, bringing direct returns.

The first of these cases is by far the most complex, and although its discussion enters somewhat into the domain of political economy, it is nevertheless finance in its highest application, and should be studied by the engineer. It can, perhaps, be best understood by discussing an illustration.

Investments by the Public.—It has been found by experience that certain kinds of projects which benefit a relatively large mass of people in common, but to a small extent individually, can best be conducted by the public as a whole through municipal, State or national organization. Among these investments are roads, highways, bridges, sewers, street paving, public waterways, harbors, canals, river improvements and other public enterprises of a like nature.

Let us take the case of a street pavement and analyze the methods of financing it. Here it will be seen that no revenues are to be received in cash, but many thousands of persons are daily saved annoyance, expense, wear and tear, and are enabled to transport much greater loads at much less expense than formerly, so that they can accept a less price for their commodities, and still be saved annually a small sum by the proposed improvement.

Now it would be possible to allow private capital under suitable restrictions to undertake the paving of the streets as a financial enterprise, and in return for its use, collect a few cents from each vehicle using it, as was formerly done in the case of toll roads. This would result in raising the necessary reward to the invested capital from the vast mass of people who would have to pay the slightly increased prices which the vehicle owners would have to charge, but if this vast mass of people should itself raise the necessary capital by self-taxation and pave the streets with the proceeds, instead of receiving their return on the investment in annual cash installments, they then might receive it directly in the benefits of decreased transportation charges and reduced wear and tear, and by reason of such an arrangement, much book-keeping and complex organization, with its attendant friction, would be saved.

Advantages resulting from such direct arrangement are, however, nearly always counterbalanced by other considerations. The benefits of street paving are not nearly so easy to adjust as would appear from a theoretical statement. Adjacent property is largely increased in value by the increased facility and convenience, and the general public says to the lot owners, "You are receiving a very large portion of the increase from this project in the form of increased valuation of your property. You will therefore have to share largely in the original expense, so that your rate of return will be relatively reduced." Certain teaming interests may be benefited in ways which they neglect to pass on to the consumer, and the general public reaches them in the form of team license, thus reducing their disproportionate return. And finally the vast mass of the public do not share equally in the remaining benefits at all, but such benefits are usually very unequally distributed.

Nevertheless, underlying all these difficulties is a simple principle which is everywhere the same: that every investment must make adequate return in income or else it results in waste and loss of human energy, direct and severe upon those by whose mistaken judgment it was made and whose strength it wastes, and indirectly on the whole community.

Investments Aided by the Public.—The above example of a complex return is modified in the second case where private capital makes an investment aided by the public at large. This aid generally takes the form of permits, grants, rights of other kinds, and rights of protection. Let us assume an example.

It is proposed to build a railroad from A to B so that formerly where one had to drive or walk at great expense or go by the more roundabout railways, he can now be accommodated at a minimum of expense and time. If there are enough people who will travel by the new line, and will pay a rate for the privilege that will cover all its expenses and leave a profit to the investor, the financier will call the project a paying one. In other words, the communities A and B are able and willing to reward him for the assistance and saving the railway has become to them. But, furthermore, the State, in order to encourage such projects, permits the railways to organize into an association under certain laws which it provides, so that such associations are known as corporations and have all the advantages of unified and individual action. It also permits such corporations to take from individuals their private property if necessary to its uses, upon just payment for the same, and in return for these valuable privileges requires of them certain just dealings with the public, such as liability for personal injuries due to its negligence, and fixed rates of charges which, under any given circumstances, will not return unreasonable or extortionate profits. Where railway corporations of this kind operate in cities or towns, they were granted an immense saving of capital in the use of the streets belonging to the public, in return for which further restrictions and liabilities are imposed on them.

All such enterprises as these where private capital forms what is to all intents and purposes a copartnership with the public are called public utility corporations, and the main difference from a financial point of view between capital so invested and capital invested in strictly private enterprises, lies in the fact that when it is once decided to finance a public utility corporation, the public requires of its projectors first and foremost that they shall perform in a reasonably adequate manner certain commonplace and obvious duties as to service, even if it be at a loss in financial return, but with the privilege that having fulfilled those duties, they are free if possible to make reasonable but not extortionate profit. The risks of such enterprises must therefore be well discounted at the very outset.

On the other hand, capital used in strictly private investments, may and actually does consider its first duty is to provide itself at all times and under all conditions with adequate financial return, and that is accomplished by serving society at large only for the sake of its own interests.

Investment Features.—The simple case of investment of capital in private enterprises is wide and varied. A great deal of it does not come under the notice or study of the engineer, and most of it only partially engages his attention. But very largely in many ways, it is necessary for him to understand the essential principles upon which all investments which need his aid are made in order that he may render efficient service to his client, and co-ordinate his technical information to the financial necessities of any given problem.

The Physical Plant.—Enterprises which interest the engineer usually have three important elements of value. There is first of all a physical plant of some kind which is the result of his study, thought and energy, and is the visible reality of the enterprise. It may consist of very varied and miscellaneous groups of constructions, or one compact and monumental engineering work.

From the financial and engineering point of view the important feature is that as a whole it should be exactly adapted to the needs of the enterprise, and fill the needs at a minimum of cost and a maximum of efficiency. When any given enterprise is studied from this point of view, many things are found to be proper which from a purely structural standpoint are not ideal engineering. A new railway, for instance, through a new and unsettled country is fully justified in not adopting low ruling grades or heavy bridges; and the use of perishable materials in a structure is quite proper when experience shows that such structures are quickly thrown out of use by changing conditions. To pave a 50-foot roadway with granite for a traffic of three wagons a week is sorry engineering and worse finance.

The component parts of a physical plant have a limit of life due to wear, corrosion, or changing conditions. This known life has a most important bearing in financing any given project, as such parts must be replaced or made good from time to time. Moneys spent in this way must be estimated and allowed for before recovering profits.

The Going Value.—The physical plant of any given enterprise is the mere beginning of business. Ordinarily skilled mechanics and proper labor must be secured, drilled and organized, initial business must be acquired, which will pay the operating expenses as early as possible. All of this takes time, and requires a considerable further expense of actual cash in addition to that required for construction.

The courts have come to define this further expenditure as the "going value" or the value which an operating business has over a completed but idle plant. Included under this head is interest on capital that is idle, cost of organizing and loss while waiting growth of income. This is real expenditure which, no matter how it may vary in different cases, is as necessary to the project as the cost of buildings or machinery. It must surely be estimated upon in considering the feasibility of any given proposition.

The Earning Power.—A third element of value which a given project may have is due entirely to its success or non-success in meeting the wants of society. This is the element of its earning power, its value can seldom be accurately computed in advance, but must be surmised from the relative success of other similar enterprises. Only the broadest kind of experience in the special lines of business under consideration is competent to predict what a given industry or service will do under differing conditions.

To summarize the three elements of value in general undertakings then, we have:—

First. The cost of the physical plant, to which must be added;

Second. Cost of getting it into operation This is our cash investment upon which the business ought to show;

Third. Earning power sufficient to repay the following items: (a) Rent for the use of money invested, that is to say interest. (b) Operating expenses of whatever character, including management and direction, maintenance and taxes. (c) Replacement of physical plant from time to time as it wears out or becomes antiquated or uneconomical, that is to say loss from depreciation. (d) Profits, sufficient in amount to be an inducement to the investor to undergo all the risks connected with the undertaking.

Unless an investment can show clearly that enough income will be returned from the output or service rendered to cover all these four items, the financier condemns it, because he feels that the community will not find such an industry or service of sufficient benefit to render it adequate return.

So far we have dealt with the bare proposition of the invested capital and its adequate return. It is these facts that interest the engineer and upon which his opinion is often sought. The general public does not have the matter presented to it in this way, but are asked to buy stocks and bonds in the enterprise. Let us briefly examine the ordinary relation of these to the real investment.

Bonds.—In the first place, when a business involving a physical plant has progressed sufficiently to have an actual income, it forms what is called a security and money may be borrowed upon it. The promissory notes issued with such security are a mortgage upon the property and are called bonds. They take precedence over any other obligation and when issued in reasonable proportions of the full value of a good security, can be then sold for low rates of interest. The bondholders, then, are the ground-floor investors in any project, to use a common expression, and their money must be returned to them intact before any one else can be considered either as to interest or principal.

Stocks.—But before any bonds can be issued on a given project, however, the originators are obliged to raise a proper amount of money as a working capital of the company or enterprise, with which the initial expenditures are made.

In case of hazardous undertakings, it may be that this original capital comprises the whole investment, as the risks are too great to enable money to be borrowed upon the business. Or it may be that the original capital must be ample in amount to build the plant and start the business in order to demonstrate that it is a security upon which money can be properly loaned. In any event, this original capital is an evidence of faith on the part of the originators in the project. It may be divided into a number of shares, allotted proportionately to those who pay in their money, and these shares may be assessed in case of failure or rewarded with dividends in case of success.

Such shares are usually called stocks, and their owners, stockholders; and as each share carries with it usually the right to a vote, such stockholders may elect their officers and directors and control through them the policy and management of the enterprise subject always to the rights of the bondholder where the business has been mortgaged.

Preferred Stock.—Stock is sometimes divided into common and preferred shares, in which case it is provided that the first profits up to a certain amount shall always be divided pro rata to the preferred stock, while the surplus, if there is any, will be divided among the common stock. In such cases, then, the common stock often represents only the chances of increasing business, a lucky good year, or at the most future opportunity of growth, together with the right to control the management.

The shareholders are the real risk-takers, and as they are generally believers in the success of their project, they very often place the aggregate value of their shares at a much larger sum than that actually invested in cash and divide them pro rata among those who will advance money on the project. In due course of time the business may increase or it may diminish, and the value of these shares fluctuates largely as they really represent in most cases the last margin of profit or of loss. It is not possible here, nor is it necessary, to go into all the manipulations which can be effected with shares of stocks complicated with bond issues. But enough has been said to clearly point out that the real root of the matter is the actual amount of cash investment and the earning power both for the present and the future.

Conclusion.—The proper acquisition of ideas on finance comes more largely to the engineer from the actual investigation of properties and projects than in any other way. Nothing is so instructive as to learn just how a well-managed property is conducted and to talk with the men who are at the head of such enterprises. A thorough knowledge of accounts in their broader requirements is advisable, as is also a knowledge of the law affecting corporations, municipalities and general business. All of this is acquired only by much experience and study, and above all by contact with the proper environment. There are good text books on business and financial management, but most of them are written for experts, and do not give clearly the simpler ideas which underlie the matter.

Much may be learned from having an open ear for stray information such as is always available, and it is with the idea of stimulating interest in this direction, so that an open mind shall be in a position to acquire information that this paper has been prepared. In conclusion I would say that: Nothing will elevate and dignify the engineering profession more than to have the business community realize that the engineer in his riper experience has financial ideas as well as technical training, and what is more important, knows how to properly subordinate the one to the other.

The Substructure of the Fraser River Bridge.

The Fraser River bridge, at New Westminster, British Columbia, has about 2,375 linear feet of double-deck steel truss and plate-girder superstructure, including the triple north approach and excluding the pile trestle south approach. There are fourteen fixed spans of 45 to 384½ feet and one 384¼-foot swing span, which were described in The Engineering Record of April 30 and May 7 and 14. The bridge is being built by the Government of the Province of British Columbia and when opened will carry the railway and highway traffic, which ferries are now handling.

Fraser River Bridge: Building Caisson for Pier Number Four.

The bridge site is fifteen miles from the point where the river empties into the Strait of Georgia. There is a tide difference of from 3 to 7 feet in twenty-four hours, causing two currents each way during most of the year. The "run in" is frequently as rapid as the "run out." Under ordinary conditions, the current has a velocity of from 2½ to 3½ miles per hour, but during the spring freshets, 7 miles per hour has been observed.

The north bank is high, the hard cemented gravel bluff running down to the water. The bed of the river, from this side, drops off rapidly to a point between piers 3 and 4, where there is from 80 to 85 feet of water at ordinary stage. Out this far the bed of the river consists of a very coarse gravel, among which are large boulders. The remaining portion of the river bed to the south consists of fine silt through which occur layers of sand, clay and fine gravel. There are 17 piers, 11 pedestals and 3 abutments, which, together with 6,500 feet of railway and 1,500 feet of highway approaches, will cost approximately $1,000,000.

The bridge was designed by Messrs. Waddell & Hedrick, consulting engineers, of Kansas City, Mo., who are also responsible for its construction. The work is being done under the direction of Mr. Harry K. Seltzer, Assoc. M. Am. Soc. C. E., resident engineer, from whom data for this article has been received. Messrs. Armstrong, Morrison & Balfour, of Vancouver, are the contractors for the substructure and approaches. The Dominion Bridge Company, of Montreal, is the contractor for the superstructure.

The substructure is built of timber, concrete and stone masonry, and is arranged as indicated in the general plan and elevation diagrams on page 544, in the issue of April 30. The abutments are concrete walls, with concrete footings, and have moderate height and thickness. The channel piers and those on the north shore have their masonry shafts carried down to concrete foundations built in cribs or cofferdams sunk to hard bottom. Those at the south end of the bridge have similar foundations supported on piles. These two general types are somewhat varied by the depth of the water and the load they carry, so that there are in reality five different varieties of piers. There are seven small piers or pedestals which support the trestle bents for the plate-girder spans at the north end of the bridge and are substantially like the one marked R, each of them being a truncated square pyramid, with an offset base built in a pit excavated on shore. They are made entirely of Portland cement concrete finished on the battered faces with 1½-inch and on top with 9 inches of 1 : 2 Portland cement mortar. Near these pedestals on the north margin of the river there are four larger pedestals like the one marked H, which correspond to R, except that the footing is carried down to a depth of 13 feet inside a timber crib, consisting of a single rectangular chamber sunk by interior excavation.

Pier No. 2 supports the wide end of the spread span, where the shoes are 135½ feet apart on a transverse line and the water is about 80 feet deep. It is composed of two pedestals, each with a rectangular upper shaft of solid concrete supported on timber cribs built with a timber cutting edge and containing a rectangular central well, through which the excavation was made. Piers No. 3 and 4 support the 380-foot span and are remarkable for the great depth to which they were sunk by interior dredging. Each of them consists of an oblong ashlar masonry shaft with concrete backing built inside a timber cofferdam and seated on a very high timber crib, provided with ballast pockets and interior excavating wells and sunk by dredging. The walls of the crib are built with solid courses of 12x12-inch timber sheathed outside with vertical 2-inch planks. They are built on a solid timber base formed with twelve courses of timber. beveled to make inclined inner faces of a sheathed cutting edge, faced with steel, as indicated in the details. The dredging wells were framed with transverse and longitudinal courses of timber extending across the full width of the pier and forming pockets around and between the wells, which served to retain the ballast used in sinking them.

Pier No. 5 supports the pivot for the draw span and consists of a circular masonry shaft with vertical sides 24 feet in diameter below the coping and 23 feet 6 inches high to the top of the crib. Like the other river piers, it was built in a removable timber cofferdam. It is seated on an octagonal crib 28 feet in diameter and 115 feet high. The sides of the crib are about 11 feet long, but vary somewhat in dimensions. There is a central dredging well 17 feet 4 inches in diameter, with its sides parallel to those of the crib. The bottom of the well is flared out to the exterior walls, making a cutting edge of solid timber, which is triangular in vertical section and resembles that of pier 4. The sides of the well and the outer faces of the crib are sheeted with 2-inch vertical planks.

Piers 6, 7, 8, 9, 10 and 11, on the north side of the river, have masonry shafts, like those of piers 3 and 4, which are supported on footings made of concrete filled around piles, the upper parts of which are enclosed in timber cribs sunk to comparatively short distances below the river bottom and extending nearly to low-water level. Their heights from the south end to the north are successively 15, 22, 22, 22, 27 and 36 feet, and the corresponding lengths of piles are 60, 60, 60, 65, 65 and 75 feet.

The pedestals in pier No. 1 are located near shore, in shallow water, where a good foundation was found in gravel at a depth of about 20 feet below the water surface. The bases are 16x16-foot cribs 13 feet high, upon which are built concrete shafts 16 feet in height. Cofferdams were built about each pier, and drained by pulsometers, and the cribs, made of 12x12-inch timbers, were then sunk in them by excavating, in the dry, with pick and shovel.

The river bed at pier 2 drops off very rapidly into deep water, the bottom consisting of a very coarse gravel and boulers up to 5 feet in diameter. The cribs upon which the masonry shafts rest are 16 feet square and 25 feet high. They were planned to be sunk by the open dredging process, but, owing to the coarseness of the material in the river bottom there, it was necessary to dredge a bench on which to set the crib. This was very slow work, but a good foundation was obtained by cutting down from 10 to 15 feet on the shore, or high side. The annular space around the well was filled with concrete placed in the dry, which served as ballast to sink the crib. When it was found that all the dredging had to be done first and that the wells were not needed for this purpose, they were reduced from 7 feet square to 2 feet square. Through them the bottom chamber was filled with concrete deposited through a tremie. Both cribs have been protected by coarse rock paving. Pier 3, although near the north bank of the river, is located in the main channel in 80 feet of water, and was the most difficult of all the cribs to sink. The base is a 22x40-foot timber crib 87 feet high, filled with concrete, upon which stands a masonry shaft 27 feet 9 inches high. This crib is founded in a bed of coarse gravel and boulders, over which there are 20 feet of fine sand and silt. When it landed on the bottom, the surface of the concrete around the wells was 35 feet below the outside water surface. The concrete was then gradually carried up as the penertation was increased, but, owing to the fact that the height of the pier was great and the first 20 feet of material very soft, it was found advisable not to bring the surface of concrete nearer than 15 feet below the river surface.

After sinking 10 feet into the soft material the crib landed on several logs on the north side and later landed on the same side on the hard material, which was 18 inches higher there than on the opposite side. All of these obstructions caused the crib to lean badly. Its total height, at this time, was 102½ feet, and the top was 4 feet out of plumb. Its condition was rather serious, and all agitation in the wells with either jets, hydraulic elevator or dredge caused the crib to lean more. The logs encountered were of good size and well preserved. One of them extended completely across the caisson and was 2 feet in diameter. An auger 100 feet long was constructed, its point was set by a diver and it was turned from above. After boring a number of holes, a charge of dynamite was placed and the log broken into several parts. A large body of concrete, together with all the masonry and stone that could be piled there safely was placed along the high side of the crib and the exterior along this side was dredged to remove the boulders which prevented the crib from leveling. This operation required several weeks, as there was nearly 20 feet of soft material to be removed before the boulders were uncovered. A large basin was formed before the soft material ceased to run into the excavation. As soon as the removal of the coarse material was begun, the crib began to settle evenly until a firm bearing was reached on the low side, after which it gradually came over to a level position. Owing to the great height of this pier and its small penetration, together with the severe scour, the crib has been protected by placing 8,500 cubic yards of paving rock about its base and thus increasing its penetration to 40 feet. The stone used for this purpose is known as "derrick rock," the bulk being of large sizes, although the smaller sizes accumulated in the quarrying were also used.

Pier 4 is similar to pier 3. Its 22x37-foot crib is 124 feet high and supports a masonry shaft 32 feet 9 inches high, making the total height of the pier 159 feet 9 inches. This crib landed on the bottom in 50 feet of water, but during its sinking, 15 feet of scour occurred, increasing the depth of water around the pier to 65 feet and giving a final penetration of 70 feet. The crib was landed in a bed of fine gravel 135 feet below the ordinary stage of water.

The bottom at pier 5 is a very fine silt and sand with underlying strata of clay and gravel. The cutting edge rests in a bed of gravel and clay at a depth of 125 feet below ordinary water level and 90 feet below the river bottom. At the time the dock for this pier was driven, the ordinary depth of water was 35 feet, which was increased to 50 feet by scour during the sinking. This basin will be filled with large paving rock, as in the case of piers 3 and 4. Cribs 2 and 5 inclusive, were built to a height of 14 feet, on ways on the north bank, launched and towed into their respective docks, which had been previously prepared at the pier sites. Pier 3 dock contained seventy-five 100-foot piles, the largest portion of which were on the up-stream side, where the dock area was the largest. A solid V-shaped wall of piles was tightly driven at this end of the pier in order to protect the crib and give dead water about it. Two guide piles were driven on each of three sides at a distance of 1 foot from the crib, and after the crib had been set into its place, the remaining two guide piles and the closing side of the dock were put in. Blocking was attached to the crib, opposite each guide pile, leaving only a few inches clearance, and in this way the crib was landed in almost perfect position.

Every effort was made to thoroughly calk all seams between the timbers in the outer and well walls, in order to place the concrete in the best possible condition. This was particularly important in the case of cribs for piers 3, 4 and 5, where the safety of the cribs depended on their being tight. In the construction of the crib for pier 5, the first of the large cribs to be built, only the 12-inch sheathing planks were calked, beginning at the steel cutting edge. Although great care was taken in sheathing and calking, the crib leaked badly, and it was, therefore, decided to calk the seams between the 12x12-inch wall timbers in all other cribs. Great care was taken to make the deck of the caisson tight, since the greatest water pressure, and, therefore, the greatest tendency to leak, was at this point. The two top courses of timber were calked, and each seam then filled flush with hot pitch. The calking in these two courses had to be done from the top, and as the pressure tended to press the oakum out of its seam, instead of into it, as is the usual condition, resort was had to the pitch, which made a very tight deck.

Directly after the cribs were launched, their decks, which were usually about 3 feet above the water surface, were covered with 8 inches of 1:2:3 concrete, which was allowed to set several days before the walls were extended up, and, by their weight, forced the deck below the surface of the water. In piers 4 and 5, as soon as a small amount of penetration had been gained, the concrete around the wells was built up above water level and all but the 2-inch sheeting was omitted around the wells.

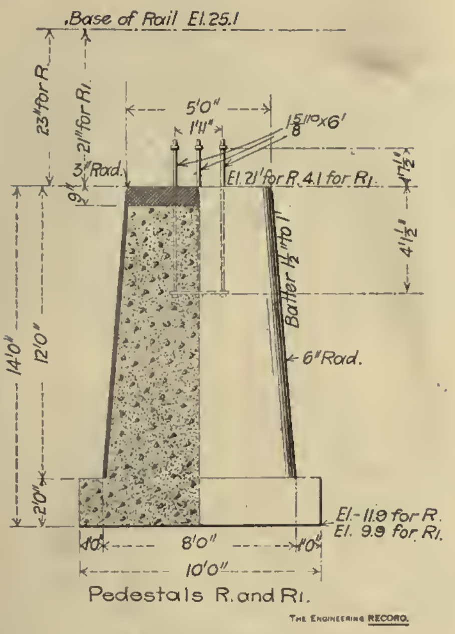
The amount of concrete deposited through water in piers 3 4 and 5 was regulated by the depths to which the cribs could be conveniently pumped out. At pier 5, the first sealed, 50 feet of concrete was deposited through water, by bucket, which gave a height of 75 feet to pump. In piers 3 and 4 the maximum pump lifts were respectively 55 and 65 feet below the surface of water. The remaining concrete was deposited in the dry. The well sheeting was removed above the concrete, in order to give the outside and inside portions opportunity to bond. At pier 3, owing to the great difficulty found in holding the crib plumb, it was never possible to bring the concrete to the level of the water surface, and, therefore, it was necessary to bring the solid well timbers up to the full height of crib. In all cribs it was endeavored to get a continuous layer of concrete at least 2 feet thick over the whole top of the crib next to the masonry, which course, considered by itself, was truly monolithic. To accomplish this it was arranged that the last set of cross ties should be 2 feet below the top of the crib.

For piers 4 and 5, where the foundations were the deepest, fully 95 per cent. of the excavation was made with an hydraulic elevator, with which anything of a thickness less than 3 inches, the diameter of the throat, could be handled. The elevator was a simple ejector operated by a 125-pound hydraulic jet, delivering upwards into the foot of a 5-inch vertical cast-iron pipe, which extended to the top of the excavating well and terminated in a 90-degree long-radius bend, which discharged the mud, sand, etc., horizontally over the top of the crib. The bottom of the 5-inch pipe terminated in a special Y, shown in cross-section by the detail drawing. One branch of the Y had an interior cone, concentrating the discharge from the 4-inch vertical pump pipe through a 1½-inch nozzle and causing the upward current that tended to produce a vacuum. This induced a strong flow through the other branch of the Y, which had an intake that could be set at any angle or in different positions and could have different extensions, as desired. The pressure and discharge pipes were clamped firmly together and handled as a unit by a line operated by the derrick boom and attached to the fork of the Y. The top of the pressure pipe terminated with a ball-and-socket joint and a long-radius 90-degree bend with a flanged enlarger closed at the end and tapped to receive three lines of 2½-inch fire hose from the pump. It is interesting to know that with a height of 145 feet, lifting from 140 feet below the water surface, the elevator was as effective as at less depths.

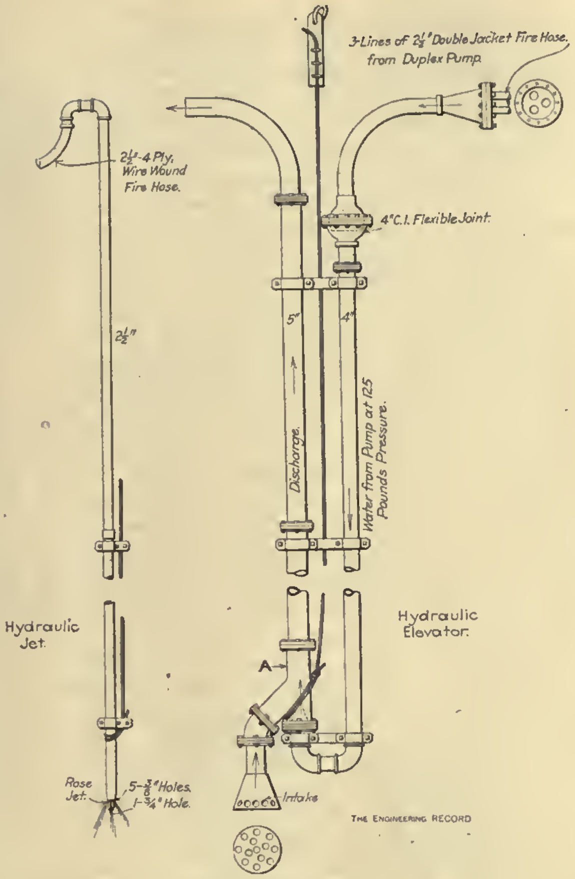
The water pressure for operating the elevator was obtained from a Worthington duplex pump having 20-inch steam cylinders, 12-inch water cylinders, 14-inch stroke, 9-inch suction and a 7-inch discharge. The steam was supplied by two 50-horse-power locomotive boilers built for a working pressure of 125 pounds per square inch. They were 48 inches in diameter, 15 feet long and had forty-four 3-inch tubes 12½ feet long. A steam pressure of 100 pounds from both boilers, giving a water pressure of 125 pounds was usually required.

A rose jet, operated by the elevator pump, was used as an agitator, and, when placed near the suction, greatly increased the efficiency of the elevator. When coarse gravel or other material was encountered which the elevator could not handle, the elevator was lifted clear of the bottom and placed in one corner of the well and its service was discontinued for a short time while a clam-shell dredge was operated. The elevator was superior to the dredge for maintaining the cribs in position. With it, by placing the suction close to the side of the well, the material was drawn from the high side or the point that was "holding up," and by extending its intake, material was drawn from directly under the cutting edge. The rate of sinking depended greatly on the material encountered, varying from 2 to 6 feet in 24 hours.

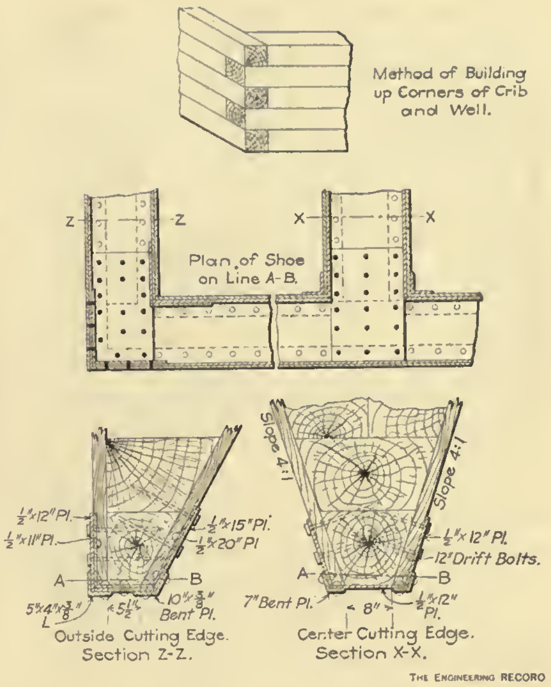
The foundations of piers 6, 7, 8, 9 and 10 each have thirty-two piles, and pier 11, which is an end pier, has twenty-one piles. The piles were first driven by jet and hammer and the cribs were built around them. They were made of 12x12-inch timber, dressed on two sides to exact dimensions, and the joints were thoroughly calked from the outside. The piles were arranged in eight transverse rows and four longitudinal rows, between which passed the inside bracing. Two rose jets, of the pattern shown in the sketch, were placed on each pile. They were operated with a water pressure of from 150 to 200 pounds, provided by the boilers and pump which operated the hydraulic elevator. All hose and fittings were made sufficiently heavy to withstand a 250-pound pressure. A single jet, supplied by a slow acting pump, taking its steam from the pile-driver boiler, was first used, but it could not penetrate the gravel layers. The rose jets were necessary, as it was found that with the ordinary single-opening jet the pipes could not be withdrawn after the pile was down, and it was necessary to send a third jet about half way down in order to relieve the friction holding the pipes.



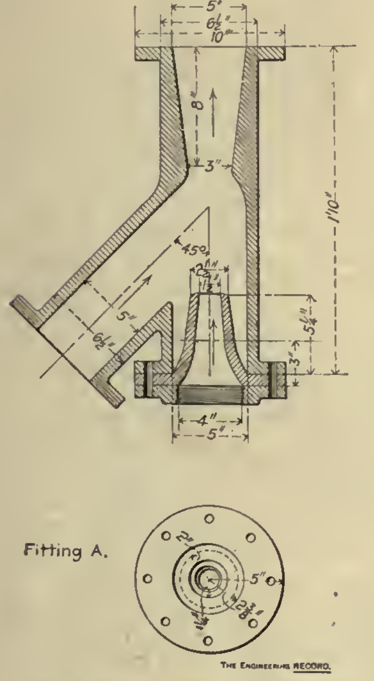
Shore Substructure.


3-Lines of 2 1/2" Double Jacket Fire Hose, from Duplex Pump.
2 1/2"-4 Ply, Wire Wound Fire Hose.
4" C.I. Flexible Joint.
2 1/2"
5"
4"
Discharge
Water from Pump at 125 Pounds Pressure.
Hydraulic Jet.
Hydraulic Elevator.
A
Rose Jet.
5-3/8" Holes. 1-3/4" Hole.
Intake
The Engineering Record

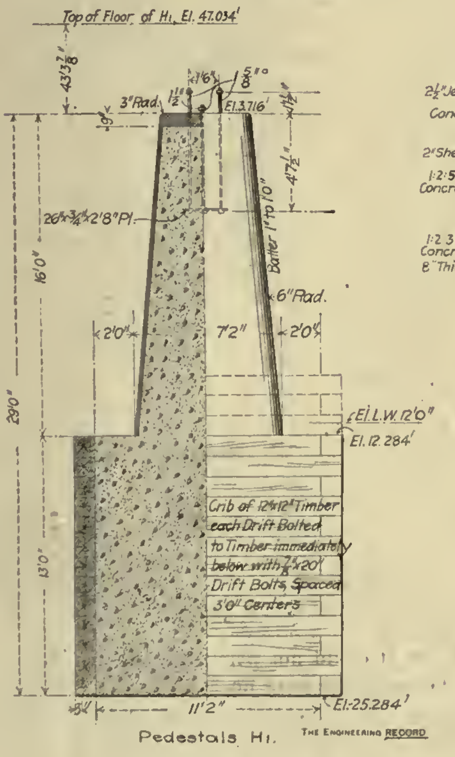
Apparatus for Excavating Inside Crib under Water.



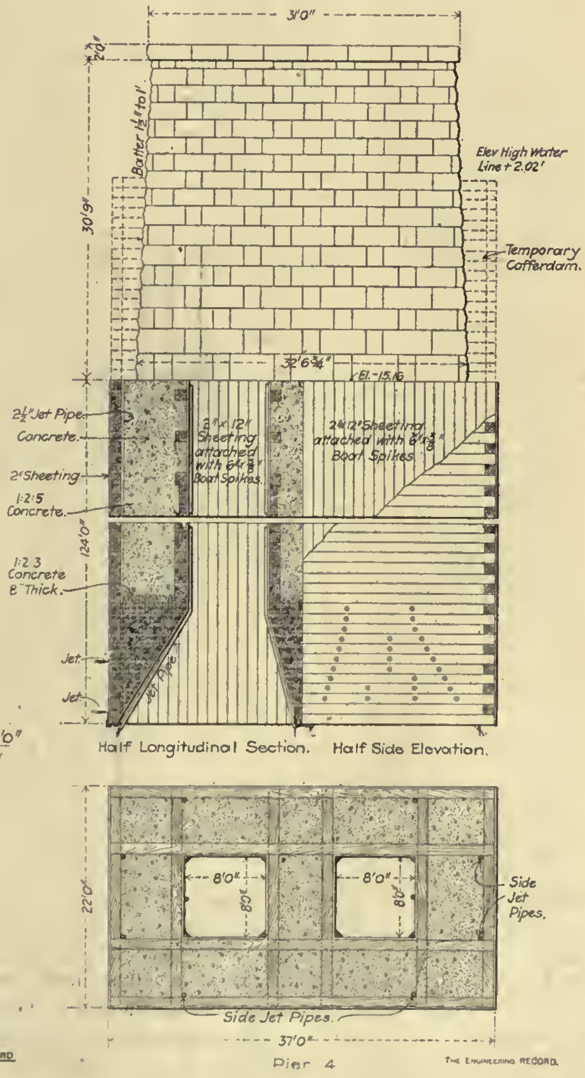
Details of Crib for Pier 4.



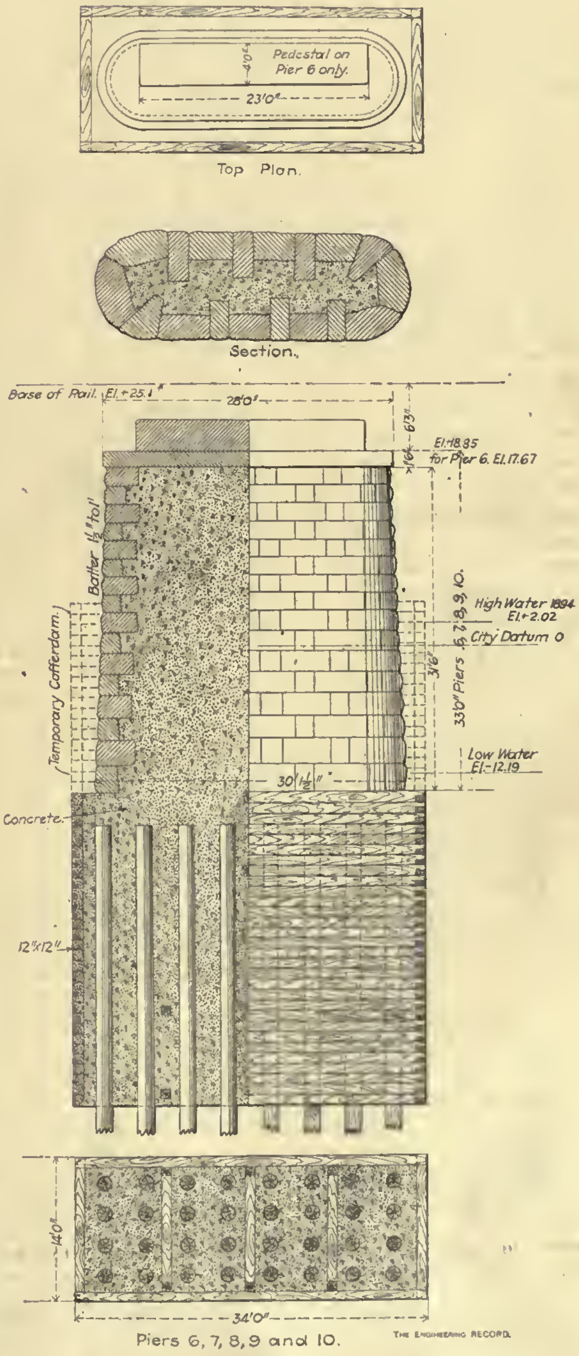
Y-Piece of Hydraulic Elevator.



Shore Substructure.



Deepest Pier Foundation.



Typical Pier with Pile Footing.

FRASER RIVER BRIDGE, BRITISH COLUMBIA: DETAILS OF PIERS, FOUNDATION CRIBS AND EXCAVATING APPARATUS.

After the piles were driven, the cribs and their cofferdam extensions were built to their full height, about them, and timbers were laid across their tops and loaded with masonry stone for sinking them. The hydraulic elevator was then placed in position inside the crib, connected to the pump, and sinking was begun. The cribs were sunk from 10 to 20 feet below the original level of the bottom, but their actual penetration, when sinking was completed, was only a few feet, owing to the scour and to the material being drawn in from the outside by the elevator. This left the crib standing in a basin, which, in each case, was filled with paving rock, giving the piers a splendid protection below the original level of the bottom. After these cribs were landed, they were sealed with from 5 to 10 feet of 1:2:3 concrete deposited around piles by a steel pipe trémie. This concrete was allowed to stand one week, when the crib was pumped out and cleaned. The piles were then cut off 5 feet below low water, with tops at slightly irregular heights, after which the remainder of the concrete was laid in the dry up to the base of the cofferdam, the upper cross struts being removed ahead of the concreting.

In all cribs the timbers at the main corners of the wells were alternately lapped for the full size of the stick, no half-lapping, notching or checking being done at these points. This method is more economical than framing, both as to time and material consumed; there is less calking to do, and it can be done very much better, thus giving a tighter crib.

All concrete backing in the pier shafts was made 1:3:5 with Portland cement and stone broken to pass through a 2½-inch ring. Concrete used for the coping and upper surfaces and concrete deposited under water was made 1:2:3 with ¾-inch broken stone. All exposed surfaces of concrete are faced with 1:2 cement mortar 1½ inches thick. In order to satisfactorily join this facing to the main body of concrete ¼-inch steel plates 12 inches wide and about 4 feet long, with their ends overlapping, were blocked out 1½ inches from the inner faces of the forms. A 9-inch layer of concrete was then laid and tamped against the inner faces of the plates and an 11-inch layer of mortar was tamped between their outer faces and the moulds, the spacing blocks being removed as the work progressed. As soon as this was accomplished the steel plates were withdrawn by hooks engaging holes through their upper edges and the mortar was again tamped to fill the space vacated by the plates and secure a thorough bond between it and the concrete before either commenced to set. Special care was taken to make the moulds strong enough to resist all distortion and to provide a surface which should give a uniform texture to the concrete finish and prevent the appearance of any joint or grain marks. To this end, the inner faces of all the forms were planed and matched and covered with gloss oil, sanded with a bellows.

The principal quantities involved in the substructure include about 5,000 cubic yards of masonry and concrete, 9,400 cubic feet of piles and 1,600 cubic yards of excavation for pedestals, abutments and retaining walls. The total mass of cribs and caissons for piers 1 to 11 inclusive is estimated at 11,250 cubic yards. These quantities are those of the preliminary estimate.

Recording Pressure Gauges for ranges from vacuum to 10,000 pounds per square inch and recording thermometers and pyrometers for ranges from 60 degrees below zero to 1,000 degrees Fahrenheit are exhibited by the Bristol Company, of Waterbury, Conn., in the Electricity Building at the World's Fair, St. Louis.

Some Forms of Pyrometers.

In connection with the presentation of a report of a committee on pyrometers to the Iron and Steel Institute at its recent meeting in London, an exhibition was held of instruments of this class suitable for metallurgical work. Some of these can be described in a general way without illustration and as relating to high-temperature measurements are referred to in the following account:

A recording pyrometer, based on the alteration of the viscosity of a gas with temperature, was shown by the Steinbart-Uehling Company. Air from the furnace is sucked through a very small hole maintained at the furnace temperature; it is then cooled down to 212 degrees Fahrenheit and sucked through a hole of the same size as that first named, and finally expelled into the atmosphere. The head necessary for suction is obtained by a steam-jet, and is kept absolutely constant on the suction side of the cooler orifice. The vacuum in the space between the orifices then alters with the temperature of the air entering the hot orifice, and thus forms a measure of the temperature. The waste steam from the suction-jet serves to keep the temperature of the cooler orifice constant at 212 degrees. An ingenious recorder is combined with this pyrometer, and the recorder can, by the use of air-tight tubing connecting it with the pyrometer, be placed at any desired distance from the furnace.

There were a number of different types of optical pyrometer. In one of these, due to Mr. Walter Rosenhain, and made by the Cambridge Scientific Instrument Company, the heated body, the temperature of which is desired, is inspected through a telescope, in the field of which is a platinum wire which can be heated by an electric current. The current is increased until the wire vanishes in the bright field, and the temperature is then deduced from the readings of a delicate ampere-meter which measures the current passing through the wire.

An instrument embodying the same principle was also shown by Dr. R. Hase, of Hanover; but in this the radiation from the hot body is broken up by a prism into a spectrum, and part of this spectrum is then balanced against the light of a small electric incandescent lamp which serves as a standard of reference. This instrument, like Mr. Rosenhain's, requires the use of electrical connections to the telescope.

The Callendar platinum thermometer, with its recorder, was also shown. This is made by the Cambridge Scientific Instrument Company. In the discussion of the committee report, Mr. Rosenhain said that he considered this instrument the most useful type for temperatures lower than, say, 2,300 degrees. The Le Chatelier pyrometer appeared to be in good favor and fairly widely used. For temperatures of 2,350 to 2,700 degrees, however, Mr. Rosenhain found it would not stand exposure for more than a half-hour or so, where continuous records were desired, and he substituted two different platinum-iridium wires on his couple.

The Water Supply of St. Petersburg is taken from the Neva River a short distance above the city. This water was formerly considered of good quality, but according to a recent article in "Public Works," it is now not above suspicion on account of the large number of bacteria it contains. The works were owned by a private company until 1891, when they were purchased by the city. In 1901 a daily average of about 88,000,000 gallons was supplied to the consumers. The water is filtered through eighteen open sand filter beds having a combined effective area of somewhat less than nine acres, the rate consequently being too high.

Notes.

The Efficacy of Lightning Arresters is questioned in a report of a committee of the Berlin Electrical Society. In forty-one cases accidents occurred with all known systems of lightning arresters in use, and in one case four different systems of arresters were used simultaneously. However, experience seems to show, it is stated, that it is desirable to insulate the iron frames of the machines and apparatus from the earth.

Heating from Central Stations, as a subject in the question box of a recent meeting of the Iowa Electrical Association, brought out some interesting information. The Brice Gas & Electrical Company, of Mason City, Ia., which uses a hot-water heating system, wrote that it figures the amount of radiation required, according to the glass surface, wall surface and cubical contents, and makes a rate per season based on the amount of radiation required. If a consumer installs less radiation than the amount called for, he is compelled to pay for the full amount, which nearly always insures his installing it. If the radiation should be found insufficient, no extra charge is made for additional radiation installed, provided the normal temperature of the room does not exceed 70 degrees. Mr. H. C. Eddy, of the Chicago office of the American District Steam Company, contributed the following data: In a city in central Illinois the heating business is for public buildings exclusively, all on a meter basis of charge. The highest rate of condensation per 1,000 cubic feet of space per season last year was 10,779 pounds. The lowest was 1,650 pounds, and the average of all the customers served 5,328 pounds. A city in Nebraska heating public and business buildings gives the following figures: Highest rate, 7,475 pounds; lowest, 1,302; average of all customers served, 4,522 pounds. A city in Kansas finds the highest rate 13,709 pounds; lowest rate, 1,278 pounds; average of all customers served, 4,693 pounds. A city in Colorado: Highest rate, 24,666 pounds; lowest rate, 1,611 pounds; average of all customers served, 8,653. In a city in Missouri the average results are: Residence, 9,400; public library, 5,800; theaters, 2,900; hotels, 5,410; churches, 2,840; stores and office buildings, 7,030; average of all meter customers, 5,503; average of flat rate customers of the same general class of occupancy, 19,720. In a city in Pennsylvania for the first four months of this year one customer on a flat rate used 7,800 pounds of water per 1,000 cubic feet space. Another customer under the same conditions used 7,250 pounds, and a third customer under the same conditions, but for three months instead of four, used 4,250 pounds. In the first instance, if the condensation used by the consumer had been paid for on a basis of meter registration at the regular prevailing rates the cost for the four months would have been $1,065.42. The flat rate for the entire season was $1,200. In the second instance, if the condensation had been paid for at the regular prevailing rate, the cost would have been $848.16. The flat rate for the entire season was $720. In the third instance, the three months on a meter basis would have cost $305.22, while the flat rate for the entire season was $300. In another case where the meter customers and flat-rate customers represent practically an equal amount of space, it was determined that for the meter customers it required at the plant 712 pounds of coal per 1,000 cubic feet space heated per season, and for the contract customers it required at the plant 3,280 pounds of coal per 1,000 cubic feet space heated per season.

The New York Times Building.

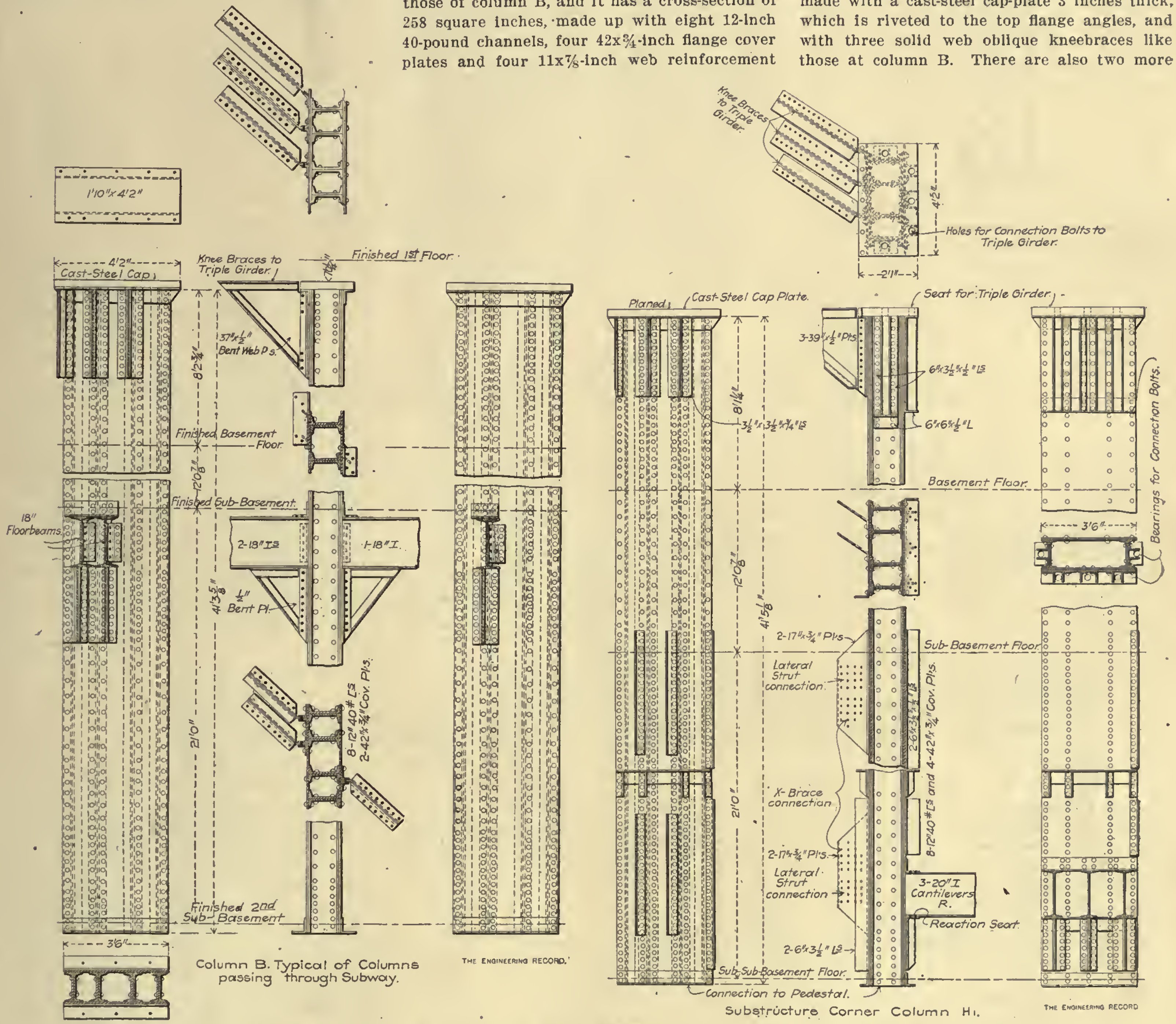
Part III.—Substructure Columns and Girders

Column B is typical of the heavy columns which were required to pass through the subway roof and floor with a maximum width of 16 inches. It carries a load of about 1,162,000 pounds and has a cross-section of 157 square inches built up with eight 12-inch 40-pound channels and two 42x¾-inch cover plates. It receives the end of girder 22-B on a cast-steel cap-plate 3 inches thick, and is connected to each of the three webs of the girder by a solid kneebraced plate stiffened with flange angles, as shown by the detail. It also has wide bracket seats to receive the sub-basement floor girders clearing the under side of the subway. These are made with solid web plates having their flanges stiffened with pairs of angles, thus making rigid kneebraces, which add to the transverse resistance of the building. Like the kneebraces for the triple girder, the ends of their webs are bent to an angle corresponding with that between the subway and the line of columns, and are field-riveted to the vertical connection angles on the column. The long diameter of the column makes an angle of about 48 degrees with the axis of the triple girder, which it supports on a cast-steel cap-plate 3 inches thick. The foot of the column is seated on a cast-steel pedestal 27 inches high, made with several vertical stiffening webs which distribute the load over the 4x4-foot granite capstone of a three-course pier seated on the solid rock. The steel in the pedestal webs is 2 inches thick and the pedestal corresponds with that shown for columns D and K.

The heaviest of the sub-basement columns is marked K and is proportioned for a load of about 1,070 tons. The details are similar to those of column B, and it has a cross-section of 258 square inches, made up with eight 12-inch 40-pound channels, four 42x¾-inch flange cover plates and four 11x⅞-inch web reinforcement plates. Column H is of the same general type, but is special in the provision to resist a possible upward reaction from the cantilever load imposed by column 9 of the superstructure. It has a cross-sectional area of 220 square inches and sustains a maximum load of 570 tons. Under extreme conditions of loading and wind pressure, it is calculated that this load may change to an upward reaction of 500,000 pounds. In order to resist this, three horizontal 20-inch I-beams 15 feet long are web-connected to the foot of the column, and are built into the base of the 44-inch vault retaining wall, so that its weight will act as a counterbalance. Besides this the I-beams are anchored close to the column by two vertical bolts 3 inches in diameter, which extend about 7 feet into the solid rock, where they are securely wedged.

This column H is also connected to the adjacent column K in the plane of the end wall by two horizontal struts and a panel of heavy riveted X-bracing in the press room or second sub-basement story, thus continuing the wind bracing in the extremity of the building to the foundations and providing for a distribution of stress between the columns. The connection to the triple girder which it carries to support the offset lines of columns in the upper stories is made with a cast-steel cap-plate 3 inches thick, which is riveted to the top flange angles, and with three solid web oblique kneebraces like those at column B. There are also two more similar kneebraces for the connection of the sub-basement floor. At the top of the column long vertical distribution angles are riveted to both sides and are fitted at the lower ends to the horizontal flanges of shelf angles which give bearing to vertical anchor bolts. These pass through the cast-steel cap and engage the top of the triple girder so as to transmit the upward reaction to the column which resists it by the weight of the wall that rests on the lower 20-inch beams and crossbracing, and by the strength of the anchor bolts which connect the beams to the solid rock.

The girder supported on the top of columns H and K carries the two corner columns 8 and 9 and supports the entire north wall of the build-



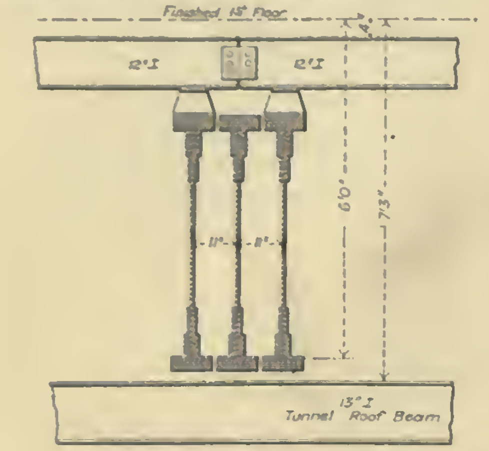
Column B. Typical of Columns passing through Subway.

Substructure Corner Column H1.

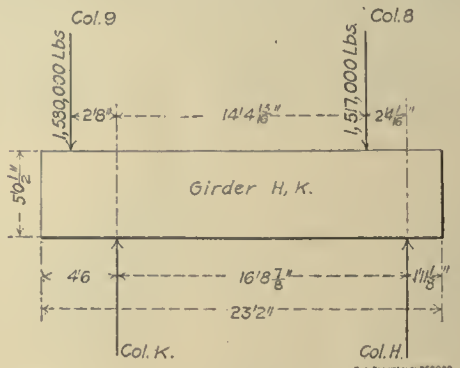
The Times Building, New York: Typical Details of Heavy Substructure Columns.

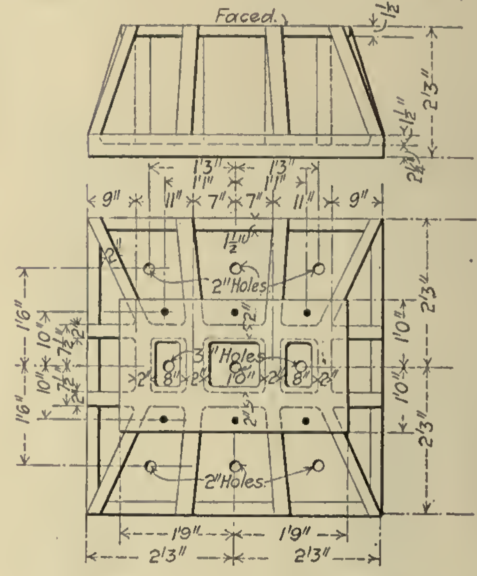
ing. The columns have an estimated total load of 3,097,000 pounds. The total length of the girder is 27 feet 8 7/16 inches, and it has a cantilever arm of 2 feet 8 inches and two supports 16 feet 9 inches apart, as shown in the diagram of loading. In calculating its dimensions it was assumed that the maximum load in column 9, including pressure from a wind sufficient to overturn the building, is 3,097,000 pounds. Under these conditions there could be no wind load in column 8, and in equating the moments it is found that the reaction in column 9 multiplied by 19.4, divided by 16.75, equals 3,590,000 pounds. Subtracting from this result the total load of columns 8 and 9, leaves at column H an upward reaction of 493,000 pounds. This vertical strain is transmitted to the column, as already described, by means of the vertical bolts engaging the column top. This girder is made with three separate pieces, one of which is shown in detail. They were each riveted up complete in the shops and shipped separately to the site and connected together by intermediate transverse diaphragms and cover plates riveted to the end vertical web-stiffener angles. The diaphragms were connected by bolts placed through hand holes left in the web for that purpose.

On account of the heavy moment in the girders and the short cantilever arm, the method of proportioning the girder was as follows: The 60x1¾-inch web has a moment of resistance of 1,750,000 foot pounds at a maximum stress of 20,000 pounds per square inch. Allowing one-quarter of the section for rivet holes, the net moment of resistance is 1,312,500 foot-pounds. The maximum moment of the three girders at column K is 3,097,000x2⅔, equal to 8,259,000 foot-pounds. Therefore the moment for one girder equals 2,753,000 foot-pounds. Subtracting

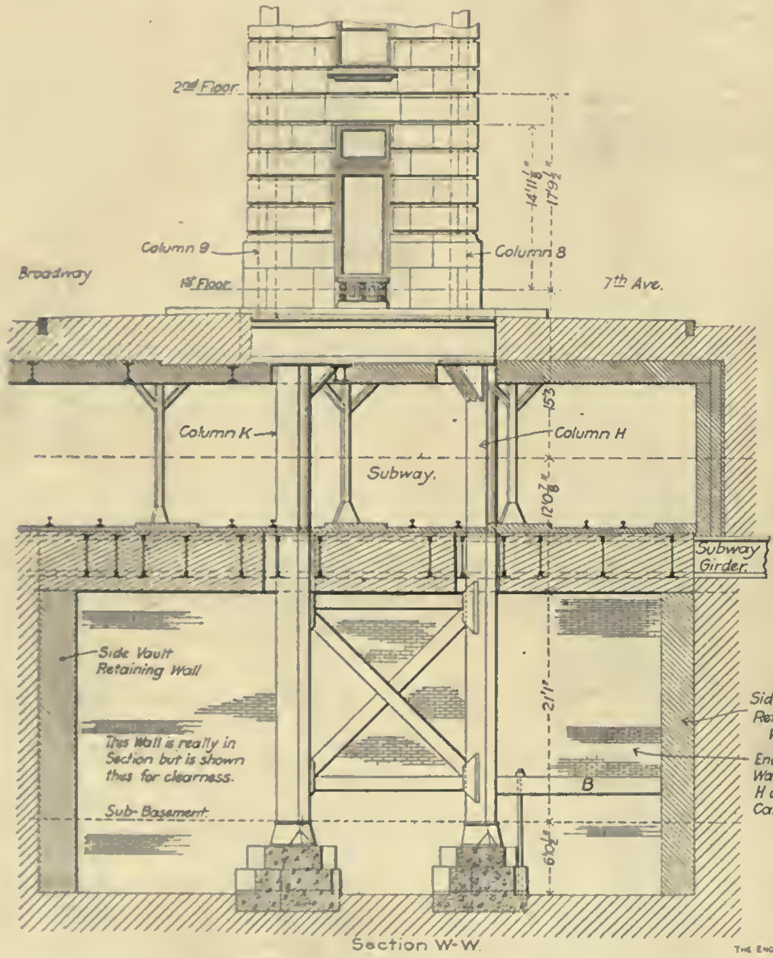


Typical Section through Triple Girder.



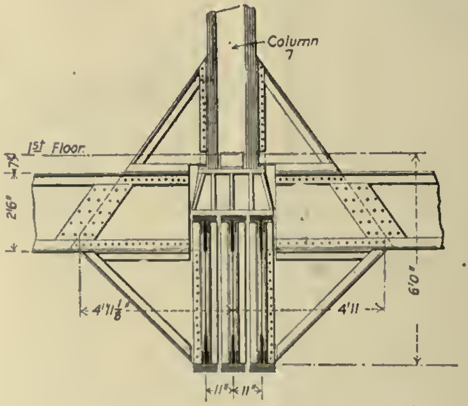


Bases for Columns D and K.

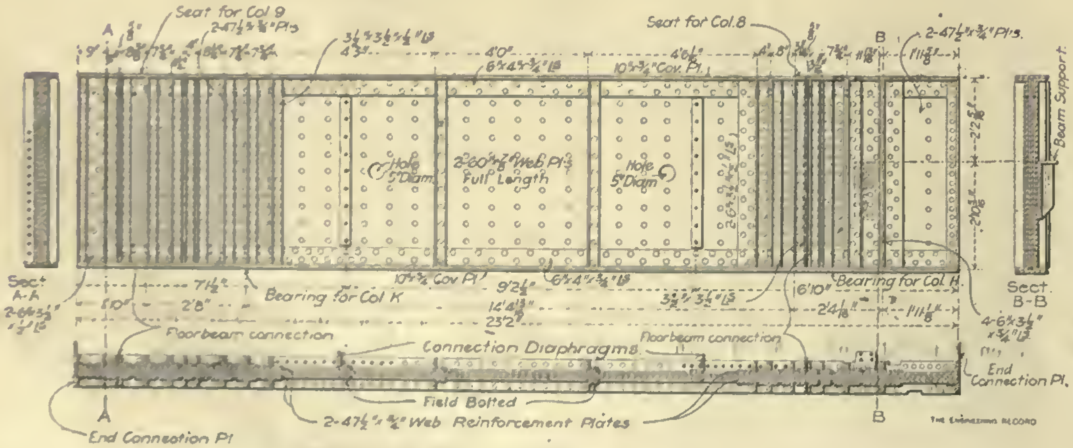

2nd Floor
Column 9
Column 8
Broadway
1st Floor
7th Ave.
14'11 5/8"
17'9½"
Column K
Column H
Subway.
15'3"
12'0 1/2"
Subway Girder
Side Vault Retaining Wall
This Wall is really in Section but is shown thus for clearness.
Sub-Basement
21'1"
B
6'0½"
Side Vault Retaining Wall.
End Vault Retaining Wall, in Plane of Columns H and K, supported on Cantilever Beams "B"

Section W-W.

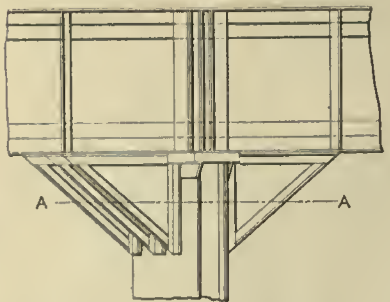
Elevation of North End of Substructure.



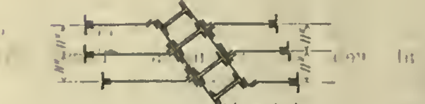
Typical connection of Triple Girders to Superstructure Columns.



One Section of Triple Web Girder H, K.



Elevation on Column F.



Plan on Line A-A.

Brackets under Cross-Girders.

Typical connection of Triple Girders to Substructure Columns.

THE TIMES BUILDING, NEW YORK: DETAILS OF SUBSTRUCTURE, SHOWING POSITION OF RAPID TRANSIT SUBWAY.

from this 1,312,500 foot-pounds, the moment of the web, the remainder, 1,440,500 foot-pounds, equals the bending moment which must be resisted by the chord angles. Allowing for a maximum stress of 21,000 pounds per square inch, it gives a required area of 14.2 square inches, which is provided for by two 6x4x¾-inch angles and one 10x¾-inch plate. The ends of the girders are covered almost solid with pairs of 6x3½x¾-inch vertical web-stiffener angles and the webs are connected together by thirteen horizontal rows of ⅞-inch rivets.

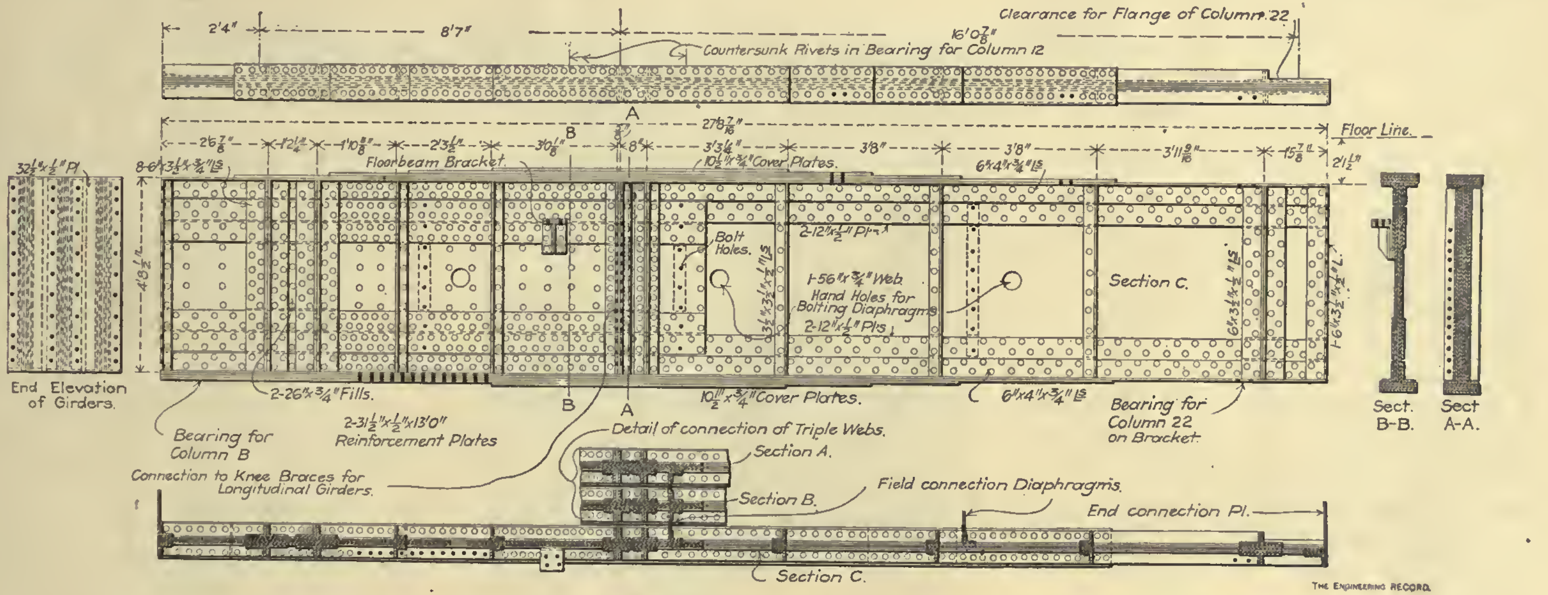
The girder marked C is one of the three equal pieces forming the girder supported on substructure column B and interior column 22, which carries the wall column 12. It is made with vertical side plates in both flanges and with reinforced webs and additional side cover plates both sides of the supporting column at the cantilever end. The flanges are proportioned to carry all of the bending moment and are reinforced with 12x½-inch plates. The girders are riveted to the cast-steel cap-plate on column B and to the web of column 22, and have the kneebrace connections to their lower flanges, which were described in connection with column B. The cantilever ends are connected together by field-driven rivets through a ½-inch plate 32½ inches wide which closes the spaces between them, and they are intermediately connected by three sets of transverse diaphragm plates bolted in position through the hand holes shown in the general elevation.

The west ends of the three parts of the compound girder are connected together by their connection to column 22, which is made with horizontal seats bracketed to the faces of the column. It does not include any web rivets except those connecting the end vertical web-stiffener flanges of the two outside members of the girder to a vertical transverse plate similar to that at the other end. This plate clears the flanges of column 22 and is field-riveted to them. This girder is typical of all of the triple web girders shown in the diagram plan and in the beam plan for the first floor. It supports the upper story columns on heavy cast-steel bases similar to those which distribute the column loads over their foundation piers. All of these girders support the floorbeams at right angles to them by web connections made with very deep gusset plates riveted between their vertical web-stiffener angles. These gusset plates have their horizontal and inclined edges stiffened with angle flanges and serve as kneebraces, giving great rigidity to the framework. They support the floor-beams, as shown in the cross-section detail, at such a height that the top flanges of the beams are nearly flush with the base plates of the upper tiers of columns.

The ends of the floorbeams are cut obliquely and are spliced to the gusset plates in such a manner as to make the connections continuous with solid-web kneebraces riveted to their top flanges and connecting them to the lower ends of the upper sections of the columns. This virtually provides a deep and wide solid transverse diaphragm enclosing the triple girder and its connection to the supported column. The 12-inch floorbeams intermediate between the floor girders are continued across the triple girders and are web-spliced on their center lines. Their lower flanges are several inches clear of the tops of the girders, from which they are supported by pedestals seated on the two outer girders only, thus giving no direct connection to the center girder. This detail, together with the relative position of the roof beams in the subway construction, is clearly indicated by the diagram of the cross-section of the triple girder.

Messrs. Cyrus L. W. Eidlitz and Andrew C. McKenzie are the architects, and Mr. W. B. Bamford and Mr. Paul Gemelin, of their staff, are respectively general superintendent in charge of the building and chief draftsman. The designing of the structural steel was done in the New York office of Purdy & Henderson.

(To be continued.)



The Times Building, New York: One of the Triple Girders over the Rapid Transit Subway Structure.

A Prony Brake with which rope has been found to give best results is employed in the hydraulic laboratory of the University of California. The brake pulley is 24 inches in diameter and 10 inches face and a double rope surrounds the pulley, one end fast to the brake framework and the other engaged by a threaded hook, which is moved by a hand wheel to secure the required tension.

Feed-Water Measurement by means of open tanks was referred to as a permanent adjunct of boiler-plant operation at the recent meeting of the National Electric Light Association by Mr. Wm. R. Gardener, of Pittsfield, Mass. Two tanks are employed, one above the other, the upper as the filling and measuring tank and the other as the suction tank. The former is provided with an overflow pipe to indicate when it is full and is fitted with a float which actuates a revolution counter every time the tank is emptied, thus recording the number of full tanks of water passed into the suction tank.

A Mechanical Filtration Plant for Watertown, New York.—II.

The effluent from each filter is conducted through a 10-inch pipe into the filtered-water main, and on the way passes through a rate controller and a regulating gate, set as indicated on the pipe detail drawings. The following description of this apparatus is taken in part from the general specifications, and the essential features of the controller are shown by one of the drawings. The main casting of the controller is essentially a 20x10-inch flanged cross with one of the 10-inch branches, the one through which the filtered-water enters, continued inside the cross and terminated in a 12-inch diameter vertical cylinder open at both ends. One of the 20-inch ends is closed with a blank flange and serves as the base; the flange at the opposite end, or top, is rebated to receive a stilling device.

To the upper flange just mentioned is bolted a 20-inch flanged cylinder about 1 foot high, lined with brass, to the top flange of which is bolted a cast-iron plate 1 inch thick containing a tapped hole for a 4-inch wrought-iron pipe. To the top and the bottom of the 12-inch internal cylinder are tap bolted annular cast-iron plates 1 inch thick, thus forming the stationary part of a balanced valve. The holes in these two plates, through which the working parts of the valve move, are bored precisely to a diameter of 7 inches and their exposed edges are covered with a thin, smooth coat of paint.

The stilling device consists of three disks of sheet brass 21 inches in diameter and about 0.019 inch thick, perforated with holes 1/16 inch in diameter. The total area of these holes in each plate is about 15 per cent. of the area of the plate. The disks are spaced apart by ¼-inch copper wire rings and fastened together at their edges so as to form a stiff structure. The moving parts of the controller comprise two valves, a stem and a pressure disk, the disk being attached to the upper end of the stem, one valve to the lower end and the other valve to the middle of the stem, as shown, all being of brass. The stem passes through a hole in the center of the stilling device, so that the pressure disk is above the latter. The lower end of the stem is bored to fit easily over a vertical guide bolted to the bottom of the controller body.

Each valve is 6.8 inches in diameter, leaving an annular space .1 inch wide in the ports when the valve is closed. The valve faces are tapered at the rate of 1 in 5, so that the final closing of the ports will take place very gradually. The pressure disk is hollow, about 4 inches high, and is built up of sheet brass; it has a diameter a little less than that of the brass-lined cylinder in which it travels, the annular space being 1/32 inch wide. No great pressure will ever come upon this disk, but it is essential that it should be rigid and free from vibration. The total weight of the moving parts is about 100 pounds, and their extreme travel is 3 inches. The bottoms of the valves are flush with the bottoms of the ports when the moving parts are in their highest position, and the ports are wide open when the moving parts are in their lowest position.

The regulating gate is bolted to the 10-inch outlet flange of the rate controller, with the object of furnishing sufficient resistance in the course of the water to cause the balanced valve in the controller to work. It is not necessary that this gate should close watertight, but it is essential that its motion should be constant; there should be no loss of motion, but the waterway through the gate should be of the same size for a given position of the screw, whether the gate is being opened or being closed. This gate is opened and closed by means of a wrench, and is so arranged that the position of its moving parts will not be changed by a jar or vibration in the operation of the apparatus when left for a long time without attention and so that meddlers cannot easily change its setting. It is provided with an accurate indicator showing the position, and this will be graduated to show the rate of flow after the apparatus shall have been calibrated in place.

A 4-inch tar-coated wrought-iron pipe runs from the hole, previously mentioned, in the top plate of the controller to one flange of a 10x6-inch cross in the effluent pipe, next to the regulating gate. To the other flanges of the cross are bolted a 10-inch and a 6-inch gate; the former controls the flow of the effluent to the filtered-water main and the latter permits or prevents its wasting through the rewash pipe to the drain. The 4-inch connection pipe admits water from the downstream side of the regulating gate to the controller, above the pressure disk; the chamber below the disk is subject to the pressure on the upstream side of the regulating gate.

The regulating gate having been set by hand to pass any desired quantity of water per unit of time, that is, to correspond to any desired rate of filtration between the established limits of 400,000 and 1,000,000 gallons per day, it is the office of the controller to maintain substantially the given rate of filtration with any condition of the filter from clean to dirty, and with any stage of water in the filtered-water reservoir. When the filter is first put into service after a cleaning, the pressure on the inlet side of the controller may be equivalent to 12 feet of water, and when the filter is clogged at the end of its run, the pressure at the same point may be almost zero. The total loss of head in the controller, at the maximum rate of filtration will be about 9 inches, which corresponds to the pressure required to lift the moving parts of which the 20-inch pressure disk is a part.

In case the difference of head between the water in the filter and that in the filtered-water reservoir is not sufficient to pass the quantity for which the regulating gate is set, the controller will open wide. The arrangement of the controller is such that, since the pressure of the water entering it from the filter tends to to close the balanced valve, as this pressure falls the valve will tend to open more and more and to maintain the established rate of flow, and since the chambers above and below the pressure disk are connected respectively with the downstream and upstream sides of the regulating valve, a decrease in the difference of pressure at these two points, by an increase in the opening of the regulating valve, thus increasing the rate of filtration, will tend to open the balanced valve, and vice versa, by lowering or raising the pressure disk.

For washing the filters pure water will be supplied from the pumping station under pressure through an 8-inch cast-iron main extending the length of the pipe gallery. From this main an 8-inch branch is taken off opposite each filter and connected to the main effluent collector just outside the filter. A 6-inch wrought-iron rewash pipe is connected to each filtered water outlet pipe just beyond the rate controller and regulating gate. The rewash pipes from opposite filters are connected and led under the filtered-water main so as to discharge into the concrete drain beneath the gallery floor. The arrangement of the principal pipes of the various systems and the positions of the valves for controlling them are shown on the pipe drawings printed last week.

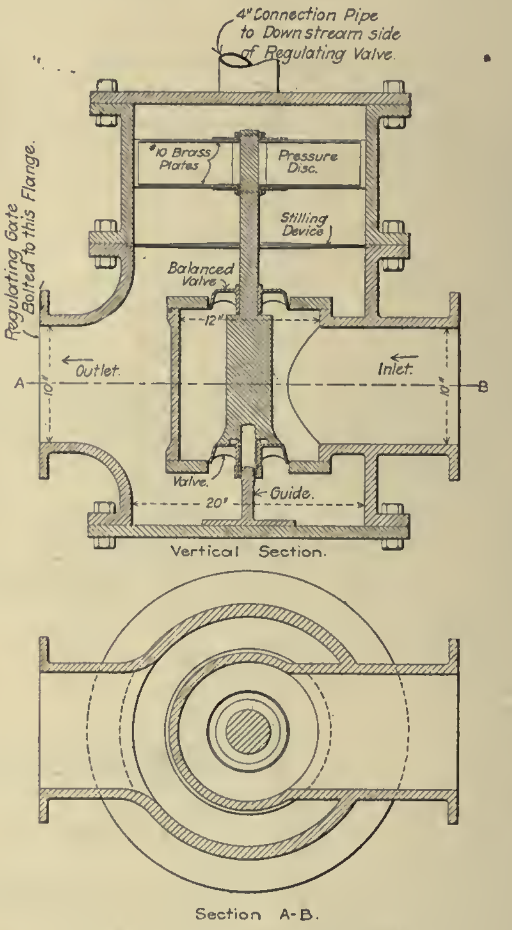
The three large mains which extend the length of the gallery are supported by brick piers 1 foot thick spaced 7 feet apart on centers. The air and wash-water mains pass through a small archway in each pier. These piers also assist in supporting the operating platform over the pipes. The concrete drain beneath the gallery floor is covered with removable slabs of reinforced concrete 4 inches thick.

The coagulating apparatus comprises two concrete steel solution tanks, two wooden dissolving boxes large enough to take a barrel of sulphate of alumina at one time, two cypress orifice tanks with orifices adjustable in area from zero to 1 square inch, two small centrifugal pumps driven by Pelton waterwheels to raise the solution from the concrete tanks to the orifice tanks, and the necessary piping, valves, controlling devices and overflows. All parts of the coagulant apparatus, excepting the tanks just mentioned, which come into contact with the solution are being made of a hard composition of copper, tin and lead, which will not be affected by the coagulant. The proportion of the ingredients of this composition have been carefully determined by experiment.

Operating Table, Watertown Filters.

Loss-of-head gauges are provided, as usual, for each filter. There are also three indicator gauges, one connected with the raw-water pipe immediately back of the gate controlling the flow in it, one connected to the end of the coagulating water pipe and the third connected directly to the filtered-water reservoir. The pipe connections for these gauges, the small pipe connections to the operating gallery and similar small pipes for other purposes are to be of Wakefield lead-lined iron pipe. As is customary in filter plants of this type, the operating mechanisms for each filter are grouped on a stand in the operating gallery, over the pipe gallery. The accompanying photograph shows one of these stands. The buildings are to be lighted by electricity and heated with steam.

The total cost of the plant, exclusive of engineering, will be about $90,000. The general contract for the excavation, building the structures and laying the pipes was awarded to the C. H. Fath & Son Construction Company, of Cleveland, Ohio; the contracts for the cast-iron pipe and special castings, for the strainer and air systems, rate controllers, filter gates and coagulating devices were given to the Norwood Engineering Company, of Florence, Mass. The large valves used in the pipe lines are being furnished by the Rensselaer Valve Company, of Troy, N. Y., and the 30-inch Venturi meter was supplied by the Builders' Iron Foundry, of Providence, R. I. The sand and gravel will be secured locally. Mr. Allen Hazen, of New York, is the engineer for the plant and Mr. W. E. Fuller is resident engineer.



Vertical Section.

Section A-B.

Sections of Part of Controller.

THE ENGINEERING RECORD.

Details of Rate Controller.

Feed Water Heating from Gas Engine Exhaust was described by Mr. F. M. Richards, of Milwaukee, at the meeting of the National Electric Light Association. The cooling water from the engine cylinders is led through a Wainwright heater and then delivered to the boilers, the pump that supplies the water to the engine jackets forcing it through the heater to the boilers. The water enters the jackets at 40 degrees, leaves them at 100 degrees and leaves the feed heater at 210 degrees. He stated that the steam fuel expense on the boiler plant, which makes 100,000,000 cubic feet mixed gas per year, is reduced 12 per cent., but gave no figures as to the proportions of engines, heater, pumps or the like.

Extensions of the Brooklyn Sewerage System; Foster Avenue Trunk Sewer.

The Foster Avenue sewer is a portion of the main trunk sewer which discharges into New York Bay at Sixty-fourth street. Under this designation will be described two sections extending eastward from the portion described last week under the name of the Sixtieth Street sewer. The first of the two contract sections extends from the end of the Sixtieth Street sewer through Nineteenth Avenue, Bergen Lane and Foster Avenue to East Ninth Street, including 1,056 linear feet of 12-foot circular brick sewer, 3,420 feet of 13½-foot sewer and 1,082 feet of 13-foot sewer, making a total length of 5,558 linear feet. There are also a few short pieces of 72, 48 and 36-inch brick sewer for connections to secondary trunks to be built. The second section is made up of 550 linear feet of 11-foot circular brick sewer, 3,860 feet of 10-foot brick sewer and 600 feet of 10-foot concrete-steel sewer, besides the following lengths of egg-shape brick sewer forming a secondary trunk in East Fifteenth Street, 1,100 feet of 60-inch, 2,670 feet of 54-inch, 2,650 feet of 36-inch and 1,620 feet of 30-inch.

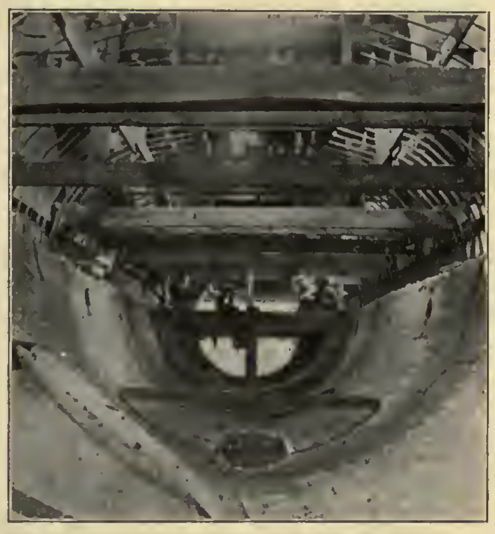
The brick sewers enumerated are all of the standard cross-sections, which, together with the methods of constructing them, have been sufficiently described in preceding articles. A considerable length of the trunk sewer in Foster Avenue, however, comes so near the surface of the street that the cover over the arch is very shallow. For about 600 feet between East Nineteenth Street and East Twenty-first Street, the depth of earth over the arch being only from 1½ to 3 feet, it was decided to substitute a concrete-steel sewer for the standard brick construction. A cross-section of this portion of the sewer is shown herewith, and, for comparison, a cross-section of the standard 10-foot circular brick sewer.

The concrete-steel sewer is of massive cross-section, and, like the brick sewer, is built on the standard foundation platform of two layers of crossed 4-inch planks. The sheeting of the trench serves as the side forms for the concrete and is left in place. For the reinforcement, which is practically all above the springing line, ⅞-inch corrugated steel bars, made by the St. Louis Expanded Metal Company, are being used. Three bars 10 feet long bent as shown are placed in a vertical plane, one just above the soffit of the arch and one in each haunch, near the outer side. Each haunch rod reaches to within 2½ feet of the center of the crown of the arch and extends down into the side wall about 3 feet below the springing line. These sets of three rods are spaced 1 foot apart along the sewer, and there are no longitudinal rods. The rods are furnished straight and are bent by the workmen at the trench with the aid of forms made by nailing short pieces of scantling on to a plank platform so that the ends of the scantling blocks form the proper curve.

At the crown of the sewer the concrete is 12 inches thick and at the lowest part of the invert is 8 inches thick. The haunch walls are 3 feet thick at the springing line. Below the springing line the sewer is lined with one 4-inch ring of hard-burnt bricks. Above the springing line the arch is faced with 1 inch of mortar composed of 1 part Portland cement and 2 parts sand, placed against the form when the concrete is deposited. The outside of the top of the sewer is also plastered with 1 inch of mortar of the same mixture, the surface of the concrete being roughened by scoring or otherwise before the plaster is put on.

This concrete sewer is being built in lengths by successive stages following each other in regular rotation in very much the same manner as was described last week from the construction of the large brick sewer. After excavating a length of trench and leveling its bottom, the foundation platform is laid and on this the concrete is placed for the portion of the sewer below the springing line. A layer of concrete having been deposited across the platform up to the proper level, the inside form is set and held down by short posts wedged under the trench braces. This invert form is made quite similarly to the arch centers for the brick portion of the sewer, the radius being increased to allow for the ring of brick lining and the collar joint between the brick and the concrete. As the concrete in the haunch walls reaches the proper elevation, the steel bars on each side are put into position. They are held at first by light longitudinal strips of wood into which notches are cut at 1-foot intervals, but as soon as the concrete around their lower ends has hardened this holds them securely and the wood strips can be removed. Before placing the concrete in the arch the brick lining of the invert is put in. The forms for the invert are left in place thirty-six hours.

The forms for the concrete arch are like the centers for the brick arch. They are set in the usual way on struts bearing on the invert of the sewer. The lagging is of narrow, planed ⅞-inch stock and is smeared with crude oil to prevent the concrete from adhering. After the form has been set the steel crown bars are put into their positions, being held at the proper distance above the form by means of small wooden wedges. These small wedges are not placed near the ends of the rods and so as the concrete is built up and the ends are held by the concrete, the wooden blocks can be removed. In this way no wood is embedded in the concrete but the reinforcing bars are accurately placed as required by the drawings. The forms for the arch are left in place forty-eight hours, and no steam roller is allowed to pass over the finished portion of the arch within thirty days after the center is removed. The centers are not made collapsible, since they can be taken down and moved forward as rapidly as required without having to pass through a portion of the sewer in which the forms are still in place.


Steel Bars and Forms, Foster Avenue Sewer.

The concrete is composed of 1 part Reliance Portland cement, 2 parts sand obtained from the trench and 4 parts Tomkins Cove broken stone, mixed by hand. The sand and cement are first mixed into a rather wet mortar and then this mortar is spread over the broken stone, previously spread in a layer on the mixing board and moistened. The mixing is completed by turning the mortar and stones with shovels. The concrete is taken to the forms in wheelbarrows, and is placed in layers and rammed moderately. The arch concrete is allowed to set at least forty-eight hours before the refilling of the trench begins. Until covered by the earth, the concrete is kept moist and protected from the sun.

On the two sections of sewer herein described but little trouble has been experienced so far with water, but an interesting incident showing roughly the rate at which the ground-water level in the sand rose and fell as the result of heavy precipitation occurred last fall. October 8 and 9, 1903, a phenomenal rainstorm visited the region around New York City, causing severe floods in numerous places. The rainfall in the vicinity of Brooklyn measured 11.6 inches. At the date of this storm a portion of the Nineteenth Avenue sewer trench was open at a place where the depth is about 38 feet, the cut being in coarse sand. The bottom of the trench was just above the normal ground-water level, but on October 18 the water was observed to have risen above the bottom of the foundation planking in the trench. The water reached a maximum level of about 25 inches above the normal water table by October 27, held about this level to October 29, and fell below the point of observation, nearly to the normal level, by November 15.

In Nineteenth Avenue, near Forty-ninth Street, the sewer location crosses the tracks of the Bay Ridge division of the Long Island railroad. At this place the trench will be 17 feet wide and nearly 40 feet deep, in sand and gravel, and will be closely sheeted and double braced, practically all the sheeting and bracing to be left in place when the trench is refilled. At this crossing two branch tracks turn from the two main tracks, so that some of the frogs are over or very near the trench; the main tracks make an angle of about 45 degrees with the direction of the sewer.

To carry these tracks across the trench a simple bridge of steel I-beams and wooden sills have been constructed by employes of the railroad company in advance of the trench excavation. Two 12x12-inch yellow pine sills about 50 feet long, placed one on top of the other, were sunk in a narrow trench on each side of the sewer location, parallel to, and about 4 feet from the edge of the sewer trench. These double sills are each supported on thirteen 6x12-inch mud sills 4 feet long, laid flat, spaced 3 feet apart in the clear and placed transversely to the main sills so as to project about 2 feet beyond them on the side away from the sewer trench. On the 12x12-inch sills were placed six nests of 24-inch I-beams spanning the trench and spaced as required by the positions of the rails. Each nest consists of three beams separated by vertical 10x12x18-inch yellow pine blocks spaced 5 feet 11 inches apart on centers. Three ¾-inch bolts were put through the beams and blocks at each point. The 8x8-inch yellow pine ties spaced 16 inches on centers were laid directly on the upper flanges of the beams, and such guard logs of 6x8-inch timbers as were necessary were placed on top of the ties and secured by hook bolts 4 feet apart passing through the ties and engaging the top flanges of the I-beams.

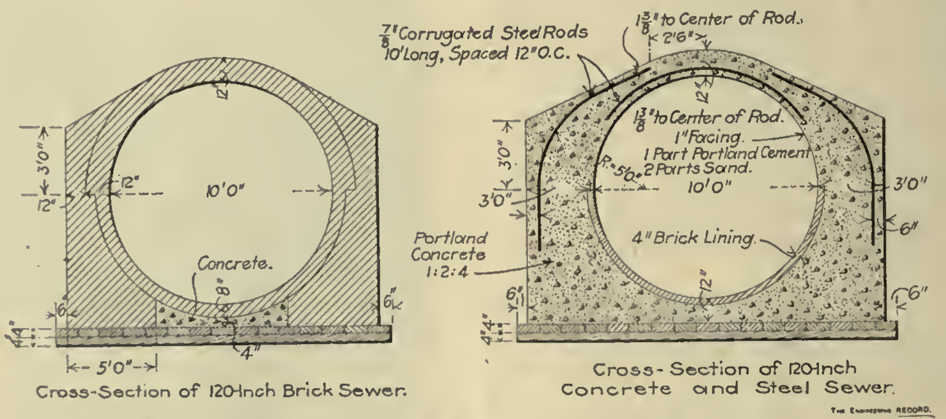
This bridge has to carry a very heavy freight and passenger traffic, including some of the heaviest locomotives run over the line, and there is a great deal of switching done at this point. With the benefit of previous experience in crossing railroads, including the Sixtieth Street crossing mentioned in a recent article, it is anticipated that there will be no trouble in executing the sewer construction at this busy crossing. This portion of the work will be undertaken in a very few days. The excavating will be done by the aid of one of the Carson-Lidgerwood cableway trench machines used on the other parts of the trench, which will be set to span the tracks. The earth will be cast to either side from beneath the railroad and then shoveled into the buckets. It is estimated that about five weeks will be required for constructing this 200-foot stretch of sewer; in other parts of the section where the trench is of similar depth an equal length of sewer has usually been built in about three weeks.

On Foster Avenue between East Fifteenth and East Sixteenth streets there is another railroad crossing, with the tracks of the Brooklyn and Brighton Beach Railroad. This work has been completed. As the trench here was only about 18 feet deep and the railroad traffic is much lighter and the trains less frequent, especially at the season when the sewer work was done, this problem was a much less difficult one. The tracks were simply supported by large bridge timbers extending well beyond the sides of the trench, placed beneath the ties by the railroad employes. Only half the trench was opened at a time, the sewer being built first under one track and then under the other.

The contract for the section immediately east of the Sixtieth Street sewer was awarded April 3, 1903, to James H. Holmes & Company, of Brooklyn, the amount of the contract, based on the preliminary estimated quantities, being about $361,000, and the allowed time 175 working days, which was later extended to 300 working days. The minimum depth of trench is about 30 feet, maximum 40 feet, and the average 35 feet. About 700,000 feet board measure of lumber were required in the foundation planking and 2,475,000 feet for the sheeting. The average number of men employed has been 130, and the work is expected to be completed by August 31, 1904.

The contract for the other section, including the concrete-steel sewer, was given to Mr. J. J. Creem, of Brooklyn, the amount of the contract being $289,700. On this section the trench varied from 13 to 32 feet in depth, averaging about 20 feet. For the concrete-steel sewer about 1,500 cubic yards of concrete and 36,000 pounds of steel bars are required. On this section 645,000 feet board measure of lumber are required for the foundation planking and 1,340,000 feet for the sheeting. The average number of men employed has been 100, and the time allowance is 175 working days. The contract was awarded July 14, 1903. Work was begun immediately and it is expected to have the sewer completed by August 31, 1904. On both sections the excavation has been wholly through the characteristic sand and gravel deposits of this part of Long Island. The approximate amounts of the contracts given above include the necessary manholes, the connections with several lateral trunk sewers and a number of minor items.

This sewer, like the others of the system, was designed and is being built under the direction of Mr. Henry R. Asserson, M. Am. Soc. C. E., chief engineer of sewers, Borough of Brooklyn. Mr. F. C. Bates is the division engineer in immediate charge of the work.



Cross-Section of 120-Inch Brick Sewer.

Cross-Section of 120-Inch Concrete and Steel Sewer.

Brooklyn Sewers: Cross-Sections of Brick and Reinforced Concrete Sewers.

LIGHTNING ARRESTERS for electric transmission circuits must, according to Mr. H. B. Gear, before a recent meeting of the Chicago branch of the American Institute of Electrical Engineers, be cleaned and repainted at regular intervals. When old the collection of rust and dust is likely to cause trouble. Some companies disconnect lightning arresters in the fall and connect them up again before the spring thunderstorms.

Types and Details of Bridge Construction; Plate Girders—II.

By Frank W. Skinner, C. E.

An early type of pocket was used in the Brooklyn Elevated Railroad standard of 1889 and 1890, in which pairs of 7x3½-inch short vertical angles were riveted to the lower parts of the transverse girder webs, and pairs of short vertical channels, back to back, were riveted between their outstanding 7-inch flanges. Their upper ends were milled even with a horizontal bracket angle riveted to the web of the outer channel, and formed a seat for the end of the longitudinal girder which was not bolted to it. The edges of the lower flange of the longitudinal girder were cut to clear the 7-inch flanges of the pocket angles, which acted as guides. At these connections the outstanding flanges of the end vertical web stiffener angles were turned toward the center of the girder so as to clear the heads of the field-driven rivets in the connections of the fixed girders.

The sliding and fixed end longitudinal girders in adjacent spans were connected by two pairs of horizontal bolts through their end web stiffener angles and the webs of the transverse girders. The lower corners of the webs were notched a little and two undesirable bends were introduced into the continuous lower flange angles to raise the bearings high enough to engage these seats. In this type the top flanges of the longitudinal girders were several inches below those of the transverse girders, and the latter interfered with the spacing of the track ties. This difficulty was obviated in the standard of 1892 and 1893 by raising the longitudinal girders and making them relatively deeper, so that the lower edges of their top flanges just cleared the upper sides of the top flanges of the transverse girders. They were continued across the latter to the center line and engaged pairs of transverse guide and bearing angles with their horizontal legs bearing on the upper edges of the vertical flanges of the latter.

The ends of the webs were beveled to clear the top flanges of the transverse girders and extended almost to its web at the seat of the lower flange in the pocket bearing, which corresponded with that of the standard of 1889 and 1890, except that it was made with a vertical I-beam and had vertical bolts through slotted holes to secure the lower flange of the longitudinal girder. All these Brooklyn Elevated Railroad girders were illustrated in a paper presented to the British Institution of Civil Engineers by Mr. O. F. Nichols, chief engineer of the Brooklyn Union Elevated Railroad.

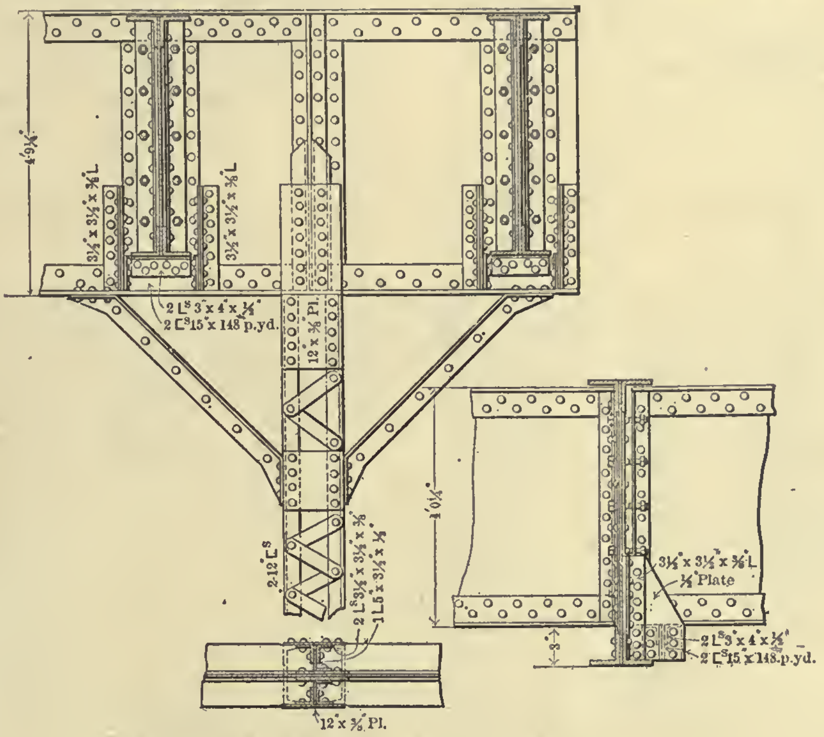
The 40-foot longitudinal girders of the double-track elevated railroad crossing the East River, New York, on the Williamsburg suspension bridge, which was described in The Engineering Record of May 12, 1900, have fixed and expansion bearings at every third panel point, the connections at intermediate panel points being all fixed. The fixed ends are connected to the transverse girders by field rivets through its web and the vertical end web stiffener angles of the longitudinal girders. At the expansion ends the girders are seated in H-shaped cast-steel saddle pockets riveted to pairs of web-stiffener angles on the transverse girders, and having their lower edges fitted to bearing on the lower flange angles. The end of the lower flange of the longitudinal girder is cut to a neat fit against the sides of the pocket, and the top flanges have guide angles riveted to their under sides to engage the projecting flanges of the pocket angles. The end vertical web stiffener angles of the longitudinal girder have their transverse flanges toward the center of the girder, and the reinforced web projects beyond their riveted flanges nearly to the transverse girder web.

Pocket connections for expansion girders for the Asylum Street viaduct, Hartford, Conn., and for the Suburban Rapid Transit Railroad, New York, were illustrated in Volume XXXVII. of the "Transactions" of the American Society of Civil Engineers. In the former structure the expansion longitudinal girders have drop ends with their lower flanges sliding on horizontal shelves about 15 inches square, made with 15-inch channels, flanges up, riveted to gusset plates on pairs of vertical web-stiffener angles. The shelf channels are reinforced by bearing on the faced upper ends of pairs of short vertical 15-inch channels riveted together back to back, with their webs parallel to the transverse girder web and their flanges riveted to the gusset plates. Shelf angles are riveted to both sides of the webs, and the longitudinal girders are bolted to them through slotted holes in their bottom flanges. Three pairs of horizontal bolts through the vertical end web-stiffener angles of the fixed and sliding girders and the transverse girder web are made long enough to allow for temperature movements.

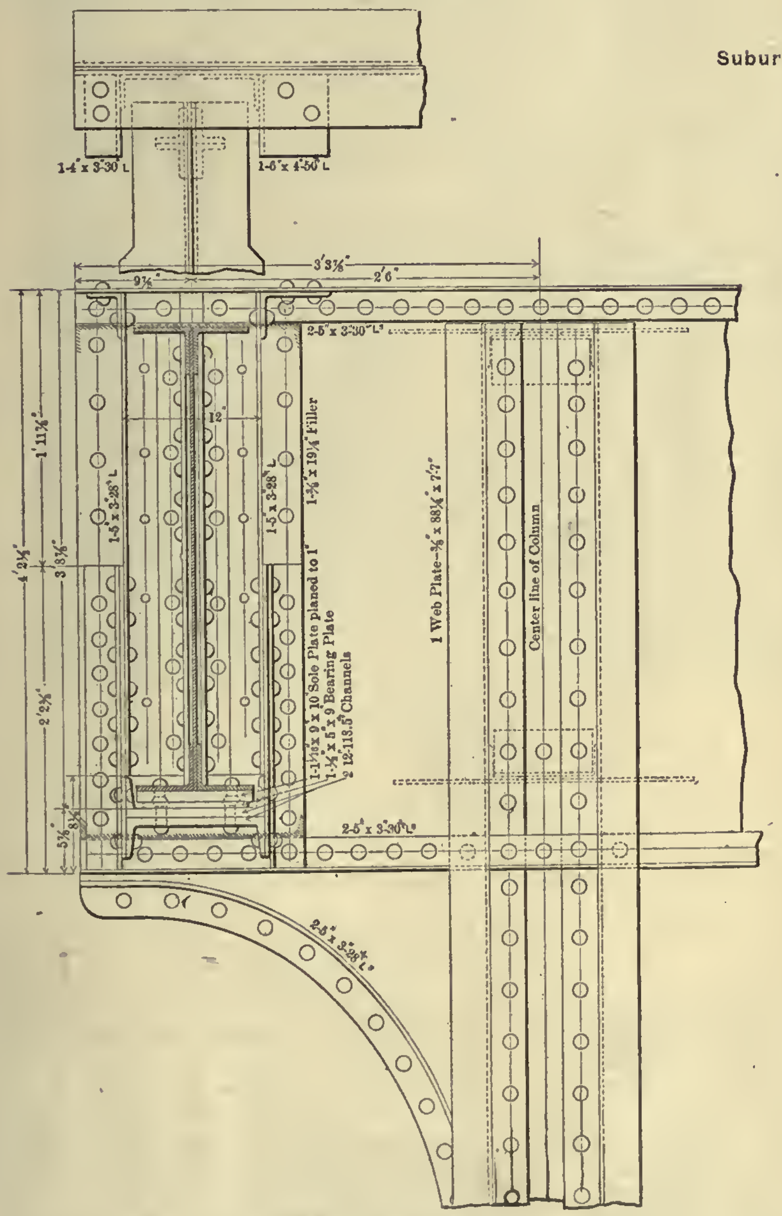
In the Suburban Rapid Transit Railway the transverse girders are seated on the column tops and cantilever beyond them to receive the outside longitudinal girders. They have flange angles riveted to their vertical web-stiffener angles and to flange plates projecting above the column tops to form jaws. The fixed ends of the longitudinal girders are web-connected to the transverse girders with field driven rivets just above knee braces from the lower flanges of the latter to the columns. The expansion end of the sliding girder is made full depth, like that of the fixed girder, and its lower flange is seated on a base made with two short vertical channels riveted together back to back, and having two top flange angles. The channel flanges are riveted to a pair of short gusset plates projecting from the lower ends of a pair of vertical web-stiffener angles. Five pairs of horizontal bolts connect the ends of the fixed and sliding girders through the transverse girder web. There is a fixed and a sliding connection to every transverse girder.

The expansion connections of the longitudinal girders of the Union Loop Elevated Railroad, Chicago, were illustrated by the designing engineer, Mr. J. A. L. Waddell, in paper No. 286 of the American Society of Civil Engineers. The sliding ends of the girders have their webs reinforced by double pairs of vertical angles, and their full-width lower flanges are seated with small clearance between the side plates of pockets riveted to the lower halves of the transverse girder vertical web-stiffener angles, which are extra wide at these points and have short outside angles as long as the gusset plates. The pocket shelves are made with a pair of horizontal-web channels back to back, with their flanges riveted to the gusset plates. A sole plate is countersunk-riveted to the bottom flange of the longitudinal girder, and its planed surface slides freely on that of a bed plate, which is narrower than the shelf, so as to prevent the concentration of pressure on the edge of the latter. The top flange angles are trimmed to 1⅜-inch clearance, with the vertical legs of short horizontal angles parallel to them, which are riveted across the under sides of the transverse girder top flange angles and to the tops of the vertical web-stiffener angles, and project about 6 inches beyond the latter.

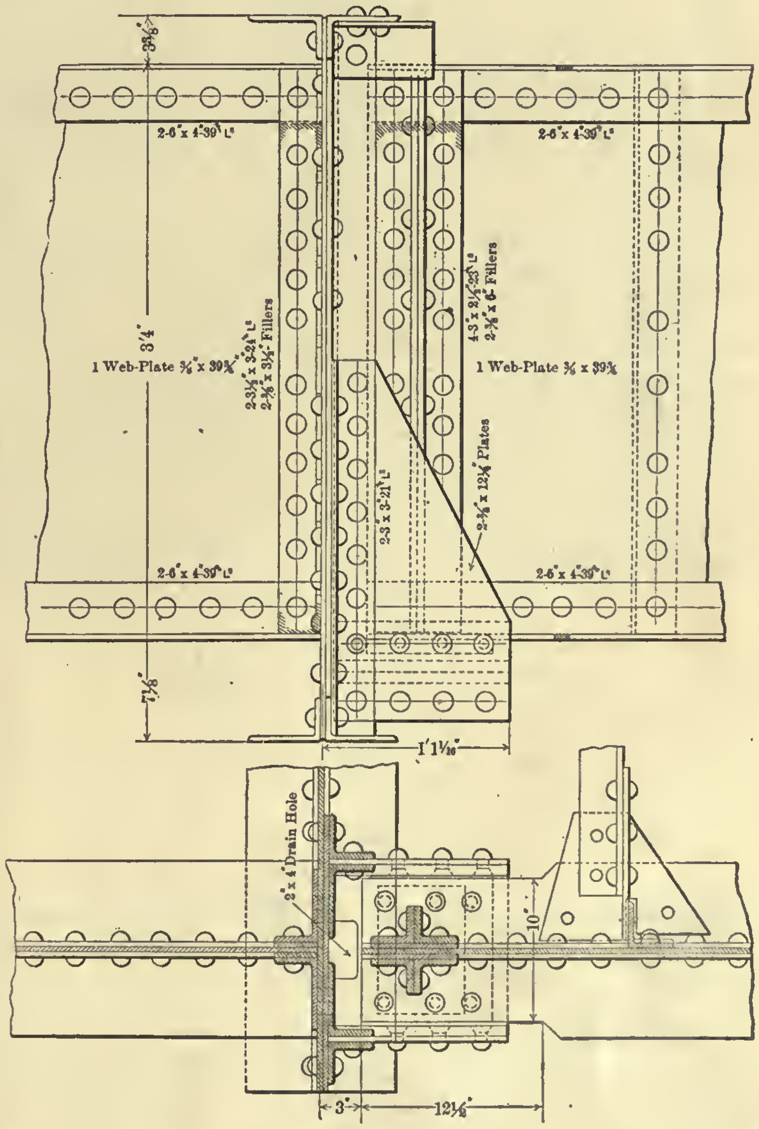
Longitudinal girders in the double track 25-foot spans of the Delaware, Lackawana and Western Railroad, at Newark, N. J., have fixed and expansion connections on opposite sides of the transverse bents. The fixed end girders are field-riveted through their end web-stiffener angles to the webs of the transverse girders and to diaphragms between the column channels. The expansions ends are supported on long horizontal bearings on the bottoms of deep pockets projecting from the columns and the side of the transverse girder. Each pocket is made with a pair of vertical longitudinal gusset plates having their lower ends connected by a horizontal diaphragm built up of a pair of 6x6x¾-inch angles and a ¾-inch plate. This forms a bearing nearly 2 feet long for the bottom flange of the longitudinal girder, which is not bolted to it, but slides freely on it with about an inch clearance between the side plates, which act as guides and can resist the transverse component of the lateral stress.



Suburban Elevated Railroad, New York; Expansion Joint.



TRANSVERSE VIEW.

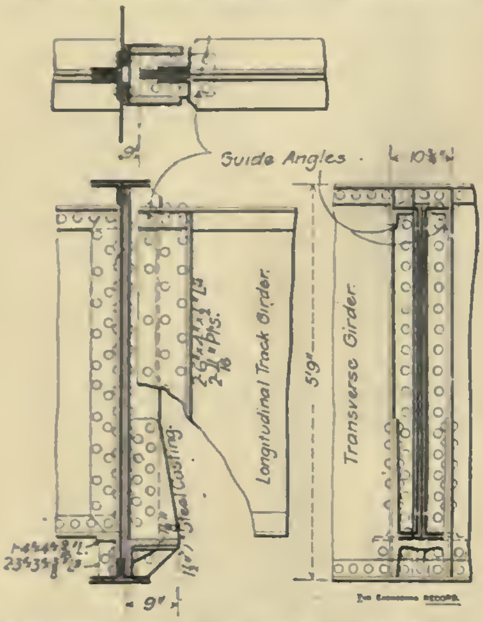


LONGITUDINAL VIEW.

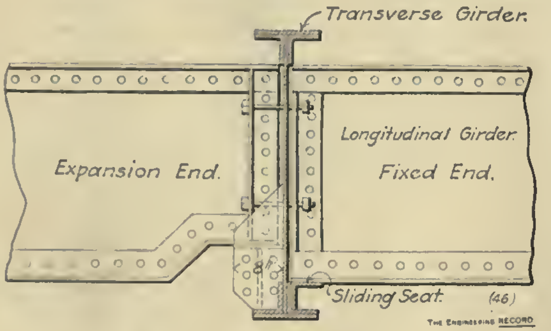
POCKET BEARINGS FOR EXPANSION ENDS OF LONGITUDINAL GIRDERS, CHICAGO ELEVATED RAILROAD.

Meeting of the National Electric Light Association.

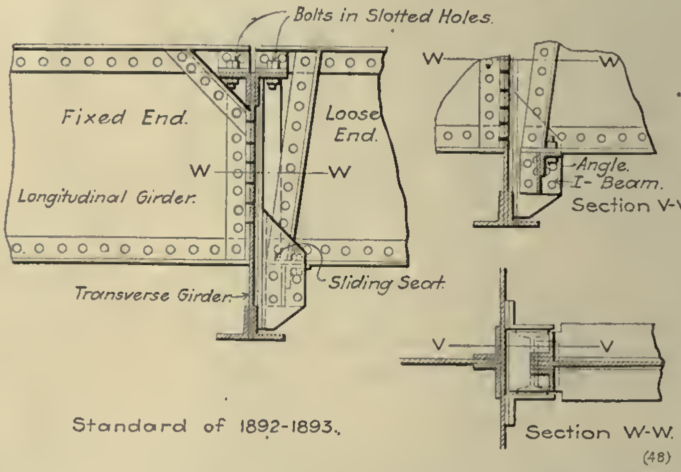
The National Electric Light Association held its twenty-seventh convention in Boston, May 24 to 27, inclusive. A large number of papers and committee reports were presented, many of which are unusually valuable. Some of these are given in the succeeding reviews, but they are necessarily condensed to keep them within the limits of the space available.



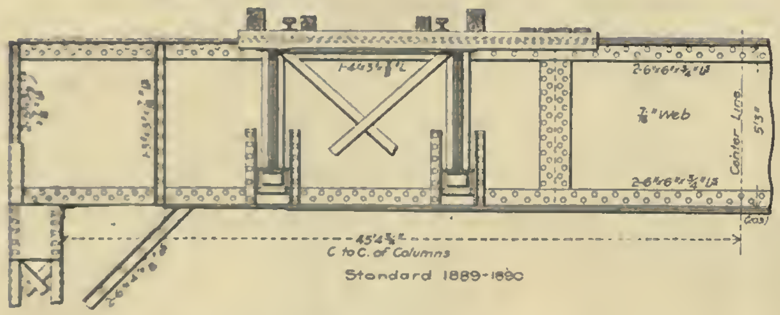
Elevated Railroad Girders, Williamsburg Bridge, New York.



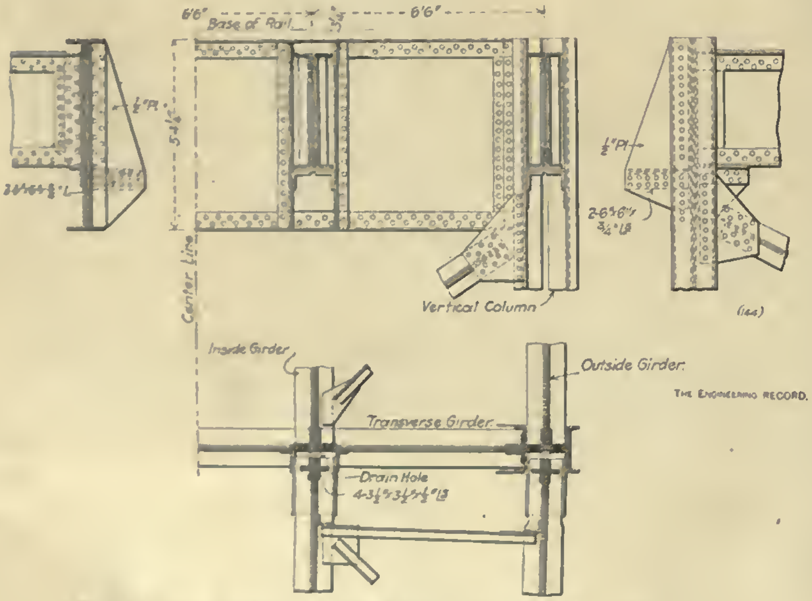
Standard of 1889-1890.



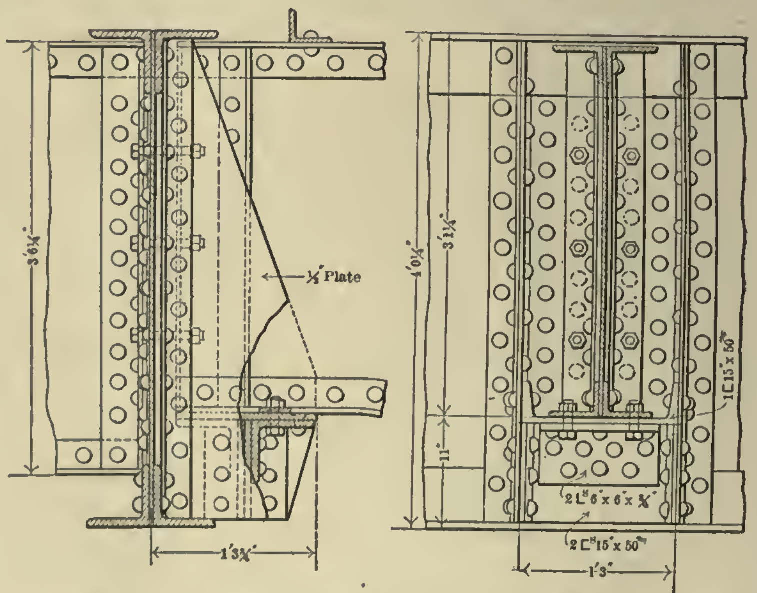
Standard of 1892-1893.



Pockets for Longitudinal Girders, Brooklyn Union Elevated Railroad.



Expansion Connections for Short Deck Spans, Delaware, Lackawanna & Western Railroad.



Expansion Pockets for Sliding Ends of Longitudinal Girders, Asylum Street Viaduct, Hartford.

TEST OF A 5,500 HORSE-POWER GENERATING UNIT.

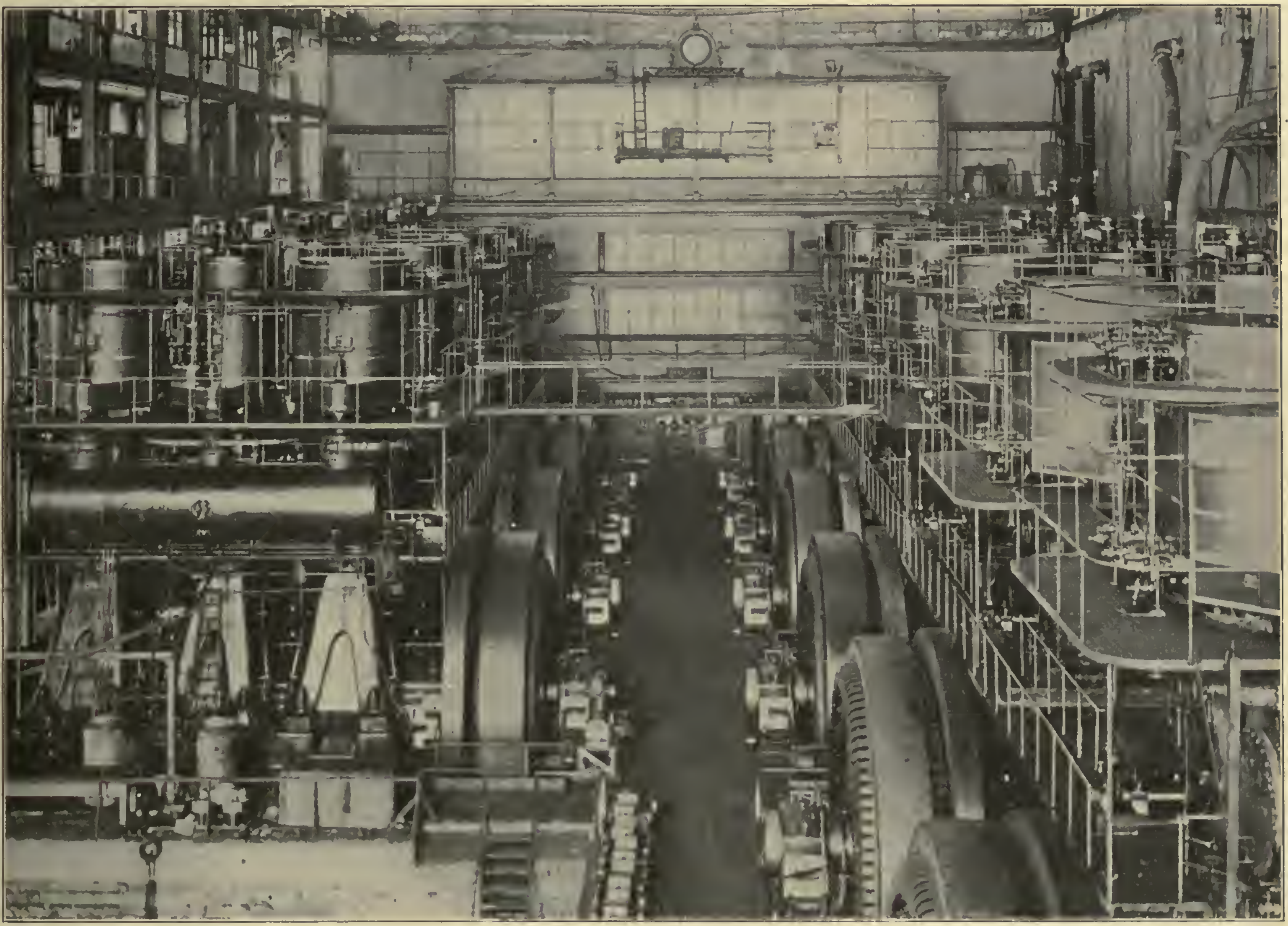
The economy test of a 5,500 horse-power three-cylinder, compound vertical engine direct-connected to a three-phase, 25-cycle, 6,600-volt General Electric alternator was reported by Messrs. J. D. Andrew and W. F. Wells, of the New York Edison Company. The engine is one of eleven built for the Waterside station of that company by the Westinghouse Machine Company, and, as shown by the figures in the accompanying tables, gave a remarkable performance. The general characteristics of the engine were described in The Engineering Record of January 4, 1902, in connection with an extended account of this central station. Suffice it to say that the high-pressure cylinder, which is between the two low-pressure cylinders, is 43.98 inches in diameter and the latter are each 75.65 inches, with the common stroke 5 feet and the piston rods all 9 inches. The ratio of the combined volume of the two low-pressure cylinders to that of the high-pressure cylinder is 6 to 1. The clearances are for the high-pressure cylinder: head end, 5.75 per cent.; crank end, 15.10 per cent.; low-pressure cylinder: head ends, 4.21 per cent.; crank ends, 4.25 per cent. One low-pressure crank leads the high-pressure by 133 degrees and the other low-pressure follows at 101 degrees, making the two low-pressure cranks 126 degrees apart.

The high-pressure cylinder is fitted with four-beat poppet valves, the head-end valves being in the head itself, the crank-end valves being in a valve chamber cast on the side of the lower head, which arrangement accounts for the difference in clearance given. The low-pressure cylinders are provided with steam jackets, and the receiver between the high and low-pressure cylinders with a reheater. This receiver is 54 inches in diameter by 21 feet 10 inches long. The steam enters from the high-pressure cylinder through a 16-inch pipe at the center into a space 34 inches long; here it divides, passing in either direction through a nest of reheater tubes having a total area of 1,130 square feet of iron heating surface, then through two 24-inch pipes to the low-pressure cylinders. Each low-pressure cylinder has a 26-inch exhaust pipe leading to a surface condenser of 9,200 square feet of tubular surface furnished by ¾-inch outside diameter, 18-gauge brass tubes.

The engine was furnished under a guarantee not to exceed 12.5 pounds of dry steam per indicated horse-power per hour, when developing between 4,900 and 5,500 horse-power with 175 pounds steam pressure, 27 inches vacuum and turning 75 revolutions per minute. The testing was conducted under the supervision of Mr. Jay M. Whitham, M. Am. Soc. M. E., as referee. The steam used by the auxiliaries was not charged against the engine in the tests reported in the paper.

An accompanying chart of curves showing the number of pounds of water per kilowatt-hour, pounds water per indicated horse-power hour and the commercial efficiency of the unit at various loads, is plotted from the data given in an accompanying table. The curves show that for outputs of from 2,500 to 4,500 kilowatts the economy varies between 17.12 and 18 pounds of water per kilowatt-hour of net output at the generator terminals. The commercial efficiency, or the net electrical horse-power divided by indicated horse-power, varies from 94.5 to 95.2. This range covers all loads that the machines are called on to carry in actual service. The duration of these tests was approximately one hour each.

Another table gives information concerning 10 different hourly tests made to study the value of the reheater and of the low-pressure jackets. The test referred to in column 1 is the one in which the best economy was obtained, 11.93 pounds of water per indicated horse-power hour and 16.78 pounds of water per kilowatt hour. Columns 2 and 3 show the behavior of the engine carrying normal load without receiver reheater or low-pressure jackets in service. Under these conditions the steam consumption was 12.158 and 12.196 pounds per indicated horse-power per hour. Columns 4 and 5 give the performance under the same conditions, except that the receiver reheater was in use. The steam consumption based on the indicated horse-power was 12.81 and 12.65 pounds. A comparison shows a disadvantage in the use of the reheater. To demonstrate further this relation, a series of tests was run with loads varying from 1,400 to 6,300 horse-power, both with and without the reheater, and the results, as shown in water-rate curves reproduced in the paper, charged the engine roughly with one-quarter to one-half pound more steam per indicated horse-power when operated with reheater than when it was run without.



The Fifty-Five-Hundred-Horse-Power Engines in the Waterside Station of the New York Edison Company.

RESULTS OF EFFICIENCY TESTS.

Kilowatts armature	867.	2166.	2981.	3737.	3739.	3740.	3746.	3979.	4483.
Indicated horse-power	1428.	3088.	4218.	5283.	5265.	5278.	5273.	5598.	6326.
Steam pressure, lbs	193.6	187.	186.3	185.	182.4	183.	182.8	183.7	181.6
Receiver pressure, lbs	21.1	24.5	24.4	24.8	23.5	23.5	23.3	24.7	24.8
Vacuum, inches	27.15	24.4	26.9.	26.31	26.37	26.36	26.36	26.75	26.6
Cycles	25.6	25.45	25.43	25.41	25.64	25.45	25.59	25.55	24.92
Armature volts	6318.	6324.	6522.	6588.	6600.	6582.	6588.	6342.	6360.
Kilowatts in field	13.8	15.3	18.5	20.4	20.3	20.3	20.2	19.8	22.1
Kilowatts, net output	854.	2150.	2962.	3717.	3719.	3720.	3726.	3959.	4461.
Electrical horse-power	1144.	2882.	3971.	4983.	4985.	4986.	4994.	5307.	5980.
Dry steam, per ind. horse-power per hr., lbs	15.88	12.62	12.45	12.09	12.19	12.15	12.19	12.11	12.44
Dry steam per kw-hour—net output	26.58	18.08	17.7	17.18	17.27	17.25	17.26	17.12	17.64
Efficiency, per cent	81.4	93.9	94.7	94.7	95.2	95.	95.2	95.25	94.8

Column 6 gives the economy for the heaviest load conditions under which the engine was tested; namely, 6,326 indicated horse-power. The water consumption was 12.44 pounds per indicated horse-power hour.

Column 7 deals with the lightest load condition, 1,428 horse-power, the water consumption being 15.88 pounds.

Column 8 shows the results of a test with the low-pressure jackets in use and without the reheater. The water consumption here was 12.59 pounds.

Column 9 shows the results of a test with both jackets and reheater in use, and, as will be seen, is even worse than Column 8.

Column 10 deals with a friction test. In making this test the engine was kept at normal speed and compelled to operate all of the inlet valves by slightly throttling the steam supply; this accounts for the somewhat lower pressures shown.

This friction load of 118.6 horse-power, or 2.25 per cent. of the normal load of the engine, appears low, but the authors feel that the combined efficiencies of engine and generator already noted, add proof of its correctness.

The second chart of curves is for the purpose of comparing the effect of varying vacuum and varying receiver pressure or distribution of load on economy both in water consumption and heat consumption. The data from which these curves are derived are given in the third table. An examination of the curves will show that increasing the vacuum from 25.3 inches to 27.3 inches decreased the water consumption only 0.06 pound and the heat consumption 2.6 thermal units, whereas increasing the receiver pressure from 21 pounds to 36.8 pounds or changing the distribution of load from about two-fifths on the high-pressure cylinder and three-fifths on the two low-pressure cylinders to about equal load on all three cylinders, decreases the water consumption 0.25 pound and the heat consumption 2.6 thermal units. The heat consumption estimates are based on the assumption that all water is returned to the boilers at the temperature of the steam from which it is condensed.

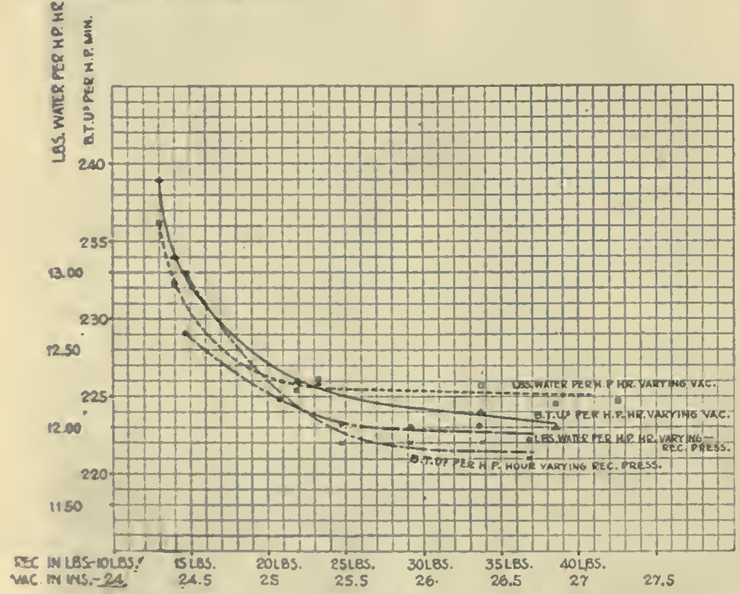
STARTING A 4,000 HORSE-POWER WATER TURBINE.

In a paper by Mr. Robert Howes describing at length the construction and operation of the 100-mile transmission line of the Washington Water Power Co., Spokane, Wash., reference was made to a phenomenon observed every time one of the 4,000 horse-power wheels is started. For this he has found no explanation. The pressure at the center of the shaft, according to gauge, being 24 pounds and the vacuum in draft tubes being zero, the gate of the wheel is opened slowly. Full speed is reached in about one minute, the gate being 9 per cent. opened. The vacuum is noted as rising rapidly. The speed remains steady for two or three minutes and the vacuum increases to 10 inches of mercury; suddenly the wheel slows down 20 per cent., the vacuum continuing to rise to about 13 inches of mercury, where it remains practically stationary. The wheel continues to run at steady speed and 20 per cent. low until the gate is further opened, requiring 16 per cent. gate opening to bring the wheel back to speed. The pressure gauge shows a loss not to exceed 0.1 pound, while the vacuum remains about the same.

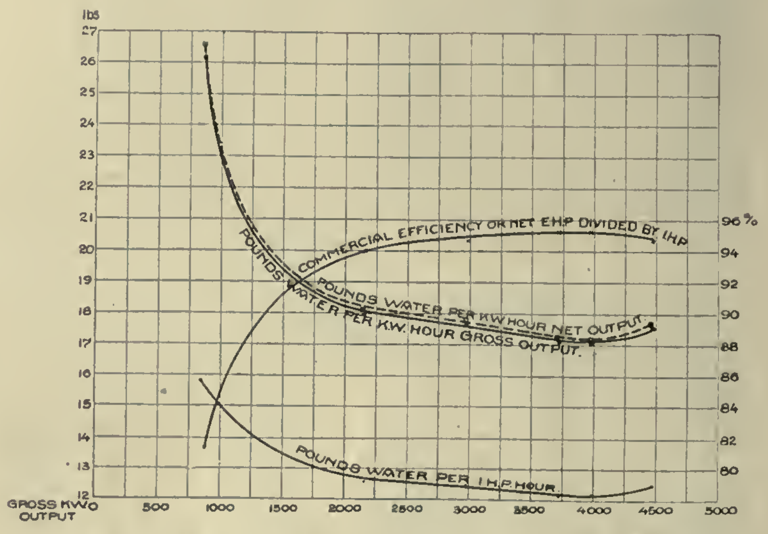
Results of Tests of Receiver Reheater and Low Pressure Jackets.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Average kilowatts	3872.	3752.	3751.	3765.	3764.	4483.	867.	...	...	...
Pressure at throttle, lbs.	185.6	183.1	182.8	184.	184.1	181.6	193.6	187	184.7	150.7
Pressure at receiver, lbs.	36.8	23.5	23.3	23.2	23.7	24.8	21.1	23.8	26.2	13.1
Pressure in reheater, lbs.	0	0	0	138.	138.	0	0	0	130.	0
Pressure in jackets, lbs.	0	0	0	0	0	0	0	29.2	29.7	0
Vacuum, inches	27.25	26.36	26.36	25.26	25.32	26.60	27.15	24.66	24.44	27.25
Barometer, inches	30.26	30.16	30.16	30.44	30.44	30.22	30.22	30.42	30.42	30.27
Temperature, high-pressure exhaust, deg.	284.8	268.2	268.3	267.6	268.1	277.2	262.7	268.4	271.8	311.3
Temperature, low-pressure inlet, deg.	284.1	267.5	267.5	277.5	278.2	276.8	262.7	267.8	274.2	289.8
Moisture, at throttle, per ct.	.75	.70	.70	.06	.6	1.11	.78	.7	.7	22.5*
Indicated horse power	5442.	5278.	5273.	5281.	5315.	6326.	1428.	5294.	5449.	118.6
Water from receiver, lbs.	3456.	3948.	3973.	575.	577.	4422.	189.	2501.	528.	95.
Water from reheater, lbs.	0	0	0	4846	4470.	0	0	0	3736.	0
Water from jackets	0	0	0	0	0	0	0	64.	63.	0
Dry steam, I. h.-p.-hour	11.93	12.158	12.196	12.81	12.61	12.44	15.88	12.59	12.68	1367.
Dry steam, kw-hour	16.78	17.10	17.17	17.97	17.81	17.56	26.13	....	....	....
B. T. U., I. h.-p.-min	221.	223.	224.	232.	229.	229.	295.	228.	229.	....
B. T. U., kw.-min	309.	313.	314.	325.	323.	322.	486.	....	....	....

*Superheat, 22.5 deg. Fahr.



Effect of Varying Vacuum and Load Distribution.



Water Consumption and Combined Commercial Efficiency.

Test of a 175 Horse-Power Gas Engine.

Another one of the papers was presented by Mr. E. E. Arnold, on the internal-combustion engine as applied to central station service. In the main it is an interesting compilation of the performance of a number of central stations operated by gas engines, describing the installations and recording the operating figures. In addition to this the paper contains an instructive illustrated study of the crank efforts of different types of gas engines in connection with inertia effects as pertaining to the uniformity of angular velocity, a point of importance in the parallel operation of alternators driven by gas engines. A tabulation of brake tests of gas engines is also given, and one of these of an engine built for the Keystone Bank Building, Pittsburg, is abstracted in the succeeding paragraph.

The engine is a 175 horse-power, vertical, three-cylinder engine of the four-cycle, single-acting type, with cylinders 14x18 inches in size. Natural gas was used, averaging 990 British thermal units total, or 905 effective, per cubic foot. At a load of 203 brake horse-power, 10.3 cubic feet of gas were used per brake horse-power per hour; at a load of 178 brake horse-power, 11.3 cubic feet were used and at a load of 90 brake horse-power, 14.9 cubic feet per horse-power hour were used. At the full load the heat consumption per brake horse-power per hour was 9,800 British thermal units. The mechanical efficiency of the engine at full load was approximately 87 per cent., and the thermal efficiency based on the useful work obtained was about 26 per cent. A chart showing the total gas consumption with respect to power output approached closely to a straight line and the curve for the unit consumption differed from the corresponding water-rate curve of the steam engine in that a progressively lower consumption was indicated up to the ultimate capacity of the engine.

Results of Varying the Vacuum and the Distribution of Load.

Pressure at throttle, lbs.	185.6	184.2	180.7	185	180.6	181.3	183.7	182.4
Pressure in receiver, lbs.	36.8	33.7	29.2	24.8	20.8	14.8	24.7	23.5
Vacuum, inches	27.2	27.2	27.3	26.3	27.25	27.2	26.75	26.37
Revolutions per minute	76.3	75.85	76.36	76.8	76.48	75.84	76.55	76.68
I. horse power, high pressure, top.	900.	990.	969.	1027.	1088.	1207.	1085.	1013.
I. horse power, high press., bottom	1023.	1092.	1081.	1174.	1183.	1305.	1161.	1162.
I. h.-p., No. 1, low press., top	859.	870.	787.	784.	729.	710.	818.	777.
I. h.-p. No. 1, low press., bottom.	886.	865.	851.	782.	833.	765.	853.	826.
I. h.-p., No. 2, low press., top	700.	800.	755.	754.	708.	668.	800.	762.
I. h.-p., No. 2, low press., bottom	874.	839.	802.	761.	700.	636.	750.	725.
I. h.-p. per hour	5442.	5526.	5357.	5283.	5360.	5375.	5598.	5265.
Water per I. h.-p.-hour	11.03	12.02	12.01	12.08	12.19	12.6	12.11	12.19
B. T. U. per I. h.-p.-min	221.	222.	222.	222.	226.	233.	223.	224.

The Electric Lighting Industry.

The report of the committee on progress presented by Mr. T. Commerford Martin recorded a great amount of interesting statistics relating to the advance of the electric lighting industry. He felt it safe to say that the rate of increase each year was not less than 10 per cent. At the time of the enumeration, covering 1902, 3,620 central stations were in operation. Their total cost was over $500,000,000; their gross income $85,700,000 and their total expenses $68,000,000. They furnished employment to 23,330 wage-earners, who received nearly $15,000,000 during the year. The power equipment included 5,930 steam engines, with 1,380,000 indicated horse-power, and 1,390 water-wheels with a horse-power of 438,500. Some 815 plants were operated under municipal control. The current output for the year was over two and one-half billion kilowatt hours, or about 25 per cent. of the possible work the stations could do in 24 hours of daily operation.

In the United Kingdom two-thirds of all the electric lighting was in municipal plants, while in the United States only about 5 per cent. was municipal. The average rated capacity of the British station was about 1,400 kilowatts, while that of the United States was only 340 kilowatts. The total rated station capacity in Great Britain was, however, given as 480,000 kilowatts, while in this country the total in June, 1902, was 1,200,000 kilowatts. In Spain there were 5 watts of lighting capacity per inhabitant; in Germany, 7.5 watts; in England, 12 watts, and in the United States 16 watts.

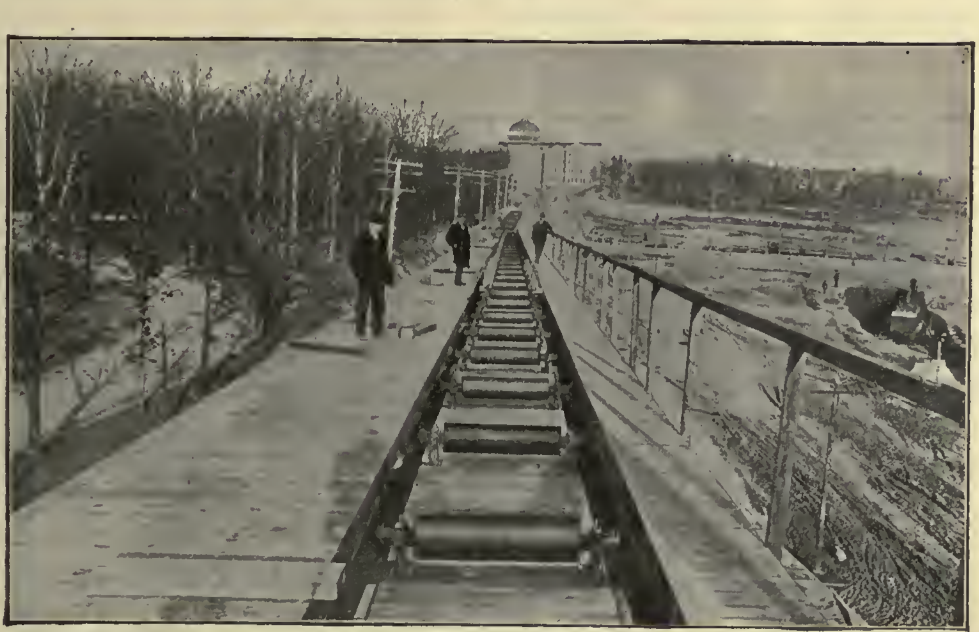
The report was replete with comparisons of this nature. The record of progress was also extended to cover the Nernst, the osmium-filament, the mercury vapor, special reflector incandescent and some newer lamps; it compared the advance of electric and gas-lighting, and discussed electric heating.

District Heating.

The report of the committee on district heating, Messrs. E. F. McCabe, D. F. McGee and C. R. Maunsell, was based on the replies to a list of 24 questions addressed to 100 companies. The 52 replies were tabulated in detail.

As a whole, it appears that the companies that are in the heating business are generally successful. Out of 35 steam systems, 31 state and show by figures returned that they are well pleased with their investments. Out of 15 hot-water systems, 11 are satisfied and 4 are not.

The best financial showing is made by those companies that charge by meters and cubic feet of air space, and insist on the use of economizing coils; that inspect and supervise the installation of buildings, and refuse to connect or give service to poorly designed heating systems; that keep separate accounts of heating and electric revenues and expenses. A few of the oldest plants report difficulties with the main lines. Only 21 companies see fit to provide for depreciation charges. On repairs most companies report low costs. The heating income pays 0.6 to 130 per cent. of the fuel bill for the entire year, averaging 60 per cent. for 30 companies. The heating investment ranges from 2 to 263 per cent. of the investment in electric plant, averaging 40 per cent. for 38 companies.



Two-Belt Conveyor: Rollers for Carrying Inner Belt.

ANTHRACITE COAL has been found near Bauff, Alberta, Canada, in a vein stated to be 10 feet thick and 10 miles long. This coal contains 75 to 80 per cent. of carbon.

CAISSON DISEASE is the malady resulting, in some cases, from working in confined spaces in which the air pressure is much above the normal atmospheric pressure. Dr. Leonard Hill, an English physician, states, according to the "Surveyor," that the real cause of the illness is the frothing off of air in the blood, a frothing which takes place when a man, after exposure to compressed air, is quickly "decompressed" or returned to the normal atmospheric pressure. The physical data given by Dr. Hill in this connection are abundantly sufficient to account for the severe distress thus set up. Each hundred volumes of human blood, under ordinary pressure, is capable of dissolving one volume of nitrogen, but, when saturated under four atmospheres' pressure, for example, it dissolves four volumes. Rapid "decompression," that is, the process of re-entering the normal atmosphere—results in the giving off, as bubbles, of the three volumes which have been absorbed in excess. These bubbles obstruct the circulation and set up varying forms of illness, such as deafness, vertigo, paralysis, and loss of consciousness. The lesson to be derived from the knowledge now available is, simply, to greatly extend the length of time during which transition from the one pressure to the other is effected, and to select for such work only young men of spare habit and temperate lives.

Conveying Belts in the Concrete Plant at the Washington Filters.

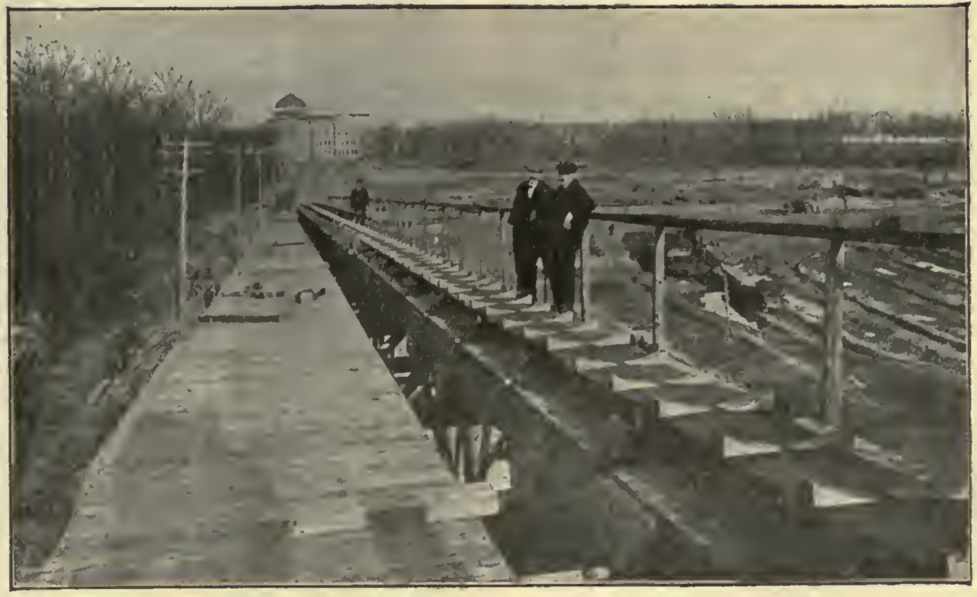
The 75,000,000-gallon slow-sand filtration plant for Washington, D. C., which has been under construction since early in 1903, has reached the stage of progress at which large quantities of concrete are being placed. An illustrated preliminary description of these filters was printed in this journal March 14, 1903. It is expected to have the works completed by the end of this year, and the time limit thus established has required rapid work on the excavation and the building of the concrete structures. The performance of the steam shovels used in the excavation was stated in the issue of April 16.

Considerably more than 110,000 cubic yards of concrete are required for the filter structures, which are being built practically entirely of this material. A large and complete plant has been installed for handling and mixing the ingredients and conveying the concrete to the forms. The sand, broken stone and gravel are delivered in hopper-bottom steel cars over a spur track, and are discharged from the cars onto a belt conveyor, by which they are separately delivered either to the mixer bins or to storage bins.

There are four concrete mixers of the cubical type, and they are each turning out on an average of about 200 cubic yards of concrete per day. From the mixers the concrete is discharged into buckets on cars on a track immediately under and in front of the mixers. These cars are then hauled to the site of the structure in which the concrete is being used. In some parts of the work the buckets are then taken by a Lidgerwood cableway and conveyed to the point of deposit for the concrete. Besides the conveyor belt carrying the concrete materials from the cars to the mixers or the storage bins there is another belt conveyor installed beneath the storage bins for supplying materials from these bins to the mixers in case of any interruption in the car delivery.

The belt conveyors in this equipment are of interest as being different from those with which engineers and contractors have become familiar from their frequent employment in other places. The better-known types of belt conveyors have one belt, which is formed into a trough shape to hold the load by means of concentrating rollers, of which there are usually three in a set, one under the bottom of the belt and one on each side, the latter being set at an angle. The type of belt conveyors at the Washington filters, however, makes use of two belts, an interior troughing and supporting belt and the load belt or conveying belt proper. The former runs over its individual head and tail pulleys, having separate take-ups, and is entirely independent of the latter. The conveying belt is threaded over its head and tail pulleys in the usual manner and has its separate take-up, so that the two belts, although moving together in the same direction at the same speed, are entirely separate and distinct. This enables the conveying belt to be lifted off the supporting belt and out of the troughing blocks and passed through either a stationary dumper or a movable tripper.

The conveying belt has no work put upon it other than that required to drive the lower carriers and its own head and tail pulleys; all the carriers on the upper line, which comprise two-thirds of the total number used, being revolved by the inner supporting belt. The strains, therefore, are divided, the belt revolving two-thirds of the moving parts not being subject to the wear and tear of carrying the load, and the belt carrying the load being relieved of the strains and wear and tear of revolving the majority of the moving parts of the machine, and this results in considerable economy, it is claimed.



Two-Belt Conveyor: Inner Belt in Position With Troughing Blocks Attached.

The interior belt is driven by a compensating drive from the main driving shaft, with the two belts in tension just sufficient to prevent slip on their driving pulleys; both belts move at exactly the same speed in the same direction and there is no rub of the conveying belt on the troughing blocks.

An accompanying illustration shows the carriers used in this system. They are straight rollers fastened to steel shafts revolving in babbitted boxes, the boxes being ball and socket, ring-oiling, felt-washered and dust-proof. By this method not only is cheapness attained in first cost, but power is saved and supervision is cut out as far as lubrication is concerned. A second view shows the interior troughing and carrying belt with its troughing blocks attached. The conveyor belt for the two-belt system is a machine-made belt with a protective cover. The inner or troughing belt carries the outer or conveying belt through the upper line of working travel and the outer belt carries the inner belt on its return. The ability to use straight rollers, all stresses being in compression and not bending, permits the use of light castings. This has a double advantage in reducing weight and cost and minimizing power. Only a clean belt comes in contact with the upper carriers. Other good points of the system will be apparent on examination.

The installation at the Washington filters was furnished by the Ridgway Belt Conveyor Company of 29 Broadway, New York, which owns the patents, fully protecting the system in both the United States and foreign countries.

The Detection and Prevention of Water Waste at Marion, Ohio.

Extracts from a paper by Mr. Edward H. Cowan, Superintendent, in the "Journal" of the New England Water-Works Association.

Marion is a rapidly growing city with a population of about 15,000, which obtains its water supply partly from an impounding reservoir and partly from ten 10-inch driven wells. During the lawn-sprinkling season of 1900 it was with the greatest difficulty that enough water could be obtained. It was considered that the use and waste of water was excessive, and that steps should be taken to reduce the consumption. Consequently it was determined to make a complete waste survey of the entire system.

It was thought that the greater part of the leakage was on the customers' side of the curb cocks, and subsequent events have shown that this view was correct. The installation of meters was decided upon, and has been going on ever since. The water-works plant is owned by a private company, and under the terms of its franchise a customer has his choice whether he will pay fixture or meter rates, in the latter case furnishing and maintaining his own meter. It is thus impossible to place a customer on a meter basis against his will, unless he be found wasting water, in which case the franchise provides that he may be required to buy a meter and pay meter rates, or his water may be shut off.

The policy adopted was, therefore, that the water company should place a meter on the service pipe of each fixture-rate customer, who should continue paying the same rate as before, so long as the meter showed him not to be wasting water. A monthly allowance is made for each individual customer, and if he uses more than this amount a postal card notice is sent him to the effect that his meter indicates a large waste of water, which must be stopped.

If at the end of the next month he is still using more than his allowance, the same notice is sent again, with the words "Second notice" stamped across the face. At the end of the third month the following is stamped on the postal card: "Last notice. We have already sent you several notices to this effect. If the amount used next month indicates a waste of water, you will be required to buy the meter and pay by the thousand gallons." At the end of the fourth month he is required to buy the meter as above, and pay the original cost of setting it.

The monthly allowance for any customer is obtained by dividing his monthly fixture rate by the regular meter rate per 1,000 gallons. If a customer should consume exactly his allowance each month, he would be obtaining water practically at meter rates, yet with the water company furnishing the meter, instead of the customer. The margin between what he does use and what he is allowed to use may be said to reimburse the water company for setting and maintaining the meter.

The apparatus used for the water waste detection survey consisted of a horse and wagon, a 1¼-inch Gem meter, nine 50-foot lengths of 2½-inch hose, gate keys, curb cock wrenches and lanterns. The writer took personal charge of the work and was assisted by two men, one of whom was an old employe, familiar with the system. The work was done between the hours of 10 p. m. and 5 a. m.

Washington Filters: Portion of Two-Belt Conveyor for Sand and Gravel.

After two or three nights it was found unnecessary to follow out in detail the original plan, but that certain modifications might be made which would greatly facilitate the work without making it any the less thorough. The original plan of operations will first be described and afterward the ways in which it was modified.

Two gates were closed, thus cutting out the section to be tested. This section will be referred to as a "block," although in some of the older parts of the town gates are as many as three or four blocks apart. A line of hose was laid from the nearest "live" fire hydrant to a "dead" one, and the meter placed in the line next to the "dead" hydrant. Both hydrants were then opened, and if the meter showed water to be passing into the "dead" block, its rate of flow was noted, and one of the men started to close the curb cocks in that section.

Careful watch was kept at the meter, and, if after closing any curb cock, the rate of flow diminished suddenly or ceased entirely, it was concluded that either there was a leak on that service or the customer was using water, and an investigation was made to determine which was the case. Whenever the flow ceased entirely the investigation of that section was at an end. After closing all curb cocks, if water was still running through the meter, one or more leaks were shown to be in the "dead" block, and they were located in every case by listening at the curb cocks.

The work went on in this manner, block after block, for several nights, resulting in the finding of only two or three leaks. The writer then concluded to try four or five blocks at once. In this case quite a number of gates had to be closed, and most of them were attended to in the daytime, leaving only as many to be closed in the night as were required for efficient fire service. At the first trial the meter stood still, so from that time on still larger sections of the town, containing from two to three miles of mains, were cut out and tested at once.

When a leak was found its rate of flow was noted, as before, and then the size of the "dead" section was reduced one block at a time by opening and closing the proper gates, working toward the meter. In this manner the block or blocks on which there were leaks were located.

After the first few nights the shutting off of curb cocks was discontinued, as very few leaks were being found, and those could be easily located, in the stillness of the night, by placing the ear against one end of the street key, holding the other end on the curb cock.

When testing two or three miles of mains at once, a simple system of lantern signals was used between the man at the meter and the men who were opening and closing gates. Sometimes these latter were nearly a mile away from the meter, and without signals much time would have been consumed going back to it after cutting in each new block.

The method of finding leaks in street mains and services above described proved perfectly successful, as well as economical. It is thought that no leak escaped detection.

THE STORAGE BATTERY AS A WATER-WHEEL GOVERNOR was described by Mr. B. F. Cresson, of Easton, Pa., at the National Electric Light Association convention. The water power supplies both a lighting and a railway load, driving synchronous motors direct coupled to railway generators, which work on a booster battery system. If the water wheel governors are cut out entirely, and the wheels run at constant gate opening, with a battery floating across the line, the variations in voltage at the alternating-current switchboard are within the range of a voltage regulator.

The New Works of Graham, Morton & Co., Leeds, England.

An industrial establishment which will appeal to American readers on account of its special provision for illumination and the quickness with which it was built, has recently been completed by Graham, Morton & Company, Leeds. This corporation manufactures retorts and charging apparatus for gas-works, conveying machinery for many purposes, mine cars, light railway equipment and structural steel-work. The new works cover nearly 77,000 square feet of a tract which was a marshy field a year ago, and were built in six months, being started up on November 2, 1903.

The main building is a 420x150-foot structure with steel framework, corrugated siding and 54,600 square feet of glazing, disposed in the walls and roof so as to make the interior remarkably light. The main floor is divided into three aisles, each with a roof like that shown in the view of the central aisle, although the roofs of the side aisles do not contain so much glazing as that in the center, because the illumination from the sides renders it unnecessary.

The Center Aisle of the New Shops of Graham, Morton & Company.

The left-hand aisle in the illustration is used by the structural steel department, which turns out railway and highway bridges as well as framing for buildings. The center aisle is used for smith work and the forges have their hoods connected to an exhaust duct leading out of doors. The right-hand bay is the fitting and machine shop, where several of the tools are of American manufacture. At one end of the building is located the tool room, with the store room adjoining. On the floor above, at one end, is the chain department, where link belts for conveyors are made, with a section near it devoted to the manufacture of idlers for belt conveyors. The entire works are operated by electricity furnished from a 50x55-foot power station.

All workmen entering and leaving the works pass through a time office, where each man registers his time on a Dey recording clock. There is also a system of bells here for the messenger boys, for the latter are used by the workmen to bring tools and supplies, thereby saving the time of the mechanics.

The pattern shop is a 60x24-foot building containing in addition to the woodworking tools needed in such a department and a storeroom for the patterns, a room for the supplies required by the erectors.

The offices are grouped in a 270x41-foot building located on a slope so that at one end there is a basement containing storerooms, lunch rooms, a reading room and minor offices. The main entrance hall on the first floor separates the drafting department from the offices. The drafting office is 117 feet long and at its extreme end is the weighing office with its windows looking out on the scales. The lighting of this building is as interesting as that of the shops. The roof is in three spans, the center one being glazed so that the center of the structure receives ample illumination. The windows are numerous and large, with their lower panes ground glass and the upper panes and the hinged ventilators transparent glass.

Freezing Water to Store It has been successfully adopted on the ranch of the Poindexter & Orr Company, nine miles south of Dillon, Mont. Natural reservoir sites are lacking in that vicinity, so Mr. Benjamin Bond, a Dillon engineer, constructed a series of shallow basins, into which the winter flow of a neighboring stream was directed and frozen. A series of levees were built with a grading machine, forming basins along the face of a gentle slope. The water was turned into the highest basin, overflowed when it was filled into the next one, and so on through the entire series. Two to three feet of ice formed, which melted in the spring and proved very useful for irrigation. The work was so successful and inexpensive that Mr. Bond has suggested the development of the plan on a larger scale, allowing the winter flow in the streams to pass slowly into basins so that it would freeze as it reached them, thus forming a mass of ice to melt slowly in the spring.

Letters to the Editor.

A Word about Photography.

Sir:—Within the last ten or fifteen years the engineering world has come to make extended use of photography in recording the various stages of developing enterprises, and the importance of this tool is now pretty well recognized in practice. There is no need at this time to enlarge upon the value of the camera in construction work, through the preservation of the details of difficult problems, or its usefulness to operating companies as an instantaneous and accurate eye-witness of unusual events like accidents, extra heavy traffic congestion and tests out of the ordinary day's run of business. During the construction and operation of the elevated railway lines in Boston the fullest use of photography was made by the engineering department of the operating company, pictures being taken of every detail of the work as it advanced from the structure foundations to the completed stations, tracks and cars. If the writer's memory is correct, the Boston Elevated Railway Company obtained in this way three or four thousand admirable photographs constituting a continuous history of the development of the overhead system that is almost invaluable to-day as an accurate and complete record. One of the company's civil engineers devoted his entire time to the work, and through his technical knowledge was able to secure pictures of scientific value, a result which could scarcely have been obtained by the employment of a professional photographer alone.

As far as the writer is aware, the engineering courses of many of our professional schools contain no instruction in either the theoretical or practical sides of photography. Doubtless numbers of students acquire the art as a pastime, in these days of inexpensive camera outfits, but it is not so easy to find amateurs who can secure good photographs of power-plant interiors and machinery as it is to locate experts in taking snapshots on sunny days. The instructing staff of every college is sure to include one or two skilled and enthusiastic devotees of the camera among its members; the departments of physics and chemistry are likely to have a dark room in common also, so that the teaching force and material for securing some sort of photographic instruction are generally available. There is little good reason why at least a short course in photography should not be made a part of every undergraduate engineer's curriculum. Even three or four weeks' practice in the photographic course gives a man sufficient facility in handling the camera to at least *take* satisfactory engineering photographs, and the time is pretty sure to come at some part of his professional life when the ability to use the photographic tool will be the means of illuminating facts and conditions in a striking and efficient manner. The power to make the pencil express one's ideas in designing is scarcely more useful than the ability to record the embodiments of those ideas in completed form upon the photographic plate and film, speaking in a broad sense.

Perhaps any recommendation which adds anything more to the already overladen curriculum is bound to be regarded as but one more straw laid upon the educational camel's back. It is certainly a difficult question to find time to cover the ground of engineering foundation studies in the space of four years. Nevertheless, the writer firmly believes that at least some practice in photography should be given to every student of engineering whose previous work or recreation has not included it. The chemistry of photography readily entitles the art to take its place in the laboratory of chemical science, and there certainly can be found matter in every technical course which is so useless from the standpoint of the engineering world's requirements that it may be replaced by a little photographic training to the advantage of the student who otherwise would know no more about taking pictures after graduation than he understands about the manipulation of an astronomical telescope. Anything which shortens the gap between the academic world and the field of commercial engineering is bound to work out as worth while when the student leaves the college life behind him, so long as it does not cut into the training in the great fundamental principles upon which engineering rests. That photography is yet to attain still greater importance in engineering practice cannot be doubted by anyone who has experienced its usefulness, and upon the strength of its present and prospective value to the engineer is based the belief that it should constitute at least a small part of every professional school's curriculum. Yours truly,

Denver, May 9. Howard S. Knowlton.

Tests of Piles.

Sir:—It is a well-known fact that piles, when left to stand for any length of time, have their supporting power considerably increased through various causes. The law of this increase is an important matter in connection with the use of any pile-driving formula.

I would be greatly pleased if contractors and inspectors having it within their power would test piles according to the following scheme and submit the data to me directly, or preferably, through the columns of your magazine: Length of pile, depth and kinds of materials penetrated, weight of hammer, height of fall for last blow, corresponding penetration, date and time of test, penetration under similar conditions approximately 1 hour later, penetration under similar conditions approximately 12 hours later, penetration under similar conditons approximately 24 hours later, penetraton under similar conditions approximately 3 days later. Exact date and time of each test and actual fall and penetration observed should be given.

Yours very truly, E. P. Goodrich.
New York, May 13.

Stress Diagrams.

Sir:—Will you kindly explain to me how to make a stress diagram of enclosed truss. The stumbling block is the extra load at a point near the apex, as well as the variation the truss takes from the regular Fink truss. Yours truly,

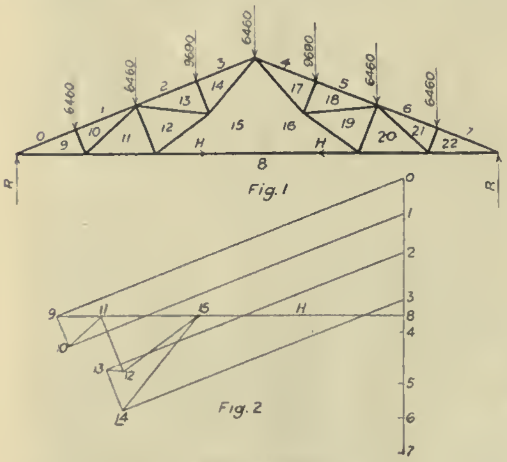
Newark, May 9. Charles J. Bock.

Sir:—In reply to the above inquiry I would like to state the following:

The problem presented by your correspondent has an apparent difficulty because of the five members which meet at the middle points of the inclined chord. Their number does not allow of the usual procedure in drawing the Cremona stress diagram beginning at the points of support and proceeding consecutively from panel point to panel point. This difficulty is not a real one, the truss as a whole being statically determinate. Trusses of this kind are treated by Professors Merriman and Jacoby in the second volume of their work on "Bridges and Roofs," under the heading, "Ambiguous Trusses." Most text books on bridges and graphical statistics consider one case or the other of such trusses. Mueller-Breslau in his great work, "Die Graphische Statik," gives several solutions of the most general character. The solutions given by Professors Merriman and Jacoby apply to certain cases, such as equal loads or panel lengths, parallelism of certain members, etc., or they depend on the introduction and temporary substitution of auxiliary web members. The solutions presented by Mueller-Breslau, on the contrary, are quite general. They are all based on the graphical determination of the amount of the stress in the member 8-15 and denoted by H, as shown in Figure 1. It is evident that the latter member may be replaced by the stress caused in it acting as an external force. This force being determined, the drawing of the stress diagram can proceed in the usual manner.

The easiest way to determine the value of the stress H in 8-15 is to take moments around the apex, a section through it cutting this member only. The loads and reactions being necessarily known, their resulting moment around the apex divided by the perpendicular distance to the connecting tie 8-15 gives the amount of its stress H. In drawing the stress diagram, Fig. 2, the vertical forces together with H are laid off to scale and the reciprocal figure is begun in the usual way by considering the end panel. When arriving at the intersection of 8-11-12-15, the place of the tie 8-15 is taken by the computed force H and 8-11 being determined before only two unknown stresses remain which can, of course, be drawn. Similarly only two unknown stresses remain in the panel point opposite. The stresses are thus found in the ordinary way and the closing of the diagram for one-half of the truss offers a check for the correctness of both the computation and the drawing. It will be noticed that this method is independent of any symmetrical disposition of loads or truss or of its geometrical figure as long as the general type of the truss is preserved. Fig. 2 shows the Cremona stress diagram drawn to scale for the truss and loads shown in Fig. 1. Respectfully,

New York, May 18. Leon S. Moisseiff.



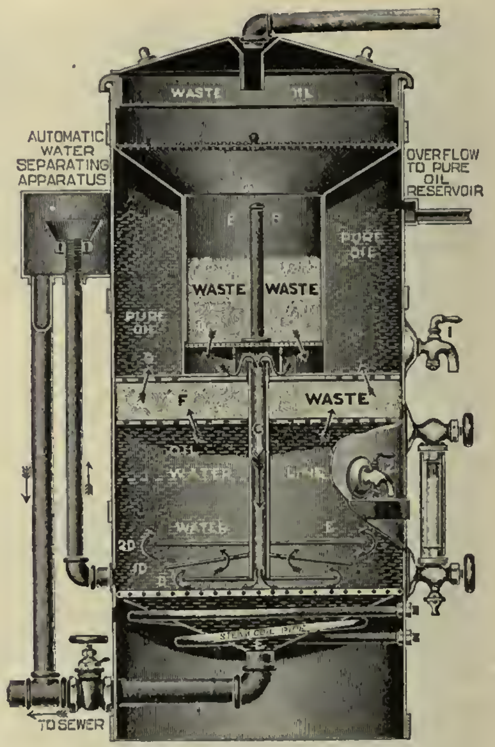
An Unusual Stress Diagram.

Steam Hose for blowing off the soot in boiler tubes can have its life increased fourfold by putting Greenfield tubing inside of it, according to Mr. Edgar B. Greene in a paper on economy in minor station supplies, read at the Boston convention of the National Electric Light Association.

The Refuse Destructor as a Steam Producer was referred to at a meeting of the Association of Municipal and County Engineers at Great Grimsby, England, in connection with a description of the destructor in operation at that place. The destructor is of the standard Horsfall type of 40 tons daily capacity, though it receives on the average only 18 1-2 tons daily. It is arranged to deliver steam to the adjoining municipal electric plant. For a period of three months 262,000 kilowatt-hours were generated in the latter and the total output from the steam from the destructor amounted to 36,300 kilowatt-hours, or about 11 per cent. of the total.

An Improved Cylinder-Oil Filter.

The accompanying cut illustrates a type of oil filter built for several years by the Burt Manufacturing Company, Akron, Ohio, in which several improvements have recently been made. As cylinder oil is the most expensive grade used about a plant, particular attention has been paid to this device, which is intended primarily for the purification and recovery of it. The oil enters at the top, passes through a filter of waste, and then flows down a central pipe to the water chamber in the bottom of the apparatus. It moves in a thin film along the lower surfaces of these plates and finally rises to the top of the chamber. Here it is intercepted by a second layer of waste, which further filters it before it passes into the pure-oil chamber. The sediment which collects in the bottom of the water chamber can be drawn off when necessary by opening the cock on the drain pipe leading to the sewer. The surplus water rises through a pipe leading from the bottom of the water chamber to a small overflow head in a box on the outside of the apparatus. The pure oil flows off by gravity.



An Improved Oil Filter.

It will be noticed that the location of the oil outlet pipe fixes the height of the back pressure head on the apparatus, while a cock in the water chamber enables the water level in the latter to be adjusted so that the automatic water separating apparatus will work without further attention. The apparatus is made in several sizes with capacities ranging from 3 to 500 gallons daily.

Utilizing Transformer Cooling Water for boiler feeding was outlined by Mr. George B. Tripp, of Colorado Springs, Colo., at the meeting of the National Electric Light Association. Owing to the cost of water, the supply from the city is automatically admitted into an elevated tank and the water led from it to the transformers and then discharged into a second or boiler suction tank. This is arranged to admit water from the upper tank whenever the supply from the transformers is insufficient in amount to supply the boilers and the second of the two boiler-feed pumps installed may be used automatically to return water to the elevated tank, when the water from the transformers exceeds in amount that required by the boilers.

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Dangers to Health at Panama.

During the last month this journal has received many inquiries from young engineers desirous of securing positions on the canal work at Panama, but deterred from applying to the Commission for such engagements through a very natural fear of dangers to health on the Isthmus, about which so much has been written. Many years ago, when the Panama Railroad was built the mortality among the laborers was very high, giving rise to the foolish statement that every cross-tie on the line represented a death on the construction force. Later, when the French engineers were making their attempt to dig the canal, the death rate was certainly very heavy, and this again gave rise to considerable fiction. Nobody expects to live as comfortably or as safely in the tropics as in the temperate regions, but it is now well-settled that under proper precautions a repetition of the mortality during the progress of early engineering work on the Isthmus need not occur. Unquestionably unacclimated persons will be exposed to a certain measure of risk, but it will not be so great as many assume nor so trifling as a few enthusiasts assert. These statements are made on the assumption that a thorough and vigorous sanitary supervision is exercised everywhere on the canal zone.

In order that those who desire to engage on the canal work may have a complete authoritative statement of the sanitary problem which the canal work presents, The Engineering Record has secured from Dr. W. C. Gorgas, assistant surgeon general, U. S. A., with the consent of Admiral Walker, president of the Isthmian Canal Commission, the article on the health conditions of Panama which appears on page 704 of this issue. It explains better than any previous note on this subject the nature of the dangers to health on the Isthmus, and the probability of keeping them under control. The statement may be regarded as conservative and exact. Dr. Gorgas is the leading American authority on the subject and speaks from the experience gained at Cuba during the American occupation of the island. His success in keeping down fever during the work in the streets of Havana was one of the most brilliant achievements in sanitation, and gave him an international reputation. For the first time in history he eliminated yellow fever from an endemic focus, and enabled the foul soil of the Cuban capital to be trenched without serious result to health. It is important to observe, however, the clear distinction he makes between the problem presented at Havana and that of the canal zone. At the former place, he had to contend with yellow fever, while at the latter the fight will be against malaria, which presents problems never before undertaken on a large scale. He believes these problems can be solved, although they are grave, but the solution will be neither easy nor simple. He looks for many disappointments and many modifications of the plans.

The danger to which the young engineer will be exposed will depend very largely on his personal care of his health. No one should think of going there who does not have a sound constitution and is not willing to exercise great care of himself at all times. What may be moderation in living in the temperate regions will very likely be excess on the Isthmus, and every one who observed carefully the condition of our men in Cuba knows that those who were most temperate and moderate in all habits were most healthy. The engineers who take part in the construction of the canal will be exposed to more dangers to their health than exist in most parts of the United States, but The Engineering Record believes these dangers are far over-estimated, as a rule. No small proportion of them will be eliminated if the plans of Dr. Gorgas and his associates receive the hearty support of all engaged on the work, which may be expected to be the case, for upon these plans depends the life or death of many men.

The construction of this canal, the greatest enterprise of the time, is a work which should attract to itself the best of the young engineers in the country. The commisioners are men who have ever been ready to give credit where credit was due and the chief engineer is a man whom it is great good fortune to serve under. The young men who win distinction there need not fear that their work will be unknown at home, for the nature of the service will be very different from the usual engagement in foreign lands. But the work will be harder than similar undertakings in this country, there will be fewer opportunities for amusement, and the conduct of daily life must be strictly guarded. Nobody who cannot be happy under strict discipline has any business to go to Panama, for all there will be made to conform to rules and regulations of many sorts which are not issued on work in temperate climates. But for those fitted by temperament for such work, of good physique and sound engineering knowledge of a practical character, the construction of the Panama canal offers work of a character which it is seldom the good fortune of young men to be connected with. To these young men it will be a great training school from which many graduates of distinction may be expected.

Fire-Resisting Construction.

It is generally known that the National Fire Protection Association, an organization of fire-insurance underwriters and allied interests, made a very complete study through its Committee on Fire-Resistive Construction of the ruins of the Baltimore buildings in the burned district. This investigation was conducted by men independent of any commercial alliance, and resulted in a report of the conditions in that city which is essentially the same as that published some time ago in The Engineering Record. The most important statements of the committee read as follows: "The Baltimore conflagration is directly chargeable to unprotected fire openings. Had the stair and elevator openings in the building where the fire originated been properly protected, there is every reason to believe that the fire department would have been able to control the fire at the start." Such an unqualified statement should attract the attention of those responsible for the building regulations of our cities, for if the terrible loss in Baltimore could have been prevented by sound methods of construction, these should certainly be required at once in all buildings in all our cities. The protective measures recommended by the committee are both simple and inexpensive, and their only serious drawback is the limitation they place on the decorative features of a building. "All floor opening," the committee states, "should be enclosed in brick-walled shafts crowned by a thin glass skylight and extended through the roof, with fire doors at the openings to the stories." It is considered quite as important to protect the floor openings in buildings of ordinary construction as in those of the fire-resisting type.

The fact that the fire-proof office building as ordinarily built is not a barrier to the spread of a serious fire has been pointed out several times in this journal, and the committee lays considerable stress on the point. "From a fire-protection viewpoint," it states, "it is essential that solid brick walls without openings of any kind should be provided wherever possible. Where windows or other openings of any kind are necessary they should be few in number and of small area. They should also be provided with the best known devices for the protection of such openings against fire. This conflagration has again demonstrated that where subjected to fire the most vulnerable parts in buildings of fire-resistive construction are the window and wall openings."

The design of window openings is dependent on so many conditions that their fire hazard cannot always be made as preponderating in its influence as is desirable. From the point of view of resistance to fire, all window openings should be single, in order to avoid the use of mullions and light piers which are quickly destroyed. The large cast-iron mullions over the windows of some of the Baltimore buildings caused considerable trouble by their expansion. In general, it may be said that in order to protect buildings against exterior fires and to prevent the spread of fires from within, standard fire shutters and doors and wired and prism glass in substantial metallic frames must be provided. This statement has been made several times in The Engineering Record, and is expressed by the committee very distinctly; indeed, its report says on this subject: "The general absence of protection at exposed wall openings is responsible for the spread of this (Baltimore) conflagration more than any other cause. In fact, this condition may be safely stated to have been the cause for the spread of this fire beyond the department control." Such a statement is particularly gratifying, because this journal has held for some time that fire-protection was more defective to-day through a lack of appreciation of its general requirements than any want of materials suitable for use in a fire-resisting building. Just so long as owners will insist on buildings having large floor areas without fire partitions and full of inflammable materials, stair and elevator shafts without walls, and enormous expanses of window openings without proper protection for them or suitable materials in them, a repetition of the Baltimore fire may be expected in every large city. No fire department, however capable, can be expected to accomplish the impossible, and that is the task which the owners of department stores apparently put on our fire chiefs.

It is interesting to observe that the defects of fire-proofing which the committee found were those that have been repeatedly criticised by engineers. Ordinary red brick laid properly in cement mortar proved to be the best protection for steel columns. Where tile proved defective for column casings it was because of its thinness and the inferior manner in which it was put in place. It is not just to charge this latter condition against the material, although most builders will probably agree that the mortar and the workmanship used in tile construction are often inferior to those with brick masonry. The practice of carrying pipes close to columns inevitably leads to some mutilation of the protective covering, and advantage is too often taken of the readiness with which tile can be chipped to fit about a pipe. Tile floor arches were found to be affected more from their thinness than any other cause. The committee makes the same criticism of defective flange protection which has been offered many times before. "The failure of this protection," it states, "was due to a variety of causes, the most apparent being the failure of the sheet-metal clips used to hold the flange tile, the dropping of tile which was held only by mortar, the breaking off of the skewbacks with the lower web of the tile arches, and the breaking off of the shoe tile at a point opposite the edges of the flanges." These defects relate, however, to the value of the tile as a protection of metal. As a floor material the committee expresses the opinion of most observers in stating that it resisted the severe heat when loaded, and the breaking off of large areas of its lower webs was its most serious defect. This is a matter which the makers can doubtless correct, although it is beyond their power to prevent the wanton destruction of this web over large areas by workmen engaged in placing the interior finish. In fact, the fire shows pretty conclusively that tile is an admirable material, but is too often misused by those who put it in place. It is equally true that the forms in which it is made are open to improvement.

So much has been said about the resistance of concrete in these buildings, that the exact words of the committee's report are of interest; they read: "Concrete floor arch construction was used in only a few buildings that were exposed to this conflagration, the highest being only four stories. As far as here tested the concrete seems to have stood up well."

One feature of the committee's report which is of particular interest to designers of structural steel relates to the deflection of columns in some of the buildings. Those columns which had equal transverse stiffness in every direction merely settled vertically downward. In the Calvert Building, where box sections were used, two posts were affected, each of which buckled uniformly on all sides. In contrast with this may be mentioned a column in the Maryland Trust Building, made of two channels. This bent into the form of the letter S.

Attention is called particularly to these features of construction and to the committee's comments on them because their improvement is a matter largely in the hands of architectural engineers and contractors. The really vital aspects of fire-protective construction, relating to the design of the buildings, are up to the owners. Their professional advisers cannot often compel them to adopt the safest construction, even when the fire insurance underwriters try to influence them along the right way by the coercive stimulus of well-arranged rates. Good steel, tile and concrete construction can be secured by anyone willing to pay for it, but not at the price of cheap materials and workmanship, such as too often are deemed all that are necessary. Costly decoration will not make a structure fire-proof, which is one of the most important lessons to be drawn by owners from recent fires.

Curved Masonry Dams.

The design of masonry dams has been brought to a satisfactory degree of excellence if the center line of the structure is assumed to be straight. Most of the high masonry dams of the world, like the new Croton, are straight and the analysis of stress conditions in them involves no special difficulties under the assumptions ordinarily made, which are at least sufficiently exact for most practical purposes. These assumptions may be questioned in some respects, as, for instance, the condition of uniformly varying stress in any horizontal section of the dam or the effect of partial submersion of the lower part of the structure, yet the variations from extreme accuracy due to such doubtful features cannot be serious. Nor again does the varying temperature from one portion of the year to another materially affect the problem of design, although fine cracks may occasionally result from this cause. If the selection and treatment of the materials used be such as conform to the requirements of the best engineering practice, no sensibly disturbing effects need be apprehended.

If, on the other hand, the dam be curved, stress conditions vastly more complicated than those found in the straight dam at once ensue. As in every other case of complicated engineering conditions, there are always approximate methods available which, while they are not of a character to meet the requirements of exact analysis, may be employed to demonstrate conclusively the safety of the design. It is obvious that if a high masonry dam be curved while its cross-section is designed on a purely gravity basis, it will certainly be safe—that is, the curvature may reasonably be expected to aid its stability at least slightly. Again, if it is sharply curved like the Sweetwater dam in California, and if computations show that it is safely capable as a horizontal arch to carry the water pressure against it without regard to any gravity considerations, its weight will increase its margin of safety, at least to a small extent. If, however, an attempt be made to design such a curved structure, the simple circle being assumed for the horizontal curvature, as is usually the case in curved dams, the analytic work involved if based upon a combination of the effects of gravity and curvature, will be found to be exceedingly complicated; indeed, the accurate treatment of the case has not yet been written.

Probably the nearest approach to a close rational treatment of a high curved masonry dam is that given by Mr. S. H. Woodard in Part II of the paper on the Lake Cheesman dam, in the "Proceedings" of the American Society of Civil Engineers for March of the current year. The total length of this masonry dam is about 700 feet, and its maximum height for a short distance only is about 230 feet. The horizontal curvature of its upstream face has a radius of 400 feet. The rocky gorge in which the dam is located is admirably adapted to a curved structure. The peculiarity of this dam lies in the fact that it possesses a cross-section giving ample stability when its weight alone is considered. On the other hand its curvature is sufficiently sharp to give it complete stability without regard to its weight, the rigidity of its natural rock abutments affording it abundant support. In his paper, Mr. Woodard undertakes to investigate the conditions of stress on a basis of the combined influence of gravity and curvature and ascertains with a fair degree of approximation the amount of resistance offered by the horizontal arch and by gravity. He reasons properly that the relative values of the two parts of the total resistance will depend upon the effects produced by the yielding of the masonry. The actual vertical transverse section of the dam may represent a vertical cantilever beam loaded horizontally, with the water pressure increasing from an intensity of zero at the top of the dam to a maximum value at the bottom. The loading carried on the arch will produce a deflection equal to that produced on the cantilever beam by the loading which it carries. Starting with this fundamental condition and simplifying his analysis by assumptions which do not greatly detract from its accuracy, Mr. Woodard finds, as might be anticipated that the curvature largely reinforces the top or thinner part of the dam but adds little to the stability of the lower part. The reinforcement is thus seen to be the greatest where it is most needed.

This treatment of so complicated an engineering problem is interesting and valuable, but it falls short of meeting all the requirements of the case. It leaves without complete answer, inquiries which may be legitimately made as to the stress conditions in thin curved dams like the Sweetwater structure in California and the Rio Grande dam in the Panama canal zone, built by Mr. Bunau Varilla fifteen or more years ago. Essentially, Mr. Woodard treats his horizontal arches as if made of elastic blocks of stone and as if the ends were hinged. For his purpose that may be sufficient, indeed, it probably is sufficient. In the broad problem, however, the horizontal arch should be treated as an elastic arched rib, subject to bending as well as to the direct arch thrust. These curved masonry dams are practically monoliths possessing some capacity of resistance to bending. It is only rational, therefore, that such capacity should be recognized in the analytic treatment of them. In consequence of the low coefficient of elasticity of even the best masonry, it is not probable that the bending stresses in an elastic masonry rib will be of sufficient magnitude to be serious, but the problem cannot be considered satisfactorily treated until they are recognized. Similarly, stresses in the masonry of curved dams due to variations of temperature or to deformations from any other cause must also be treated from the same point of view of the elastic arched rib, or at any rate they may be so treated. All this sounds like carrying stress analysis to a degree of unnecessary refinement, but in view of the many advances in modern engineering science, it is a little rash to hold such a view too stiffly. The theory of the arched rib properly handled may be considered almost or quite simple, and a ready method of combining it with the gravity treatment of a dam is by no means impossible.

Regarding Rake-Offs.

A few weeks ago a well-known manufacturer was asked why his excellent products were not used in a certain class of structures for which their fitness is generally recognized. In reply he stated that the expense of introducing them for that particular object was so great that it was unprofitable to put any serious work by the selling department on it. Recently an explanation of this statement has come to hand. The plans and specifications for a work of this nature were found to require all bidders to tender on a certain make of the products in question. One prospective bidder requested permission to employ, under guaranty as to quality, a different make of such materials, but this was refused. On inquiry as to the reason for the refusal, he was told that the parties preparing the plans and specifications had learned by experience and careful investigation that the materials called for would answer the purpose, which every one knows they certainly would. To secure equally definite information concerning any other make, the designers claimed that they would be compelled to make more investigations, requiring considerable time and money. They saw no reason for doing this so long as they had satisfactory knowledge of good materials of reasonable cost. If any maker of rival materials cared to pay them a proper fee, it was stated, they would investigate the products and, if suitable, admit them to their specifications.

To the average manufacturer, such a statement seems only a request for a commission. In this particular case the designers of the works are men above suspicion, and The Engineering Record is confident they took the view stated, which may have been distorted in repetition from person to person, in order to protect themselves from sales agents and their clients from poor materials. It goes without saying, however, that unscrupulous men could use such arguments as a club to pound out commissions, and there is unfortunately some reason for believing that this is actually done. Consequently, the reputable designers suffer for the practice of the disreputable. The remedy lies in the investigation of new materials as a part of the regular work of a designing office, the cost being charged to office expenses, like rent and similar items.

These facts are mentioned as indicating the top limit of the rake-off subject, where the line between conservatism and commissions cannot be readily drawn. As a good example of the lowest limit, attention is drawn to a decision of the Supreme Court of Illinois, printed in 70 N. E. Rep., page 906. According to this decision, a contract was made in 1895 between the Universal Gas Company of Chicago, party of the first part, and Andrew E. Smythe, party of the second part, to construct a gas plant for $1,177,000. The contract states that the plant is "to be built and constructed under the supervision of C. H. Evans, engineer, and, in case of his death, removal or disability, then under such other engineer as may be designated by said party of the first part, which said engineer shall pass upon the sufficiency of the work done under said contract, the workmanship and material to be first-class in all respects and the work to be done to the satisfaction and acceptance of the engineer in charge." Testimony was given proving that Evans acted as chief engineer of the gas company during the preparation of the plans, which tends to show that he was also in charge for the company during construction, as claimed.

Three years ago he filed a claim for $125,000 against the estate of Smythe, who died after the completion of the works in 1897. He claimed that he was to have half the profits of Smythe in the contract for building the works, and that the latter paid him $30,000 on account before his death, both statements being unsupported by competent testimony. The estate resisted this claim not only on the ground that no such agreement existed, but also because it would have been contrary to public policy had it been made. The court rules very strongly and definitely on this subject in the following words: "One man cannot serve two masters with reference to any matter where their interests are adverse, and it matters not whether one of those masters be a corporation, whether the servant be a director or agent. . . . If he [Evans] was also in the employ of Smythe, the contractor, and entitled to receive from Smythe one-half of the profits realized by the latter from the contract, then he was in a position where absolute loyalty to the interests of his employer, the Universal Gas Company, would bring him in conflict with his own interests as an employe of Smythe, because in the latter capacity it would advance his own interests to accept, as a compliance with the contract, workmanship and material of a cheaper grade than first-class, for the reason that Smythe's profits, and consequently his own compensation, would thereby be increased."

On the face of the testimony this suit is one of the worst ever rejected as contrary to public policy, but it has certain mitigating features which may be brought out in another trial. In the first place, Smythe was apparently without experience in gas-works construction, and may have desired Evans' help on grounds as justifiable commercially as they would be unjustifiable professionally. If the Universal Gas Company was aware of and consented to the agreement between its engineer and its contractor, then the matter was simply a case of unbusinesslike management by the company, which left it at the mercy of two men. But to prove this acquiescence in such an arrangement, Evans must introduce preponderating testimony "that the Universal Gas Company, acting through or by the authority of its board of directors, expressly agreed that he should enter into the contract with Smythe, or that, after the contract with Smythe had been made, the gas company was made aware of all the material facts, and then, through or by the authority of its board of directors, acquiesced and expressly ratified the action of its agent, Evans, in entering into that agreement." The mere knowledge by the company of such an agreement is not enough.

Attention is called particularly to this case because it shows the danger to an engineer's reputation which such a serious deviation from regular professional procedure involves. It seems unlikely that such a suit would be brought unless the gas company had consented to the agreement of Evans and Smythe, for, without such consent, the agreement is manifestly no more binding in law than a gambling debt, being directly contrary to public policy. The retrial of the case, to determine the attitude of the gas company, will be of much interest, for it rarely happens that an engineer or architect seeks the assistance of the court in obtaining commissions. The importance of the judicial opinion just rendered lies in its statement of the conditions under which an engineer is legally entitled to a commission. Professionally, he is never justified in accepting one.

Notes and Comments.

Rock Drilling Tests made in South Africa by Messrs. J. B. Carper, E. Goffe and W. C. Docharty, are described in a paper by them before the Mechanical Engineers' Association of the Witwatersrand. The tests were made by drilling holes in a 2-foot granite slab, and a Rand drill proved most economical in air-consumption of the many tested.

The Telephone Tunnels in Chicago between the La Salle Street and Union Passenger stations are to be used in transferring mail matter, according to an agreement recently made between the Post Office Department and the Illinois Tunnel Company. This experiment will be made to determine the practicability of the system, for it will involve handling the mails between the special trains of the Lake Shore and Burlington roads. These mails must be transferred without any delay, and will prove a searching test of the system.

The Kansas City Floods of last year are now being repeated, just as was predicted by the board of army engineer officers last winter. A number of temporary pile bridges across the Kaw River have been washed out and more or less damage done to other interests. According to the eminent members of the Corps of Engineers who investigated the present conditions at Kansas City, this damage by flood may be expected every year, until the river channel is restored to its original unrestricted condition or an equivalent. Some floods are due to unprecedented causes which cannot be foreseen, but the troubles at this place manifestly arise in a large measure from a failure to obey the elementary laws of nature, which have never yet been relaxed for the convenience of railways or municipalities.

The Lowering of the Chicago Tunnels was recently the subject of a hearing before Col. O. H. Ernst, Corps of Engineers, U. S. A. While the city owned two of the tunnels, it claimed that the Union Traction Company, which used them, should bear the expense of the work, although the city asserted the right to do the work itself or have it done by methods which it approves. The company maintained that the city should bear the cost of the work on the two tunnels it owned, while, in the case of the third, the company claimed riparian ownership and consequent exemption from assessment of the cost of lowering the tunnel. When it was built it was 2 feet below the river bed and consequently caused no inconvience, and if it is lowered the company claimed it should not be held responsible for the expense of the work. Other witnesses asked to have the ends of the approaches closed by cofferdams and the tunnels removed at once, in order to improve the navigation of the river, and the Chicago drainage board offered to pay the expense of the bulkheads if this was done. Other aspects of the work were discussed by those present at the hearing, and finally Messrs. Isham Randolph, S. G. Artingstall and George W. Jackson were asked to prepare plans independently for the work.

The Water Supply System of St. Louis.

By W. E. Rolfe, Engineer in Charge of Distribution.

The present water supply system of the city of St. Louis is the result of development. The growth of the city has necessitated steady and rapid improvement and extension of the water works. Owing to the able management of a line of capable water commissioners, St. Louis to-day stands among the foremost of properly equipped American cities. Her pumps are the best, her supply of the purest, and her distributing facilities unequaled.

Historical.—The first step toward the establishment of a water works system was taken in 1829. At that time a twenty-five-year contract was let for furnishing "clarified" water, the approximate supply being for "about one hundred taps, twelve fire plugs and a fountain in Mr. Ashley's yard." Through various vicissitudes, owing to non-fulfillment of this contract, the city arrived at the point of borrowing $25,000 in 1831 with which to complete the plant. Later, in 1835, the city became sole owner of her water works, the cost to that date being $54,000. The establishment of a succession of pumping stations and reservoirs of increasing size followed this acquisition until, in 1863, the "new works" were authorized by the State legislature, and a board of water commissioners was established.

The plan proposed, provided for taking water from the Mississippi River at the Chain of Rocks. This was rejected by the city council and a newly-appointed board of water commissioners, after considerable planning, fixed the location of the plant at Bissell's Point. A $3,000,000 bond issue provided the funds, and the works were started in 1867 and finished in 1872. The water works at this time consisted of a low-service station, four settling basins and a high-service station with a connecting storage reservoir at Compton Hill. The total capacity of the works was 32,000,000 gallons per day.

The city adopted a new charter in 1876, the board of water commissioners being replaced by a single commissioner. Additions to the existing system, including a second high-service station and extensive additions to the distributing system, were begun in 1881 and continued until 1894, the capacity of the entire system at that time being between 60,000,000 and 65,000,000 gallons per day.

St. Louis Water Works: Bissell's Point Pumping Station Supplying the Low-Level District of the High Service.

The ordinance under which the recent large extensions have been made was passed in 1887. This act provided for the establishment of a low-service station at the Chain of Rocks with a capacity of 100,000,000 gallons per day. Later, in 1893, the Baden high-service station was authorized, this having become necessary in furnishing an adequate supply for the higher portions of the city, then out of reach of the existing high-service stations at Bissell's Point. The work authorized by these ordinances is now complete, and further improvements and extensions are now under construction.

General Outline of the System.—The general plan of the system is shown on the accompanying map of the city, and the views reproduced from photographs by Mr. A. Z. Howe, of the water department, show the important structures. The water is taken from the river and clarified at the Chain of Rocks, the extreme northern end of the city limits. This point is 7 miles below the junction of the Mississippi and Missouri rivers. The current of the latter stream is well defined for several miles below the junction, and the water received into the city is in large proportion from this source.

From the Chain of Rocks the water flows through a conduit to the high-service pumping plants at Baden and Bissell's Point. The first mentioned station supplies the higher portions of the city, and the Bissell's Point plant the lower. The necessity for a double system of high-service pumps is due to the great differences of elevation, the city being built on a series of terraces, rising westwardly to a height of 200 feet above the river.

The distribution system is shown in skeleton outline. The pressure in the Baden or high-level district is regulated by an overflow standpipe located on Compton hill, one of the highest points in the city. The low-level district is supplied with two standpipes located near the pumps, serving only as pressure regulators, and a storage reservoir of 60,000,000 gallons capacity, also located on Compton hill. In addition to its function as a storage basin for the low-level district, this reservoir receives the surplus water from the high-level standpipe. In times of excessive draft on the low-level district, the supply is increased by means of extra pumping over this overflow, the pumps being operated more economically at Baden than at Bissell's Point.

The Low Service Station.—The water is taken from the river at the Chain of Rocks through an inlet tower communicating, by means of a down-take shaft, tunnel and up-take shaft, with the screen chamber and wet well of the pumps. The tower is of massive masonry construction with 4x6-foot inlet gates at different levels. The foundation of the tower extends to the bed rock of the river channel, the tunnel being bored through solid rock and lined with brick. The total length of the tunnel is 2,200 feet, and the diameter 7 feet. It is in two sections, the intake tunnel, 1,550 feet in length and the inshore tunnel 650 feet in length, the latter section being elevated 30 feet above the former, communicating through an up-take shaft. From the wet well at the inshore end of the tunnel the water is raised through a height of 70 feet to a delivery well connecting with the filling conduit, from which it is discharged into the settling basins.

The equipment of the pumping station consists of two Worthington compound duplex and four Allis compound pumps, arranged in pairs. The Worthington pumps are of 20,000,000 gallons capacity each, and the Allis of 30,000,000 each. The total pumping capacity of the station is 160,000,000 gallons per day, the maximum capacity for continuous operation being 100,000,000 gallons. The boiler equipment consists of three batteries of two water-tube boilers each, working under a pressure of 125 pounds, the total horse-power being 1,800. The station has a coal storage capacity of 45,000 bushels.

The Settling Basins and Conduit.—The settling basins are six in number, each 400x740 feet, of 30,000,000 gallons capacity. The method of operating the basins, until the recent introduction of a scheme of coagulation, consisted in an alternate fill and draw plan, in such order as to permit of a simple settlement of 24 hours. At the end of the time specified the water was drawn off through the drawing conduit. This plan was effective in accomplishing the removal of the greater part of the heavy matter in the water, but the product was far from clear. A peculiarity of Mississippi water is the possession of a certain amount of finely divided matter held in suspension, which plain settling will not remove in any length of time.

Various remedial measures have been suggested from time to time for doing away with this condition, and the plan finally adopted was that of coagulation and sedimentation, with sulphate of iron and lime as a medium. The various systems of coagulation in general use received scant consideration previously to the inauguration of the present municipal administration. Filtration schemes in plenty were suggested, but were found to be undesirable and impracticable on account of the entailed expense of installation and operation.

During the past year extensive changes and improvements have been made in the settling basins with a view to the proper operation of the system. The separating walls, formerly on the same level, have been so altered as to permit of a slight drop from basin to basin, throughout the series. The top surfaces of the walls have a slight fall with double rows of brick set on end to break up the moving sheet of water and so aid in mixing and aerating it. The basins are arranged in three pairs, the separating walls between basins being 8 feet thick and the separation between pairs being 40 feet. The sloping tops afford a drop of 6 inches over the 8-foot walls and of 12 inches over the 40-foot spaces. A receiving and stilling chamber communicating with the discharge chamber of the pumps extends nearly the full length of the first basin of the series, a distance of 610 feet. From this chamber the water flows in an even, thin sheet into the basin.

The sulphate of iron is introduced into the water in the up-take shaft of the tunnel. After passage through the pumps the lime is added in the discharge well, the proportions of both constituents being altered as required by the chemical conditions of the water. The apparent crudeness of these arrangements is due to the hurried installation of the system in advance of the opening of the World's Fair. More convenient and elaborate mixing facilities will be installed later. The desirability of the points now in use as the proper locations for the introduction of the coagulant has been proved by experiment. Future investigation may develop more accurate knowledge on this point.

The method of introduction of the lime differs from the plan usually pursued, in that it is introduced in the form of "milk of lime" (lime slacked with warm water). The ordinary method is to dissolve the lime and introduce the solution (lime water) into the supply. This would have necessitated enormous storage capacity for the lime water, which would have been impracticable. No precedent exists for the adoption of the plan in use in St. Louis, and its successful operation is highly gratifying. Coagulation has been found to be complete in the first basin and precipitation practically so in the third. Eighty-five per cent. of the total precipitation takes place in the first basin.

The great improvement in the clearness of the supply is decidedly marked, even at the present comparatively experimental stage of the system's operation. It is confidently expected that, with the completion of the work, a high degree of clarification will be readily and constantly maintained at a very small cost. The present cost of operation is about three mills per week per inhabitant, basing the calculation on an estimated population of 700,000.

An important item in the operation of the system is the cleaning of the basins and the removal of the heavy precipitated matter. The original method was by means of alternate emptying and removing of the deposit with manual labor. This plan has been partly superseded by an electrically-operated suction dredge with flexible discharge.

Two Stand Pipes in Low-Level District; Compton Hill Tower, in Center.

The dredge is drawn across the basin by winding a cable on a drum. Through a narrow suction opening 10 feet in lateral dimension, the deposit mixed with water, is drawn by a rotary pump, the suction resting on the bottom of the basin as the dredge moves across. The power for the operation of the dredge is furnished from the water works electric plant. The sediment from the bottom of the basin has been found to constitute about 40 per cent. of the discharge. In the completed system it is proposed to introduce a series of by-pass siphons as an aid in the cleaning operations. By means of these siphons any basin may be taken out of service for cleaning or examination, the water by-passing temporarily to the next succeeding basin. The siphons are of cast iron 7 feet by 3 feet in effective section, arranged in batteries of two, and supplied with air-pump connections for producing flow. They are now being installed.

The improved clarification of St. Louis' water supply is of incalculable benefit to the city. The purity of the supply has never been called seriously in question and health department records show remarkable freedom from water-borne diseases. The supply has, however, long enjoyed a rather uncomplimentary reputation on account of its muddiness. The city bacteriologist now reports the removal of 90 per cent. of the bacteria contained in the water during its heaviest stages. One of the most notable and valuable results of the clarification is the greater adaptability of the water for steam-boiler use. Fully one-half of the scale-producing matter is done away with by the process of precipitation, and steam users throughout the city are much pleased.

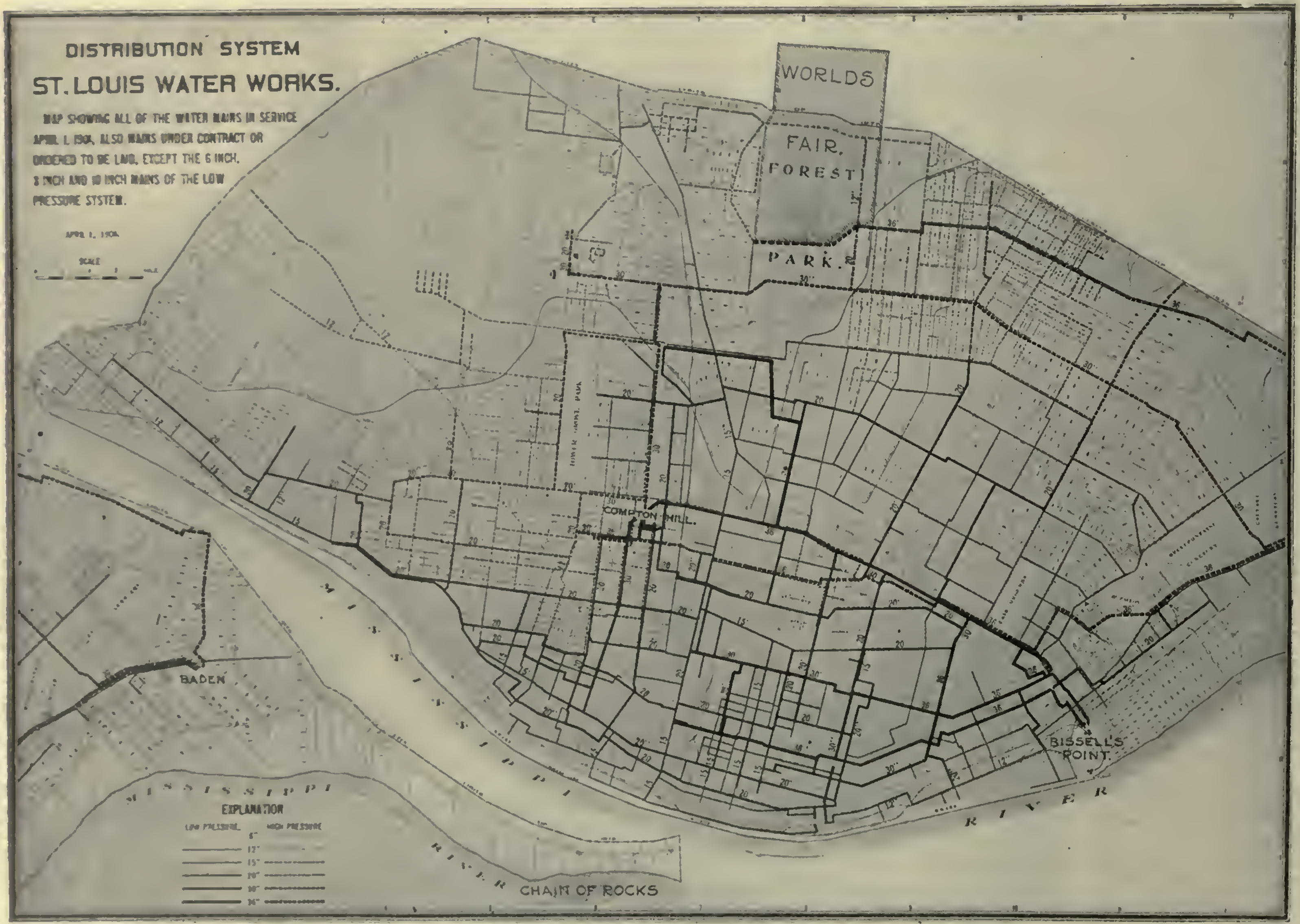
Proposed extensions of the system of settling basins include two additional basins at the Chain of Rocks to permit of prolonging the time of settlement and a storage reservoir at Baden. The new settling basins are to be of equal capacity with those now in operation, and the Baden storage will have a capacity of 25,000,000 gallons.

From the drawing conduit of the settling basins the city's supply is carried by gravity flow to the high-service stations at Baden and Bissell's Point. From the Chain of Rocks to Baden the carrying conduit is 4 miles in length and 11 feet in diameter. From the Chain of Rocks to Bissell's Point the diameter is 9 feet and the length 3.4 miles. It is of cement-lined brick construction. In cross-section it is in the form of the upper half of an ellipse with the major axis vertical, the lower half of the curve being replaced by a flat inverted arch. Its course parallels the river bank, falling with a uniform slope of one in 10,000. The total discharging capacity is 115,000,000 gallons per day through the 11-foot section and 75,000,000 gallons through the 9-foot section.

The High-Level Station.—The equipment of the Baden pumping station consists of six Allis triple-expansion engines, two of 10,000,000 gallons and four of 15,000,000 gallons capacity, the total capacity being 80,000,000 gallons per twenty-four hours. The boiler plant contains four batteries of two water-tube boilers each, with Hawley down-draft furnaces, the total horse-power being 2,400. A coal storage shed is located at this point with a capacity of 115,000 bushels in addition to the regular coal house, the capacity of which is 20,000 bushels. This station supplies approximately all points of the city having elevations between 75 and 200 feet above the city datum.

In addition to the pumping plant the Baden station contains the electric light and power plant maintained by the water works. From this plant the entire system of three pumping stations is lighted and the suction dredge and electric railway operated. The lighting equipment of the electric station consists of one 100-kilowatt alternating current, 1,150-volt, direct-connected Westinghouse generator, carrying the full lighting load of the system. The lighting necessary during the daytime is carried by a 20-kilowatt 1,150-volt generator of the same type, direct-connected to a Pelton water wheel. The power equipment consists of one 100-kilowatt, 550-volt Westinghouse, and one 25-kilowatt, 110-volt General Electric generator, both direct-connected.

The electric railway is now in operation between Baden and the Chain of Rocks, a distance of about 4¼ miles. One passenger car is operated at present, five regular trips being made daily in transporting the employes of the water works, the regular street railways of the city extending only to the Baden station. Additional trips are made when necessary for the transportation of light freights and for the emergencies occasionally arising in operation of the works. The roadway of the electric line is used for the regular transportation and switching of coal and supplies to the Chain of Rocks, the work being handled by steam locomotives under contract with the local railroads. The purchase of a locomotive is now pending and it is proposed ultimately to handle this work in the water department.


DISTRIBUTION SYSTEM
ST. LOUIS WATER WORKS.
MAP SHOWING ALL OF THE WATER MAINS IN SERVICE APRIL 1, 1904, ALSO MAINS UNDER CONTRACT OR ORDERED TO BE LAID, EXCEPT THE 6 INCH, 8 INCH AND 10 INCH MAINS OF THE LOW PRESSURE SYSTEM.
APRIL 1, 1904.
SCALE
WORLDS FAIR. FOREST PARK.
COMPTON HILL.
BADEN
BISSELL'S POINT
MISSISSIPPI RIVER
CHAIN OF ROCKS
EXPLANATION
LOW PRESSURE
HIGH PRESSURE
6"
12"
15"
20"
30"
36"

The electric road is now being extended from Baden to Bissell's Point. The completion of this addition to the present equipment, with the introduction of the locomotive, will make the water works independent of the uncertainties of regular railway switching, and all transportation will be handled on water-works property, by water-works equipment. The distances separating the several stations make this improvement particularly desirable from the standpoint of economy and convenience. The annual cost of operation of the electric plant for lighting the water-works stations and operating the railway is practically $9,000. The same service, before the installation of the plant, cost $16,500, of which amount $11,000 was for lighting and $5,500 for switching.

The Low-Level Station.—The Bissell's Point station is the original water-works plant as completed in 1894, after various additions had been made to its original equipment. There is located at this point a low-service plant, originally used to draw water from the river, but now out of service. The original high-service station, recently remodeled, with the second one finished in 1894, are still in operation, their output being distributed to points in the city with an approximate limit of elevation of 75 feet above the city datum.

The equipment of the old station consisted until recently of two bucket-and-plunger, condensing beam engines of 18,000,000 gallons capacity each, and one of the same type of 20,000,000 gallons capacity. In the remodeling of the station these pumps are being replaced by three 20,000,000-gallon Allis triple-expansion pumps, two of which are now in operation. The boiler plant consists of four batteries of two water-tube boilers each, the total horse-power being 2,400.

The second station located at Bissell's Point contains three bucket-and-plunger, condensing beam engines of 18,000,000 gallons capacity each. The boiler equipment is in two batteries of eight, and one of ten, return drop-flue boilers, the total horse-power being 2,700. The total pumping capacity of the Bissell's Point stations will be, on completion of the remodeling of the old engine house, about 118,000,000 gallons per day. Coal storage at Bissell's Point aggregates 115,000 bushels.

A set of four basins is located at Bissell's Point, these being the original clarifying reservoirs of the water works. They are not now regularly in service as settling basins, but are used as storage reservoirs to take care of the surplus water supplied from the Chain of Rocks.

The Distribution System.—The distribution system comprises at present 730 miles of pipe, varying in size from 4 inches to 48 inches. Of late years the small pipes have been replaced by larger sizes wherever practicable, and no pipes of a diameter less than 6 inches are now laid as distributing mains. The standard sizes in use are 6, 12, 20, 30 and 36-inch, these being laid to the exclusion of the 8, 10 and 15-inch sizes which were formerly used.

Reference to the accompanying map of the system will make clear its general arrangement. Between the pump mains and connecting them 20-inch and 30-inch balancing mains are so distributed as to provide for an even balance of pressure. The blocks so formed are further subdivided by the 6 and 12-inch distributing mains. Wherever consumers' supply is required on the line of a large main it is paralleled by a smaller pipe, no taps being permitted on pipes over 20 inches in diameter.

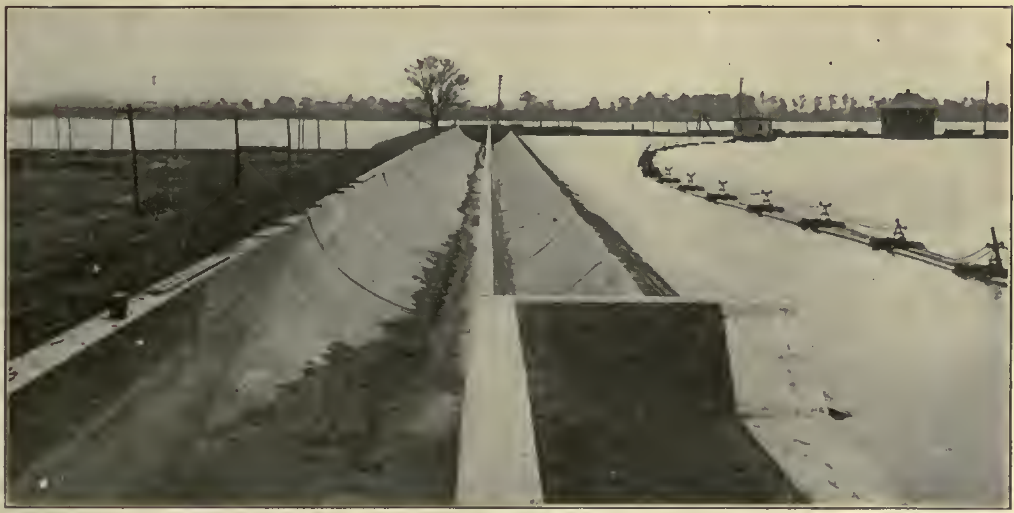
Great attention is paid to the placing of stop valves, they being distributed throughout the system so as to make shut-offs as short as possible. Three or four of the larger valves are used per mile of pipe, while on the 6 and 12-inch distributing mains they are so located as to limit the length of shut-offs wherever possible to three city blocks, or about 1,000 feet. The total number of stop valves in service is 7,668.

Eight-Foot Overflow Weir at Chain of Rocks Settling Basins.

The distributing capacity of the system, as shown by cross-sections of the supply mains, is that of six 36-inch and one 30-inch main. The pump pressure at Baden, supplying two 36-inch and one 30-inch mains, is 125 pounds. The Bissell's Point pressure on four 36-inch mains is 85 pounds. The supply into the business district of the city is large, being equivalent to three 36-inch mains.

Forty-Foot Overflow Weir at Chain of Rocks Settling Basins.

Fire protection throughout the system is amply provided for. Fire plugs of St. Louis design are freely distributed. The maximum separation in the least improved sections is 500 feet. In the residence districts this distance is about 300 feet, while throughout the business section plugs are, on an average, not over 100 feet apart. The number of fire plugs throughout the entire system averages 11.4 per mile of pipe, the total number in service being 8,334. In the heart of the business district, an area of 1.2 square miles, there are 1,350 plugs.



St. Louis Water Works: Inlet and Stilling Chamber; Suction Dredge, at Right.

Fire plugs are of two types. The underground plug has a 3-inch nozzle, the entire plug being below the pavement, protected by a flat cover. The overground plug has a 4-inch opening and protrudes above the ground in the usual form. The latter type is used exclusively on large mains where the plugs serve as air escapes and as blow-offs for cleaning and draining. The overground plug is also used in the thickly settled districts where large fire supply may be required, and also on account of its being less liable to be covered or hidden in time of emergency. The underground plug is most generally used in the residence sections. The pressure furnished in the business district is between 45 and 50 pounds; in the residence section it ranges from 25 to 100 pounds.

The maintenance of the system is effected by means of what is known as the street service. The city is divided into twenty-five sections, each in charge of a section man. These sections are grouped in five districts, each with district headquarters and supply station in charge of a superintendent. Large supplies and reserve materials are furnished from a central pipe yard. Extension of the system, except in case of special need, is accomplished by contract, from two to five lettings being made each year by the board of public improvements. As much as 42 miles of pipe have been added to the system in a year by this means.

In addition to the street service, the distribution department embraces the tap and meter and inspection departments. The functions of these divisions are suggested by their names. The city has the sole right to tap all mains, the pipe from main to building being the property of the owner of the premises. Rigid inspection of fixtures and connections is constantly in progress, and repairs are required on the part of property owners immediately on receipt of notice.

The total number of taps in service is 74,550. These connections are made through corporation cocks. Large connections for general and fire supply are made by the Smith patent saddle valve. These connections number 1,374, and range in size from 3 to 12 inches. Inside fire protection is furnished free to large plants having domestic supply, the fire system being separate from the general supply, with sealed valves and nozzles.

St. Louis has about 4,800 of its supplies metered, this requirement being optional in many cases, meters being required on all connections over 1½ inches in size. The assessor and collector of water rates has the right to order any connection placed under meter at the city's expense. This privilege is taken advantage of in places where, in his opinion, excessive use of water occurs, making a flat rate difficult of computation.

During the past year 396 meters have been placed on connections, and the number is to be increased as rapidly as possible. The efficacy of the meter as a preventive of waste is fully appreciated, and consumers are encouraged to install meters wherever practicable. The usual place of installation has been under the sidewalk, the meter being protected by a box large enough to permit of entrance for repairs or inspection. Recent decisions permit of meters being set inside buildings where easy of access at all times.

All extension and repair work on service pipes, and the making of connections to corporation cocks, are in charge of registered plumbers, who are under bond for the proper performance of such work.

Miscellaneous Data.—The Baden and Bissell's Point stations are fully equipped with machine shops and complete facilities for the ordinary repair work incidental to the operation of the water works.

The grounds surrounding the several stations and the Compton Hill reservoir are laid out as parks, large greenhouses being maintained at Baden for the purpose of supplying plants. The reservoir park in the heart of the city is particularly well kept, being a "show point."

The water department, in connection with the street and sewer departments, maintains a laboratory for the testing of brick and cement, the work being in charge of the distribution system of the water department. Owing to the steady increase in the amount of work being handled by this department, plans are now under way for the establishment of a thoroughly modern testing laboratory, fully equipped for material tests of all kinds.

The collection of the water-works revenue, with certain exceptions mentioned below, is in charge of an official known as the assessor and collector of water rates, the office being entirely independent of the water works proper. The total revenue for the past year from collection of water rates was $1,707,573.75, this amount being collected at a cost of $64,070.84.

The distribution system is a source of revenue through private work done by the street service and tap and meter departments. The receipts from these sources amounted during the year to $67,000.31. The total operating expenses of the water works amounted to $614,810.61. Deducting receipts as given above, leaves a net operating expense of $547,810. The total amount expended for maintenance, operation and improvement was $1,143,461.42.

St. Louis Water Works: Low Service Pumping Station and Inlet Tower at Chain of Rocks.

The cost of pumping was $7.81 per million gallons for the high-level district, and $11.82 for the low-level. The average daily consumption was 69,925,000 gallons per 24 hours, the maximum being 88,225,000 and the minimum 49,948,000 gallons. The above average, based on an estimated population of 700,000 is equivalent to practically 100 gallons per capita.

The organization of the water department is headed by the water commissioner, who is chief engineer. His aides are the chief mechanical engineer, in charge of pumping; the engineer in charge of construction, in charge of buildings, erection of engines, etc.; the principal assistant engineer of extension, in charge of basins, conduits, water clarification, etc.; and the engineer in charge of distribution, maintenance and extension of the distribution system.

The present head of the department is Mr. Ben. C. Adkins, who was appointed to the position of water commissioner in May, 1903. Sixteen years of active experience in the department have eminently fitted Mr. Adkins for the position. Immediately on assumption of the office his efforts were directed to the much-needed clarification of the water supply, with a degree of success beyond general expectation.

Health Conditions on the Isthmus of Panama.

By Dr. W. C. Gorgas, Assistant Surgeon-General, United States Army.

I have just returned from looking over the ground at Panama, along the route of the proposed Isthmian canal. I went down with the Isthmian Canal Commission, at their request, for the purpose of getting some idea of the present sanitary conditions, and of formulating for them some general plan of sanitation.

As some of your readers may not be familiar with the literature concerning the Panama canal, or with the character of the country through which the canal passes, a rough description will probably be of interest, and make my remarks the more easily understood. The Isthmus, at this point, runs in a general direction from east to west, and the canal route generally from north to south. The town of Colon is the northern terminus of the canal, on the Caribbean Sea, and the town of Panama, the southern terminus, on the Pacific Ocean. The great chain of mountains which extends through North, Central and South America, has at this point, about its least elevation, the highest point of the divide through which the canal runs being here about 500 feet. The country is generally volcanic in its formation, thickly studded with numerous peaks and ridges, from 300 to 800 feet high. I should describe it as being very hilly, and well drained.

The canal, in general, follows the line of the Chagres river up to the divide at Culebra Cut, some ten or twelve miles from Panama, and from Culebra down to Panama, the valley of the Rio Grande river. These streams are not swampy in any sense of the term. The rivers mentioned above, of course, have a certain amount of low ground in their bottoms, but not more than a stream the same size in northern New York. Owing to the warm climate and heavy rainfall, mosquitoes can find, all the year round, abundant places for breeding, even in as well-drained a section as the route of the Panama canal is.

Colon is built upon a coral island in Limon Bay, the island itself being slightly below the main level of the sea. The part of this island on which Colon is situated is artificial ground, having been filled in three or four feet. The rest of the island is still covered with swamp. This is the only point at which swamps of any great extent would have to be dealt with.

The canal strip, at present, I consider in the normal state for tropical regions, from a health point of view. The death rate would be very large for our country, probably running in the neighborhood of fifty per thousand. But this is the case in all tropical countries where malaria prevails.

I estimate that, at the present time, there are about 40,000 persons on the strip, 20,000 at Panama, 3,000 at Colon, and about 15,000 in the little towns along the canal route. Not considering the original Spanish settlements, the canal strip has now been occupied by the whites for about fifty years. The present railroad, which runs along the canal route, was finished about 1855. The next extensive occupation by the whites was in 1881 and subsequent years, when the French attempted to build the canal. The health history of the strip, for the last fifty years, has been exceedingly lugubrious. The death rate among the laborers on the railroad and the French on the canal has been enormous. But this has generally been the case where large bodies of unacclimated Europeans have been thrown into tropical countries. We had the same experience with our Army during the Santiago campaign, in Cuba, the French a very much worse experience during their military occupation of Santo Domingo, the Spaniards during their military occupation of Cuba, and there are numerous other examples which I could mention.

The records of the French hospitals showed that they suffered from most of the diseases to which man is heir. But their excessive mortality was caused by yellow fever and malaria, but principally from malaria. While my plan contemplates a sanitary organization a good deal such as resulted so successfully at Havana, the latter will, of course, have to be modified to some extent to meet the changed conditions at Panama. I would propose the ordinary health organization for the care of infectious and contagious diseases, such as we have in New York or any other American city, and I think that there is no doubt that such diseases can be controlled as they are in New York or elsewhere. I feel confident of being able to eliminate yellow fever by the same methods that were so successfully adopted in Havana. But malaria, in my opinion, is the disease on which the success of our sanitary measures at Panama will depend. If we can control malaria, I feel very little anxiety about other diseases. If we do not control malaria, our mortality is going to be heavy.

The condition of our marines is a very good illustration of the present health status there. Since the middle of December we have had 450 marines camped on one of the hills of the divide. The location is excellent, the hill some 200 feet high, with a small area on top, not more than an acre, and perfectly drained. The men are as comfortably fixed up as circumstances will allow. During the four months from the middle of December to the middle of April, they have had 170 cases of malarial fever out of 450 men. None of them have been severe, just such ordinary cases of chills and fever as we have in Southern United States. The men themselves, as a body, were robust and vigorous in appearance, of good color, and, evidently, had not been at all affected, deleteriously, by climatic conditions. Nevertheless, we see here, that with a body of men under the most favorable conditions, one-third of them have become infected within four months. Now, if these men were our laborers, working daily in the Culebra Cut, exposed to the sun and weather, many of these cases would be severe in type, and, at the end of a year, we would be approaching the mortality of the French.

At the foot of this hill on which the marines are camped, is a village of some 400 or 500 natives. When I say "natives," in speaking of the strip, I mean Jamaica negroes. I spent considerable time going through this village, questioning the natives, and examining the spleens of many of the children. All the children that I examined had very much enlarged spleens. This is considered an evidence of chronic malarial infection, and all the adults that I talked to spoke of having had attacks of chills and fever within the preceding six months. I accept this as evidence that this native population is very thoroughly infected with malaria, and I think our marines contract malaria from these natives. The marine, whenever off duty, spends his leisure hours, on the average, in the village. Every time he goes to the village he is bitten three or four times by mosquitoes, and occasionally one of these mosquitoes is an anopheles. This anopheles, having previously bitten some one of the infected natives, is herself infected, and gives the man malaria. The condition is very much the same as if these four or five hundred natives had smallpox, and our marines had never been vaccinated. They would contract smallpox much as they are doing malaria now. I do not mean to say that the mosquito carries smallpox, but that the malaria originates with the natives and is transferred from them to the men, and that the natives are the cause of malaria, just as they would be the cause of smallpox.

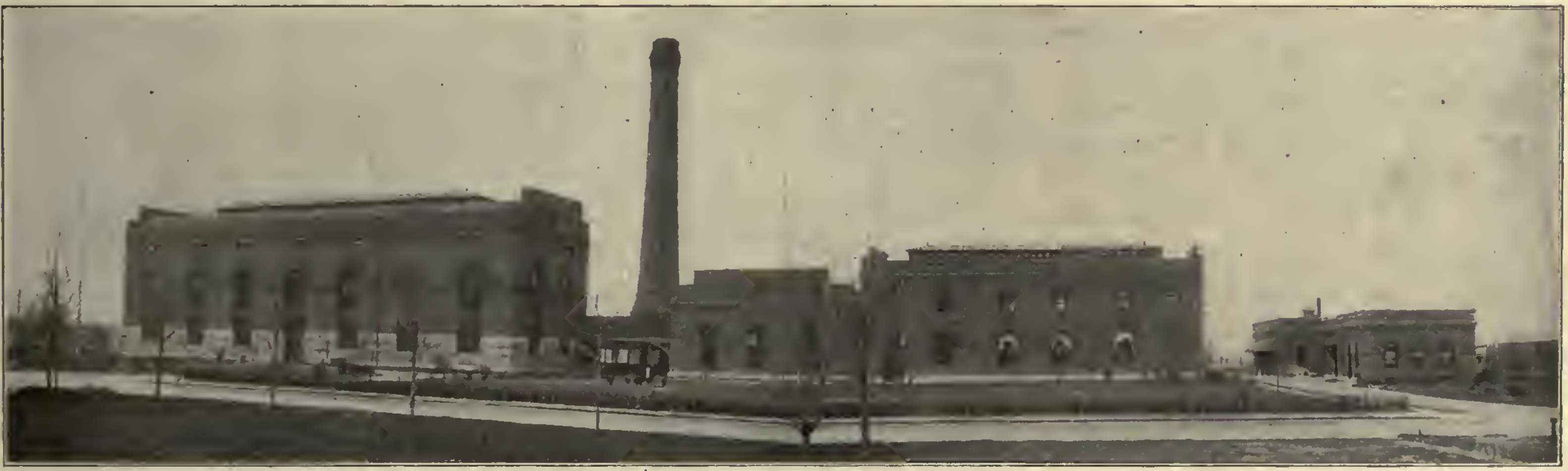
If the population of this native village were removed, I think our men would very rapidly become free from malaria, under the supervision and direction of their medical officers. What I propose, is to take this village, put it under a systematic scheme of inspection whereby we shall be able to control all water barrels and deposits of water, so that no mosquitoes will be allowed to breed, look after its street cleaning and disposal of night soil, etc., so as to get it in good sanitary condition, then have the population examined and recorded, so that we shall have on a card a short history of each individual, and keep track of them in this way. Those suffering from malaria will be put under treatment, and watched as long as the malarial parasite is found in the blood. I hope, in this way, to decrease to the smallest limit the number of anopheles, the malarial-bearing mosquito, and, at the same time, to gradually eliminate the human being as a source of infection, so that at the end of a year it will be entirely safe for an unacclimated man to live in this village.

The above scheme of mosquito destruction was put into effect, on a large scale, at Havana, and, though entirely directed against yellow fever, was almost equally successful against malaria. The same measures that destroyed the stegomyia, the yellow fever mosquito, destroyed the anopheles, the malarial mosquito. The average death rate, for a number of years, from malaria, in Havana, was about 400. The year preceding the inauguration of our mosquito work, we had 325 deaths from malaria. During the first year of mosquito work this was reduced to 150 deaths; the second year, 70 deaths; the third year, 50 deaths. In a small village, such as I have described, the mosquito work could, of course, be made very much more effective than in a large city of 300,000 inhabitants, and I am very confident that in the course of two or three years mosquito work alone would eliminate malaria in such a village.

We must, however, attain our results within a year, and, therefore, I would attempt, in addition, the freeing of human beings from malaria. This has been done successfully, on a small scale, in two or three instances, notably by Koch, in South Africa. The village above described is a fair example of what, in my opinion, will have to be done all along the strip. I have not described in detail the ordinary sanitary measures that will have to be adopted along the strip, and at the towns of Panama and Colon. Yellow fever, which, in the past, has been almost as fatal at Panama as malaria, will depend principally upon the sanitary work at Colon and Panama, and the quarantine arrangements for preventing its introduction. But this is in no way different, in my opinion, from the same problem at Havana, and the same measures there, I feel confident, will have the same results.

As to the safety of the individual in going to Panama at present, I think an intelligent man who will adopt the precaution of sleeping under a mosquito bar, such that mosquitoes could not get through, having sleeping quarters as much as possible away from the natives, and drinking boiled water, would be fairly safe.

I hear two opinions expressed with regard to the health of Panama. The general opinion, that one sees in the papers, is that it is almost fatal to live there, people expressing this opinion thinking that the conditions there now are exactly the same as when the French had fifteen or twenty thousand laborers on the work, and were losing by death and sickness a considerable proportion of this force every year. This is, of course, not true. The health conditions of Panama, at present, are not a bit worse than those of most other tropical countries. On the other hand, particularly down at Panama, you hear men talk as if it were a health resort. This is not so. The death rate now is large, as I said before, about like that of most tropical countries, and unless we can change conditions within the next year it will be far from a health resort, when our large force of laborers are on the ground and the work is in full swing. I recently saw an engineer, who had been on the ground for some time and was a man of considerable experience, quoted as saying that both the engineering and sanitary problems were simple and could be easily solved. Of the engineering problems I am no judge, but such statements with regard to the sanitary problems, by men of position and experience, I think are very rash and tend to do harm. In my opinion, the sanitary problems are grave. The question of eliminating yellow fever from an endemic focus has only been once before successfully managed, and that was at Havana. And, from this successful work, to argue that it is easy and simple, I think is not warranted. The malarial work, on the scale at Panama, is entirely new. It has never been attempted elsewhere, and any health officer, who has had any experience in enforcing measures of individual prophylaxis, such as will be required at Panama, can understand how great the difficulties of administration will be. Personally, I believe it can be done, and I approach the work with great hope of success, but I know that it will be neither easy nor simple, that we will meet with many disappointments and have to modify our plans many times.



St. Louis Water Works: Baden Pumping Station Supplying the High-Level District of the High Service.

The New Electric Works at Neuchatel, Switzerland.

By A. Steere.

Switzerland is the favored country of central water-power stations, but the cities which possess distribution systems of electric power delivered from the hydraulic plants are often led to supplement them by auxiliary installations. This is what has made Zurich, Chaux-de-fonds, Lausanne; it is what is also going to make the city of Neuchâtel through the interesting installation which we are to describe. For several years it has been foreseen that the power furnished by the Oreuse is no longer sufficient to supply the needs of Neuchâtel. These works at Pré-aux-Clées, near Boudry, utilize a fall of 183½ feet, with six turbines of 300 horse-power; they requiring for 1,500 horse-power about 95 cubic feet of water per second, and the demands have more and more approached this figure. It was thus decided to locate an auxiliary steam plant at the foot of the lake on the quay of Champ-Bougin.

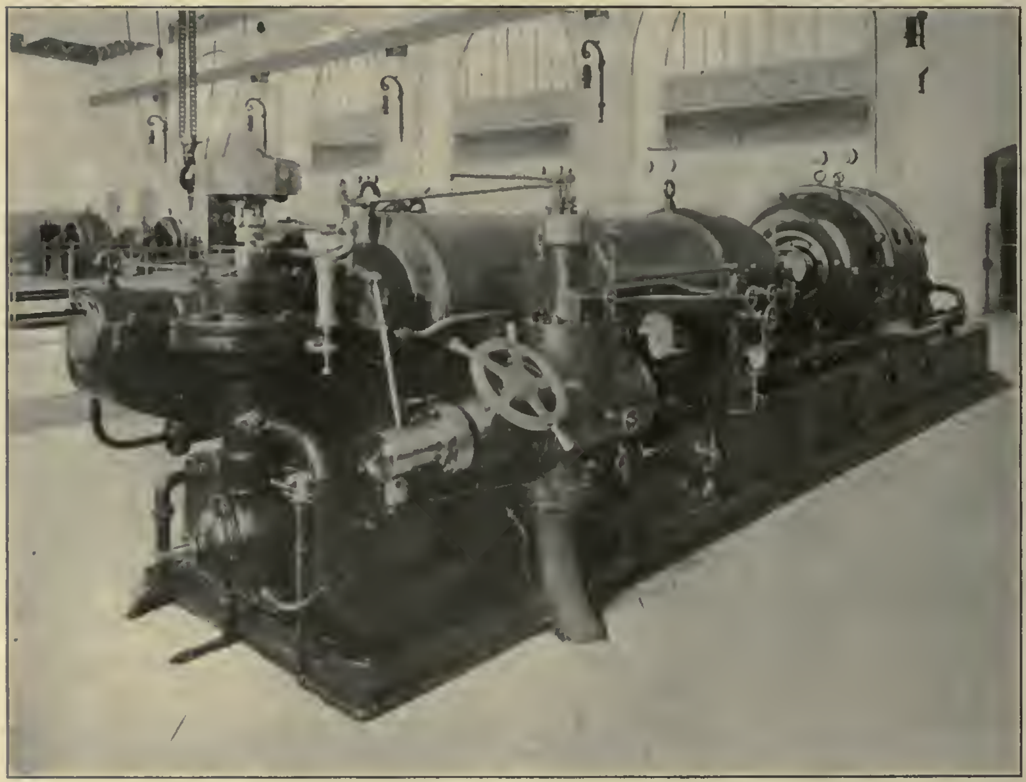
The two electric traction railway systems of the city take their current from two transformer stations, belonging to two companies. Their consolidation and the extension of their lines made it necessary to increase the power resources. It appeared desirable to consolidate these also with the steam plant which the city planned to construct to reduce the general expenses and the cost of traction.

The building has been designed for six boilers of 2,470 square feet of heating surface, for four steam turbines of 300 kilowatts, for six converters, three of 300 kilowatts and three of 65 kilowatts. The foundations rest on rock. The facades are built for the most part of ashlar masonry of hard stone from the Juras. The ceiling is of reinforced concrete and cost $3,400. It is covered with Val de Travera asphalt, ¾ inch in thickness, on which is about 8 inches of cinder filling. The object of this filling is to insulate the operating room from the effects of outside temperature and to protect the asphalt against severe variations of heat and cold. The pavement of the operating room consists of white squares of stone laid in a bed of asphalt. The squares (grès cérame) tested under a pressure of 35,000 volts have shown a remarkable insulating power.

The chimney is 182 feet high from the ground to the top and its interior diameter is 9.84 feet at the base and 6.56 feet at the top. The two boilers, of 2,420 square feet of heating surface each, are of the water-tube type built by the Guillaume Works, of Neustadt. The pressure carried is 12 atmospheres. A superheater of 687 square feet surface is placed under the steam dome at the last point of the flow of the gases of combustion. Water from the Lake Neuchâtel is employed, but previously purified. The steam is, of course, utilized in the turbines. The choice of steam turbines was first brought about owing to the limited floor space at disposal and then the decision was strengthened by a comparison with cylinder machines. The type of turbine adopted is the Brown-Boveri-Parsons, built by Brown, Boveri & Company, of Baden. This turbo-dynamo has a capacity of 300 kilowatts with steam at 11 atmospheres. The number of revolutions is about 3,000 at full load and 3,050 at no load. The speed can be varied 10 per cent. more or less.

The Parsons turbine is, as everyone knows, of the reaction type. The 300-kilowatt size has 48 sets of stationary blades and as many of moving blades, arranged on three cylinders of increasing diameter. One of the accessories is a valve that serves to admit steam directly to the second set of blades, in case the pressure is insufficient or the presence of air reduces the power. Brown, Boveri & Company have given every attention to the apparatus for lubrication and regulation. For lubrication the journals of the bearings are formed of concentric bronze cylinders placed one within the other. The oil is delivered under a pressure of 1 to 2 atmospheres and the bearings run in a bath of oil. The oil pump, driven from a counter-shaft, which is operated by means of gearing from the vertical shaft of the governor, draws the oil from a reservoir in which is established a circulation of cold water. The water for cooling is furnished by an ejector, operated by city water under pressure; the water taken from the lake is finally discharged into the sewer. The oil attains a temperature of about 100 to 105 degrees Fahrenheit. The number of oscillations of the steam inlet valve to the turbine, or the number of puffs of steam is 120. The steam is delivered into a water-tight chamber near the bearings, where its object is to prevent the re-entrance of air into the condenser.

The dynamo, mounted on the turbine shaft, is designed to operate at constant speed. Being built for 3,000 revolutions, its dimensions are necessarily restricted and this is a serious difficulty in the auto-regulation of the electric end. It is a compound-wound machine, but the shunt and series field windings are not superposed but at right angles. The object is to obtain a resultant field fixed in space, and, as a result, to avoid the displacement of the axis of commutation, which produces sparking at the bushes. The commutator, which is very long, is bound at the middle and the ends by hoops of steel to resist centrifugal force. The brushes are of copper. The operation is very good, without heating, without sparking and without its being necessary to shift the brushes with variations of load. The only inconvenience is that peculiar to a compound dynamo—and this one is over-compounded—because the tension rises slightly with the load. It is thus necessary for parallel operation with other machines to provide the switchboard with compensating devices, resistances and the like.



Neuchatel Steam Turbine, Showing Regulating Apparatus.

The condenser pumps are driven by an independent electric motor placed at the turbine level and connected to the pump by belt. A three-way valve allows for discharging the steam directly into the discharge pipe of the water of condensation.

As to the consumption of steam, two series of tests have been made with the Neuchâtel machine; the first at Baden and the second at the works at Champ-Bougin. At Baden the consumption of 23 pounds per kilowatt-hour was obtained, but at Neuchâtel a slightly higher figure resulted, proving that at Baden the testing plant presented means for very precise measurements of the condensed steam. The results of the tests at Baden are given in an accompanying table:

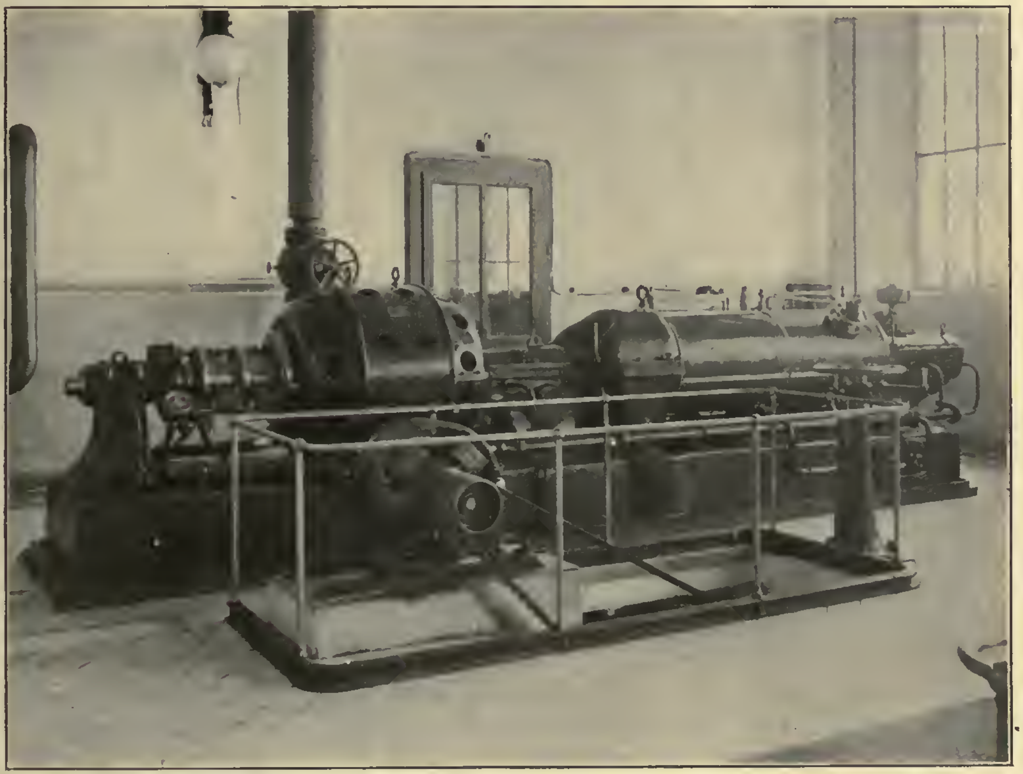
Tests of the Neuchâtel Steam Turbine.

Load in Kilowatts.	Condition of Steam.	Pounds per Kilowatt-Hour.
290	Saturated	23
311	Superheated, 100 deg.	21.2
140	Saturated	27.5
149	Superheated, 82 deg.	25.1
No load, dynamo excited (per hour)		9,150
No load, dynamo not excited (per hour)		8,600

The last two figures are given without deduction for the work of the condenser, which would have added to them about 550 pounds, or 10 kilowatts at 55 pounds. It was assumed that the work of condensing, not being measured, was about 10 kilowatts, but it has been determined at Neuchâtel and found a little lower than the amount stated. The tests at Baden should rightly be corrected for this and would better the results.

The current furnished by the hydraulic works of the Pré-aux-Clées is three-phase current at 33 cycles and 3,800 volts. It is necessary to convert this to continuous current at 600 volts. For this purpose the Champ-Bougin station contains two old units, of 100 horse-power, each consisting of a three-phase induction motor of 3,800 volts and a shunt dynamo of 500 to 720 volts. The common speed is 600 revolutions per minute. There has also been installed a new unit with a synchronous motor, driving a 250-kilowatt direct-current machine. This type of motor was selected for improving regulation in the lines from the hydraulic works. The synchronous motor is of large size and reduces the transmission losses to a notable degree and in any event absorbs less current. This is its only advantage, for in practical operation the induction motor is much superior. As a matter of fact, with future units induction motors will be employed, the present synchronous motor sufficing for controlling the current with all of these motors. The converters were furnished by the Société d'Electricité Olioth, of Muenchenstein.

It now remains to say a few words concerning the switchboards erected by Brown, Boveri & Company. They are grouped in a passage or gallery, communicating by four broad bays with the operating room of the station. This passage contains the switchboards of the three-phase distribution and a monophase at high tension and of the continuous current at 580 revolutions. The apparatus which require handling or of which the records are constantly observed are located in the bays at the side of the room. The rest are grouped on frames in the middle of the passage. The conductors which connect the switchboards and the machines are encased in lead; the floor of the room is crossed by deep trenching, lined with stone and covered with white marble, for the run of the cables. As the site of the works is of rock, expensive to excavate, and as the proximity of the lake tended to render the place moist, in short for economical reasons, it was not excavated except for the turbine condensers. The part of the switchboard which pertains to the electric railway contains in each section a meter, an ammeter, two hand switches and two automatic circuit breakers.



Neuchatel Turbine, Showing the Motor for Driving the Condenser.

PRESSURE HEAD MEASUREMENT for hydraulic investigations in the laboratories of the University of California is made by a device described in the "California Journal of Technology," by Prof. Joseph N. Leconte, assistant professor of mechanical engineering. A small bronze cylinder reamed inside and fixed in a vertical position, is connected to the pressure pipe and into this is inserted a hardened and ground steel piston ¼ square inch in area and 3 inches in length. Supported on the stem of this piston is a circular platform on which can be placed weights, and the whole is rotated continuously by a cord driven by a small motor. By means of idlers the cord is arranged to avoid any side thrust, so that by rotation the effect of friction is eliminated.

The Zoelly Steam Turbine.

The Zoelly steam turbine is of the multistage impulse type, in which the expansion of the steam takes place in the passages in the stationary parts of the apparatus. Its main point of difference from others of the type is in the construction of the rotors or bucket-wheels, which are intended for high peripheral velocities and require correspondingly few stages. The accompanying elevation of a compound turbine shows its general features. The high and low pressure ends are mounted independently on a single base. The housings are of cast-iron or cast-steel, divided on the horizontal plane through their axis, so that the upper half can be readily lifted off, and the flanges are fitted so closely that no packing is needed. The details of the mounting have been worked out with a special view to avoiding any appreciable displacement of the axis through temperature changes. The housings are covered with non-conductors and steel lagging.

The three main bearings are supported directly by the frame, and are thus independent of the housings. This arrangement was adopted to prevent any heating of the bearings by the steam or by conduction from the housings, thus keeping them uninfluenced by the condition of other parts of the turbine. They are readily accessible and easily inspected.

A rotary pump placed on the frame and driven from the main shaft by worm-gearing supplies lubricating oil to the bearings. The oil from the bearings is piped to a reservoir in the base, where it is purified and cooled in a coil if necessary, and is then ready for use again. In this way, although the lubrication is profuse, the consumption of oil is kept very low.

The disks of the rotors, of the best Siemens-Martin steel, are keyed to the shaft and have fastened on one side of their periphery a thin ring. This ring forms with the periphery of the wheel a dove-tail groove in which the buckets and their spacers are held. The radially located buckets are made of nickel steel, polished to reduce friction to a minimum. Nickel steel is employed on account of its resistance to rust. The disks of the wheels are also highly polished to keep down frictional losses.

It is considered of great importance to have the cross-section of the blades decrease from their inner to their outer ends. In this way there is correspondingly small tension due to centrifugal action in the roots of the blades, even with high rotative velocity. In other words, with the same stresses the gradually thinning blades can be made much longer than those of uniform section. The resistance to bending due to the impact of the steam is greatest where the bending moment is greatest. The strength of the rotor, in consequence of this design, is so great that a high peripheral speed can be attained, and the number of stages correspondingly reduced, as before stated. This enables the length of the turbine to be diminished and its cost reduced. The steel spacing pieces between the blades have their tops coinciding with the curved surface corresponding to the widening of the steam passage between the blades, and consequently form an inner limit for the steam jet. The rotors are carefully balanced and tested at speeds above their nominal rates before they are put in place.

Between each rotor there is a guide wheel or diaphragm in which the guide blades are held. Since the expansion of the steam takes place in these diaphragms between the blades, and there is a corresponding excess of pressure on one side of them, each must be steam-tight in the housing, as well as strong enough to resist the one-sided pressure. Cast-steel is used, and the guide blades are arranged in groups in the rim, as shown in the illustrations. Between the groups are thick projecting pieces to which a wrought-iron ring or tire is attached. The diaphragms are placed close together, the rims touching, and in this way the pressure is transmitted to the end wall of the housing. The hubs of the bucket wheels fit with slight play in holes in the bosses of the diaphragms, the construction being evident from the cuts. The blades have small ears which slip into slots in both the rim of the diaphragm and the outside tire. When they have been slipped into place they are held there by two rings screwed on the low-pressure face as illustrated. These diaphragms are made in halves, with tight-fitting surfaces, and the upper halves are screwed to the top part of the housing, so as to be lifted with it. The shaft passes into and from the housing in stuffing boxes fitted with metal packing.

The governor is a slight modification of the well-known regulator used by the makers, Escher Wyss & Company, of Zurich, Switzerland, in many water turbine installations. It consists of a ball governor which operates a pilot valve controlling the motion of a plunger directly over the main steam valve and mounted on the same rod. The pilot valve and the chamber of the plunger are connected by two small pipes, and the various operations are produced by the discharge of water under pressure through one or the other of the pipes. As this governor is one of the best-known water-wheel regulators, it is unnecessary to describe it in detail. The pressure water, or oil, in the case of the steam turbine, is furnished by a rotary pump driven from the main shaft by worm gearing. According to Mr. J. Weishäupl, chief engineer of the company, the regulator has behaved excellently in this new service, and the variation in rotative speed, even with the maximum fluctuation in the load, is very slight. Regulation by throttling the steam was chosen as being the simplest method for the purpose. In addition it has the great advantage of not influencing the steam consumption unfavorably at different loads.

If it becomes necessary to furnish more than the rated power of the turbine, the governor operates a valve which admits a part of the steam at the throttle pressure directly into the second and third stages. There is also a safety governor which shuts off the steam in case the number of revolutions rises above the normal to a predetermined limit, such as 10 per cent.

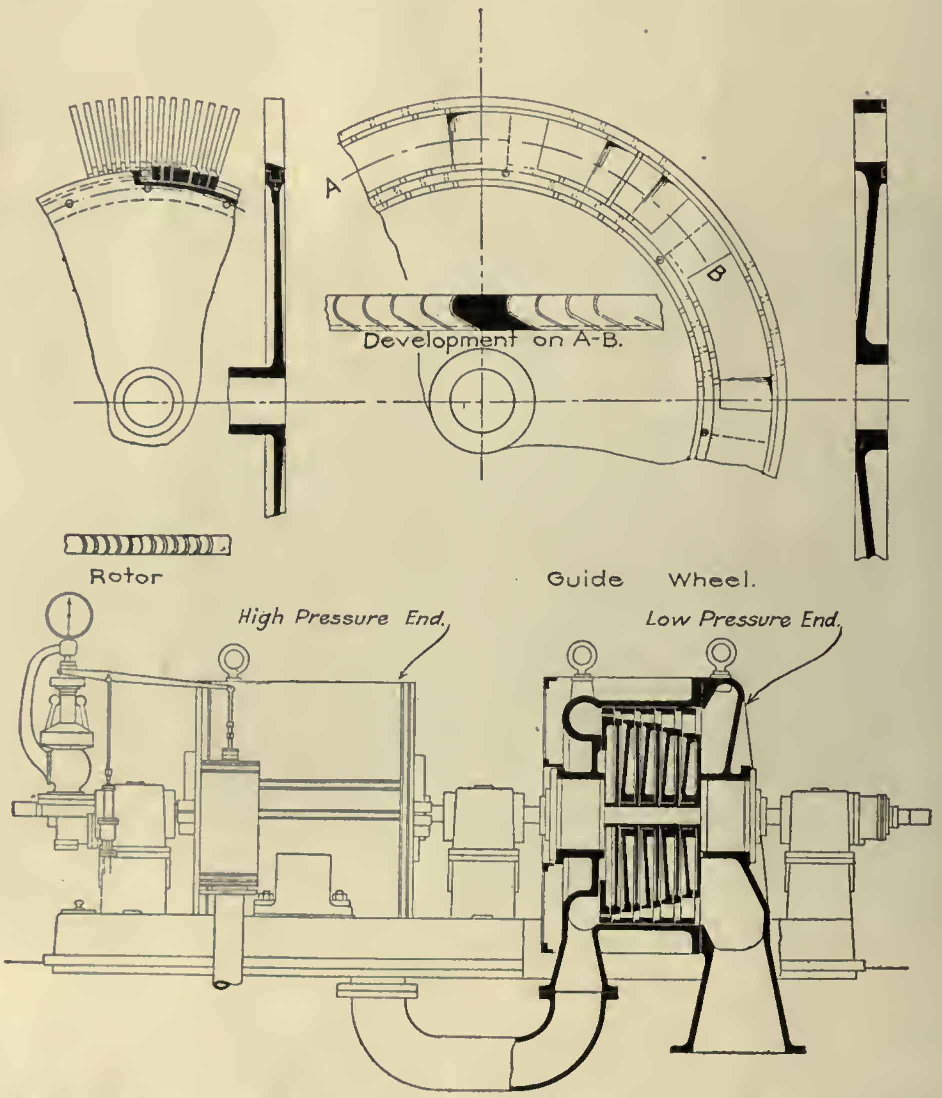
In impulse wheels, the play of the rotating parts in the casing can be made as great as seems desirable, and for the same reason the axial play between the rotors and diaphragms may be made very large without affecting the working of the turbine. Hence there need be no fear that in consequence of temperature changes or wear the running and stationary parts may rub against each other. It should be stated that a corrugated bearing like a thrust bearing is employed to keep this free play unchanged.

A ten-stage turbine of this type was put in operation at the works of Escher Wyss & Company last fall. It is rated at 500 horse-power per minute at 3,000 revolutions per minute, with steam at 147 pounds. It is directly coupled to a Siemens & Halske dynamo. A surface condenser driven by an independent steam engine is used. Part of the water for the condenser was taken from the city mains and part was pumped electrically from the works well. This renders it very difficult to determine the power needed for the condensing plant. The unit has been tested by Professor Stodola and Director Wagner, of the municipal electric station. They made no attempt to determine the steam consumption of the condenser, and the output of the turbine was figured from the current delivered by the generator. The following statements concerning the test and its results are condensed from their report.

The pressure and temperature of the steam were observed in the main in front of the separator, which is close to the turbine. During the tests with superheating a thermometer was also placed in front of the throttle valve. The pressure and temperature were also measured immediately in front of the first diaphragm and the pressure behind the first rotor was observed, from which data a check on the feed-water determinations was obtained. The pressure in the pipe connecting the two halves of the turbine, and the pressure and temperature at the entrance to the exhaust main were also observed. The temperature of the cooling water entering and leaving the condenser and the temperature of the discharge from the air-pump were measured. The cooling water was only occasionally measured, while the circulating pump was stopped and the supply obtained through a meter from the city mains. The pressures were determined by manometers which, like the thermometers, were calibrated at the mechanical laboratory of the Federal Polytechnic Institute. The vacuum was measured directly by a mercury column, and the heights reduced to their equivalents at 32 degrees Fahrenheit, a correction which seemed necessary on account of the high temperature of the housings. The revolutions were measured every few minutes by a tachometer. Owing to other uses of the steam from the boiler a measurement of the feed-water was useless. In consequence, such determinations were limited to weighing the condensed water delivered by the air pump. This was discharged into an elevated reservoir with inclined bottom, from which it flowed to the scales. The net weight of the apparatus was determined after each emptying, since the readings were restricted to ten-minute intervals. On account of the large capacity of the air pump, more frequent weighing would have resulted in less uniform readings. That a steady operating condition had been reached during the tests was shown by the uniform amount of condensation and the constant temperature of different parts of the turbine.

The electrical measurements were made with instruments calibrated by Professor Weiss, of the physical department of the Federal Polytechnic Institute. A water rheostat was used.

The turbine was first run with a mixture of moderately superheated steam from one source and saturated steam from another. In front of the separator it showed a few degrees of superheat, but this had practically disappeared in front of the throttle valve. The results of the tests are given in the accompanying table. The first eight are with decreasing loads, but a constant speed and steam pressure. The tests were at first arranged in the opposite order, beginning with no load, but the temperature readings of different parts of the turbine showed that a steady operating condition would not be reached for hours. The observations made during the eighth of the tabulated tests show this clearly. In this run, the unit was first operated at half load for about 20 minutes, in order to warm it up, and two hours afterward the temperatures of the exhaust and of the base of the high-pressure housing were still falling. On this account the computation of the steam consumption is based only on the results of the last 35 minutes. With heavy loads, a preliminary run of 15 minutes was sufficient. The last three tests were made with superheated steam. In all of these eleven runs the turbine operated with very little shaking of the shaft. The oil for the bearings was delivered at a temperature of 86 to 95 degrees Fahrenheit and came from them at 104 to 122 degrees.



Longitudinal Sectional Elevation and Some Details of Zoelly Steam Turbine.

Condensed Table of Tests of a Five Hundred Horse-Power Zoelly Steam Turbine.

Date—	Dec. 12, 1903.	Jan. 25, 1904.	Jan. 25, 1904.	Jan. 25, 1904.	Jan.25, 1904	Jan. 18, 1904	Jan. 25, 1904	Jan. 25, 1904	Feb.5, 1904	Feb. 5, 1904	Feb. 5, 1904
Length, minutes	180	80	50	50	50	60	60	35	70	20	80
Current, kilowatts	363	388	335	240	182	86	...	...	392	390	390
Revolutions per min.	2,967	2,967	2,977	2,983	2,984	2,995	2,995	3,000	2,972	2,973	2,968
Before Separator—											
Pressure, lbs.	149	149	145	147	146	147	147	149	173	178	150
Temp., degs. Fahr.	369	370	364	366	365	365	365	366	477	497	440
Before First Diaphragm—											
Pressure, lbs.	133	134	118	87	66	31	3	7.5*	128	128	129
Temp., degs. Fahr.	356	356	347	329	314	277	228	217	422	427	422
Exhaust—											
Vacuum, ins. mercury	27.7	27.7	27.9	27.9	27.9	28.4	28.4	28.4	27.9	27.9	27.8
Temp., degs. Fahr.	102	104	102	99	98	91	90	108	100	102	100
Steam con. per hour, lbs.	7,887	8,308	7,411	5,766	4,673	2,644	1,023	650	7,438	7,319	7,712
Steam con. per kw.-hr. lbs	21.7	21.4	22.1	24.0	25.6	33.0	...	...	19.0	18.8	19.7

*Ins. of mercury.

Smoke Preventing Devices are installed in 859 out of 2,041 steam boilers in the city of St. Louis. According to Mr. Charles H. Jones, chief smoke inspector, in a pamphlet issued by the Civic Improvement League of that city, these devices are divided up about as follows: Some 66 per cent. use steam jet and air-blast devices; 23 per cent. down-draft furnaces; 4½ per cent. use firebrick arches; 3½ per cent. have changed from steam to electricity; 1½ per cent. use automatic stokers, and 1½ per cent. use smokeless fuels. In addition there are 273 plants, mostly small or heating plants, which have no special devices.

A French Breaking Test of Reinforced Concrete Bridge Trusses.

By Leon S. Moisseiff, Assoc. M. Am. Soc. C. E.

In November last a bridge of 65.6 feet span, built by the Paris-Orleans Railway Company at its freight yard in Paris for this purpose, was tested to destruction. It consisted of two bowstring trusses spaced 8.2 feet center to center and having a maximum depth of about 7.5 feet center to center of chords. The lower chord and the web members were of concrete reinforced by longitudinal steel rods while the upper chord was of hooped concrete. The construction and the breaking test of the bridge are fully described and discussed by A. Considère in a recent volume of the "Annales des Ponts et Chaussées."

The great resistance shown by Considère's experiments on hooped concrete, which have been described in The Engineering Record and are given in full in the English version of his experiments, published in book form under the title "Experimental Researches in Reinforced Concrete," led him to believe that concrete so reinforced would prove an excellent material for bridges of spans longer than those usually so constructed. He prepared plans for a bowstring truss of about 196.8 feet span and about 25 feet width, but before executing them it was thought advisable to construct first a bridge to one-third scale of the one contemplated and test it to destruction.

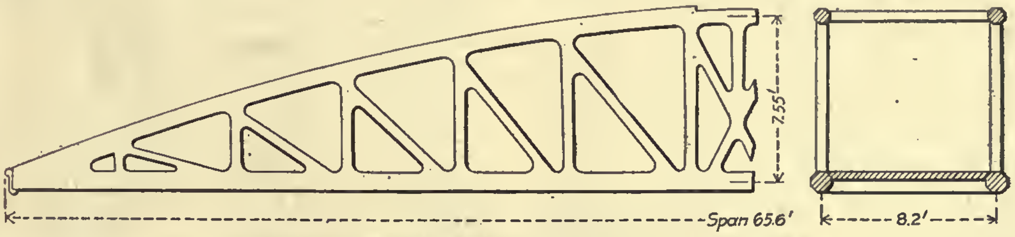
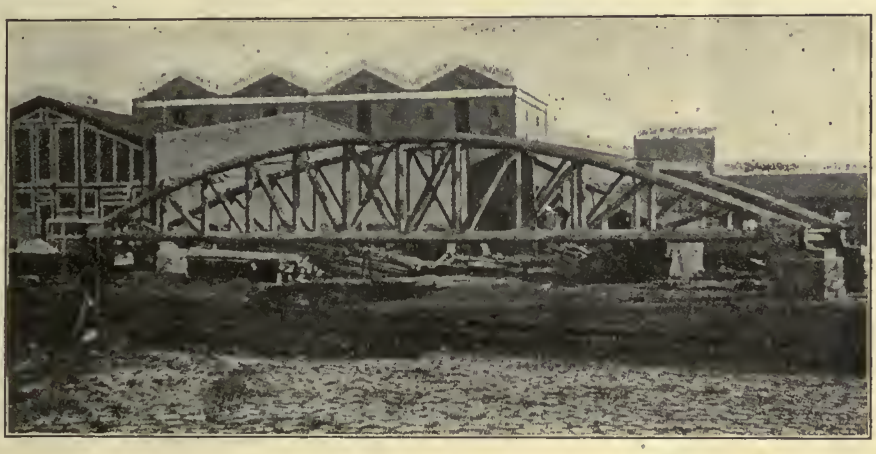


Figure 1.—General Shape of Experimental Bridge.



The Experimental Bridge of Hooped Concrete.

The bridge tested really represents not a bridge built for a span of 65.6 feet, but one of 196.8 feet reduced in all its dimensions and parts to one-third. This has resulted in some inconveniences. First, the form of truss tested is not exactly suitable for the shorter span, and, second, the diameters of the reinforcing members and the spacing of the hooping had to be reduced to a point where the ramming of the concrete became difficult.

Design.—As stated above, the bridge consisted of two bowstring trusses. The upper chord of the truss was made parabolic, the lower chord straight and the web of verticals and diagonals in panels of about 5.1 feet. Except in the two panels at each end, the bridge had an upper lateral system of horizontal struts of reinforced concrete and diagonals of steel angles. The continuous concrete floor was of a thickness of 2.4 inches and was supported on concrete-steel floor-beams at each panel point.

The exact dimensions and sizes which were prescribed for the compression members were not realized. The upper chord members had an octagonal shape of 9.8 inches diameter and the hooping spirals were of soft steel rods ⅜ inch in diameter bent to a curve with an average diameter of about 7.9 inches, with a maximum spacing of 1.4 and an average spacing of 1.2 inches, as indicated in Figure 2. Members which had thus been reinforced were used for twelve panels of the truss and are considered suitable for bridges of average spans. A second type of compression member, of smaller cross-section but containing a higher percentage of reinforcing metal, was used for the center panel. It is intended for bridges of longer spans where the weight of the structure itself becomes of great importance. This member had a diameter of 7.9 inches and steel rods of about 0.4 inch diameter hooped to an average diameter of about 6.3 inches, with an average spacing between hoops of 0.95 and a maximum of 1.4 inches. To avoid any possible tendency to flexure in this member it was supported by a small vertical strut from the intersection of the diagonals. This was ill-advised as, instead of preventing flexure, it produced bending, as will be seen later. In addition to the spiral rods the hooped members contained eight longitudinal soft steel rods of 7/16 inch diameter.

The reinforcing of each lower chord consisted of 37 soft steel rods of about 0.52 inch diameter. They passed through cast steel abutting plates and were upset at each end, preventing the spreading of the plates. An iron wire 0.16 inch in diameter was wound around the strand formed by the 37 rods. The distances between its spirals were relatively great and almost useless for the middle portion of the panels, but they became closer when approaching the panel points, in order to prevent any spreading of the longitudinal rods under the action of the load and the pull of the web members. The mortar which was poured into the bundle of rods and surrounded it had an octagonal surface of 9.8 inches diameter.

The longitudinal reinforcing rods of each of the web members were four in number and had a diameter of 0.59 inch in the verticals and 7/16 inch in the diagonals. Figure 2 shows the detail of the connection between the web members and the chords. These were followed exactly in the execution of the lower connections, but, owing to an unfortunate error, the semi-circles which connected the reinforcing rods were omitted in most connections. Instead the reinforcing rods of the web members consisted of independent rods bent over hook-like at their ends and frequently penetrating into the hooped chord to a very slight extent. It was proved afterwards that this fault somewhat hastened the failure of the bridge, not by rupturing the connection, but by adding an unnecessary additional local stress on the hooping spirals.

Construction.—As stated above, the bridge was intended to test the design and connections which would prove effective for bridges of relatively long spans where the reduction of the dead load is of great importance. For the tension chord it is, therefore, advisable to increase as much as possible the percentage of the metal in the concrete and to use a steel of great resistance and high working stresses. But if the numerous rods of the lower chord are not perfectly straight it is to be feared that they will tend to straighten under the applied load and cause deformations and possibly cracks in the surrounding concrete. To avoid this inconvenience, it suffices to put on the rods part of the stress which they will sustain later and to place the concrete around them after they have been straightened under the stress. To obtain the required tension on the rods a simple method was used in the experimental bridge. Instead of building the falsework as usual of struts and ties, the former only were used and their ends were made to abut against the cast steel bearing plates so that the reinforcing rods of the lower chord acted as ties for the falsework. The latter were thus put under part of the stress which they were designed to carry and part of the falsework material was saved. After thus erecting the falsework, it was braced laterally and distance pieces were suspended for the rods to regulate their spacing. The necessary molding boards for the various concrete members were then suspended. The verticals and diagonals were first built, then the hooped members of the upper chord and the upper lateral bracing. This was followed by the execution of the floor, and since, because of the short span of the experimental bridge, the weight of the suspended structure was not sufficient to cause in the rods the stress required to straighten them perfectly, five tons of rails were added to it. This would not be necessary in bridges of longer spans. Only after the reinforcing rods were thus stressed was the concrete put on the bars. It goes without saying that no such precautions would be taken for a 66-foot span, for it would suffice to reduce the percentage of steel and thereby increase the dead load of the bridge.

In the prisms of hooped concrete which Considère had previously tested in his laboratory experiments, the hooping was done with unannealed wire of high resistance. The use of steel of this kind for larger construction where the spiral rods required diameters much above those required by wire manufacturers was impossible, and soft steel rods of an elastic limit of about 37,000 pounds and an ultimate resistance of 58,000 pounds per square inch were used for the main members and of 33,800 and 55,000 respectively for short members. The percentage of metal was increased to allow for its lower elastic limit, but only slightly so, because the great strength of wire cannot be utilized in hooped concrete before it undergoes large deformations. Unlike the method of the laboratory experiments, the spirals were doubled here, and the slight inconvenience which may result from the discontinuity of the wires was prevented. It was not possible to mold and tamp the members vertically, as was done in the experiments, but the tamping had to be done between the hoops perpendicularly to the longitudinal axis of the member which is the position least favorable to it. Nevertheless the results were fully satisfactory. Candlot Portland cement and gravel of 0.5 to 0.6 inch diameter were used. A concrete made of 1,680 pounds of cement to one-half cubic yard of sand and one cubic yard of gravel was used for the hooped members. For the ordinary gravel, which is commonly used and which is double the size of that employed here, about nine-tenths of the amount of cement will give an equally good concrete. Only 1,260 pounds of cement to the same volume of sand and gravel was used for the rest of the main truss members, and this was again reduced to one-half for the floor system and lateral bracing.

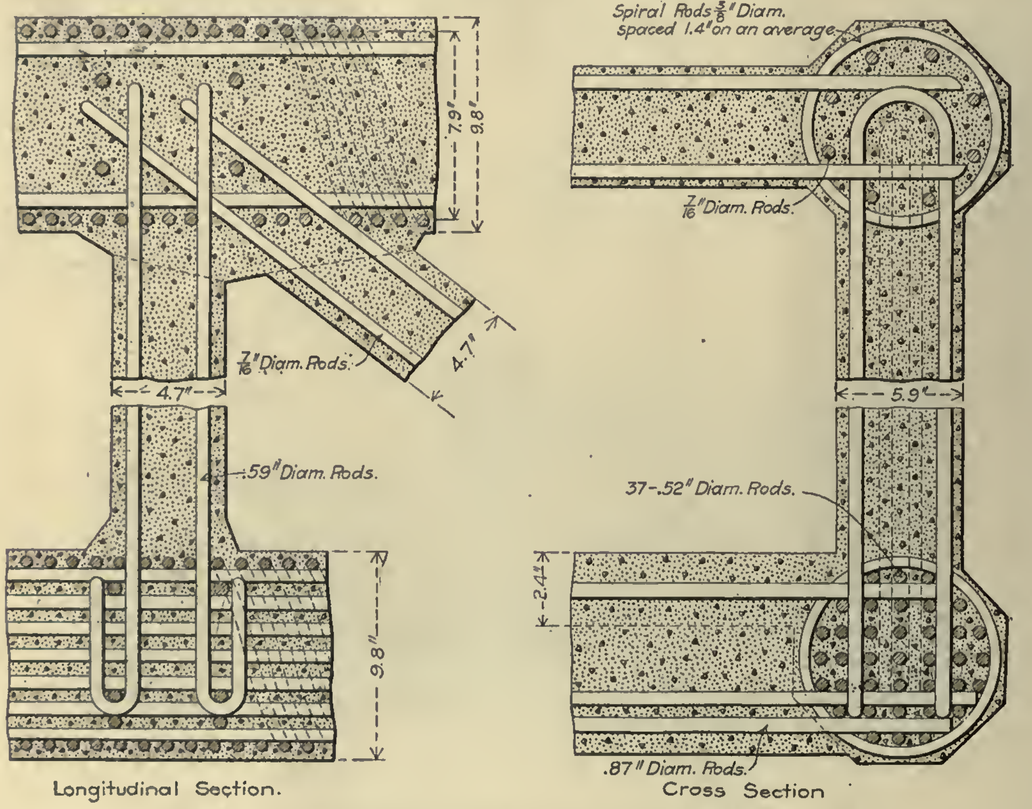
The Test and Its Results.—On invitation of Mr. Considère the French Government Commission on Reinforced Concrete was present at the test, which was conducted under the supervision of M. Mesnager. The bridge was finished July 28, 1903, and was tested Nov. 11, 12 and 13, when the temperature was from 50 to 55 degrees Fahr. The test was made with different positions of increasing loads, both symmetric and unsymmetric, rails being used as load. The deflections and deformations were measured by deflection meters and extensometers.

A load of 66 tons of rails added to the dead weight of the bridge of 27.6 tons caused in the upper chord member in the first panel from the center a stress of 1,270 pounds per square inch of total section, or practically the amount which Mr. Considère has indicated before as the safe working load for a weakly hooped concrete. The pressure on the section included between the hoops was about 1,970 pounds. No injuries of any kind were observed under these stresses, which were very high in comparison with those sustained usually by reinforced concrete. After the load had been on twelve hours the observed deflection at the center of the span was slightly more than one two-thousandth of the span. This deflection is greater than that observed on ordinary reinforced concrete structures. The reason for it is quite evident. In the latter the greatest compressive stress allowed is between 400 and 600 pounds per square inch, while in this case the stress was more than three times as much, and, although the hooping increases the coefficient of elasticity of the concrete, it does not increase it in the same proportion as the ultimate resistance. It was found that an equivalent steel member would be compressed more than one and one-half times as much as was observed on the hooped member. The comparison would prove still more favorable to the experimental bridge if the average deformations of all the members were taken in account. It would then be found that the deformation of the tested bridge was 60 per cent. of that of a steel bridge of the same form. It may be added that the greater dead load of the concrete bridge will, of course, reduce the proportion of live load to dead, and with it the influence of live load in causing deflections. The superiority of concrete structures becomes still more apparent when vibrations and shocks are considered.

The bridge did not show any weakness until the load reached about 200 tons, when the first injuries became apparent simultaneously at several places. At about a third of the span almost invisible capillary cracks appeared in the lower chord. At the panel points 1 and 2 of the northern truss and 2 of the southern inclined cracks appeared in the concrete surrounding the hooped members. At the same time, the four masonry pillars which supported the bridge settled unequally, causing a cross-strain in the bridge.

Under a load of 220 tons the previously observed phenomena were multiplied. In the compression chord in the center panel, which had the reduced cross-section previously mentioned, the concrete surrounding the hooping began to crack off and finally almost the whole envelope cracked off and uncovered the hooping. The stress which caused this surface injury amounted to 5,200 pounds per square inch of total section and to 8,650 pounds of the hooped core.

Under a load of 266 tons failure took place by the rupture of five spirals which hooped the upper chord of the northern truss at panel point 1 and caused the crushing and oblique shearing of the concrete when it lost its reinforcing. The failure of the upper chord was accompanied by a definite noise which was followed almost immediately by another caused by the rupture in the two last panels at one end of the south truss. The second failure was evidently due to the first. The lower chords were practically intact. Notwithstanding considerable deflections and shocks they show only slight cracks. Much more damaged were the web members which were reinforced by longitudinal rods only. The verticals and diagonals of the two first panels were completely dislocated and show fragments of concrete held together by distorted reinforcing rods.



Longitudinal Section. Cross Section

Details of Construction of Experimental Concrete-Steel Bridge.

Outside of the points of rupture the upper chords stood the test well and for four-fifths of their length the concrete envelope was still intact. According to the numerous laboratory experiments which have been published, this proves that when the bridge failed these members were still far below their ultimate resistance. This leads to the conclusion that the bridge failed because of a local fault and would otherwise have sustained a still higher load. On account of faulty connection in not following the design at the point of rupture, the spirals were overstressed locally which, together with their hooping stress, caused their rupture.

Besides the above, the bridge had a number of other faults of construction which had no injurious effect under the breaking load. Because the hooped cylinder has a much higher resistance and coefficient of elasticity than the surrounding concrete, it is evidently important to have it well centered. Instead, the work done was so faulty that in some places the spirals touched the surface. This resulted in excessive deflections in the member. By providing suitable concrete spacers such eccentricity can be avoided. The center lines of the members meeting at a panel point should, of course, intersect in one point, but actually this was not observed. In the hooped member of reduced cross-section the spacing of the spirals was very irregular, but no harm resulted. While the spirals can easily be correctly spaced absolute regularity of spacing is of no importance. Some spirals were not bent over at their ends and some of them scarcely penetrated 2 to 2.5 inches into the hooped core, but owing to the considerable friction produced in the compressed concrete no trouble resulted. It was the opinion of several engineers who were present at the test that the results might be considered the least favorable which should be expected from such structures. The poor construction of the bridge was due to two reasons—the author could not supervise the work personally all the time, and the workmen employed had never built anything similar.

Resistance and Ductility.—From the published experiments the compressive resistance of a hooped concrete member was found to consist of the sum of the following three elements: 1. Compressive resistance of the concrete without reinforcing. 2. Compressive resistance of the longitudinal rods stressed to their elastic limit. 3. Compressive resistance which would have been produced by imaginary longitudinals at the elastic limit of the hooping metal, the volume of the imaginary longitudinals being taken as 2.4 times that of the hooping. The amount of hooping metal referred to the section of the core was 4.6 per cent., and that of the longitudinal reinforcing 2.42 per cent. This is for the average spacing of hoops. The resistance computed, according to the above rule, is 7,540 pounds per square inch. Computing the same for the maximum spacing between hoops 7,000 pounds is obtained. The compression actually resisted by the chords did not exceed 6,540 pounds. It fell below the computed value and did not verify the given rule, but it must be remembered that not only the chord members did not fail under this stress, but even the concrete envelope did not crack off for four-fifths of their length. As found from numerous laboratory experiments, the latter cracks off at a considerably lower stress than the ultimate resistance. This was verified in the case of the member with reduced section in which the envelope cracked off under a compression of about 7,900 pounds per square inch of core, yet resisted without failure 10,200 pounds. For this member the computed value for the average spacing is 11,900 pounds per square inch, and for the maximum spacing 9,240 pounds. The value of 10,200 pounds, which probably would be still higher, lies between the two latter values.

As the failure of the bridge was caused by the rupture of the spirals at a panel point connection, there was no opportunity to observe the remarkable ductility of hooped concrete to its full extent. It was thought necessary to strengthen the upper chord of the center panel, which was of reduced cross-section, by a vertical sub-strut, as shown in Figure 1. This proved to be a mistake. The shortening produced by the compression of the member tended to bring the upper ends of the adjacent verticals nearer together, the sub-strut prevented the free motion, and flexure took place as was shown by the instruments. It was found that under the final loads, the extreme upper "fibers" of the member underwent a shortening four times as great as those of the extreme lower ones, while, at the same time, resisting a compression of 10,200 pounds per square inch.

Symptoms of Approaching Failure of Hooped Concrete.—Hooped concrete is made up of two elements which, while of the same material, differ much in their resistance and ductility. While the hooped core is stressed far below its ultimate resistance the concrete surrounding it has reached its breaking strength and limit of deformation, and begins to crack and finally breaks down completely. This takes place when the structure is still completely safe. Thus in the experimental bridge several noticeable cracks appeared under a load equal to three-quarters of the breaking load. This is very important as indicating approaching danger, but especially so for hooped concrete, because it can be repaired and reinforced at small cost. All it needs is to break off the surrounding concrete and to wind around the hooped core additional wire. The efficiency of this method has been verified by winding in iron wire around a cylinder cut out of old mortar and testing it. With 3.4 per cent. of wire an ultimate resistance of about 10,500 pounds per square inch of total cross-section was obtained.

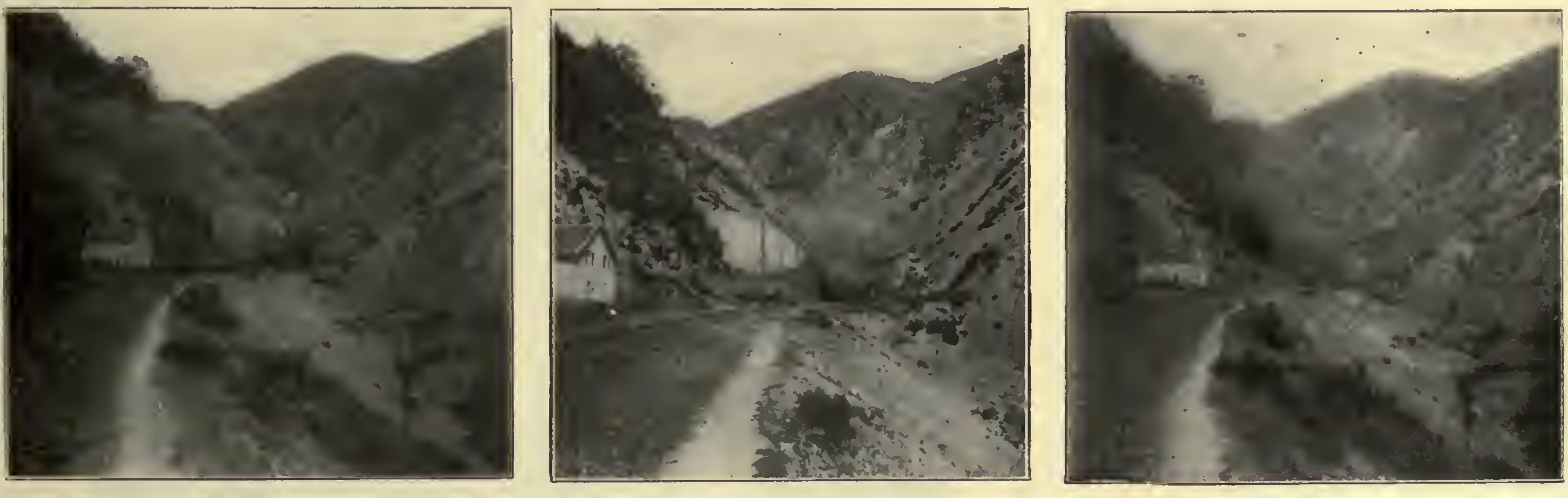
Effects of Poor Work.—As mentioned above, the adhesion of the concrete to the reinforcing is not necessary for the strength of hooped concrete, because the friction of the metal in the compressed concrete is sufficient to grip the ends of the hooping rods even if they are not deeply embedded in the concrete. This has also been demonstrated by the experience with the tested bridge, due to the poor work in its construction. As to the longitudinal reinforcing rods they exert on the concrete normal stresses only which do not require adhesion. Naturally, adhesion is also of no value in the lower-chord tension members, because the ends of each reinforcing rod are fixed to a bearing plate and the tensile stress in the metal is practically constant from one end to the other. An idea of the effect of poor concrete on the resistance of members such as those in the experimental bridge can be obtained from the following figures. If the resistance of the concrete itself were reduced one-half, the total compressive resistance of the member would be reduced from 7,540 to 6,250 pounds per square inch in the chord and from 11,900 to 10,600 pounds in the member with reduced cross-section. The margin of safety left is still very considerable.

Factor of Safety.—The considerations governing the selection of a factor of safety for hooped-concrete structures are, of course, primarily the same as for structures of other materials. Liability of errors in assumptions and methods of computation and possible increase of working loads are more or less likely to occur in any structure. Possible defects in construction must be considered, but, as shown, in hooped concrete such defects are of small importance. Secondary stresses caused by rigid connections and stresses produced by settling or leaning of supports must be borne in mind. The dangers resulting from these causes are mostly counteracted by the ductility of the material. The high ductility which is characteristic of hooped-concrete sufficiently warrants the adoption of factors of safety not much higher than commonly used for steel structures of the same class, though it is advisable to be careful at the beginning. As to the effect of shocks and vibrations, the greater weight of the hooped-concrete structure will always be in its favor. It may also be well stated here that bridges of reinforced concrete which have been in service for five years on a French railroad have resisted all shocks and vibrations and are in perfect condition. Reinforced concrete is also successfully employed for supporting machinery, causing most violent vibrations. The durability of reinforced concrete structures against rust is patent to every engineer. Mr. Considère concludes from the above that in a few years the same factors of safety will be adopted for hooped-concrete as are at present in use for steel structures. For the present he proposes to allow a working stress of 2,130 pounds per square inch for members in compression containing 6 per cent. in spirals and 2.5 per cent. in longitudinal reinforcing rods. This corresponds to a factor of safety of 3.7 compared to the results obtained in the experimental bridge and to a small factor of safety relative to the compression at which the cracking of the outer concrete begins. According to the conditions, varying with length and width of member and length of span, the percentage of metal in the hooped-concrete members may vary from 2.5 to 6 per cent. in the spirals and from 1.5 to 2.5 per cent. in the longitudinals, with an allowable compressive stress of 1,300 to 2,130 pounds per square inch of total cross-section.

The Ventilation of the Albespeyre Tunnel, France.

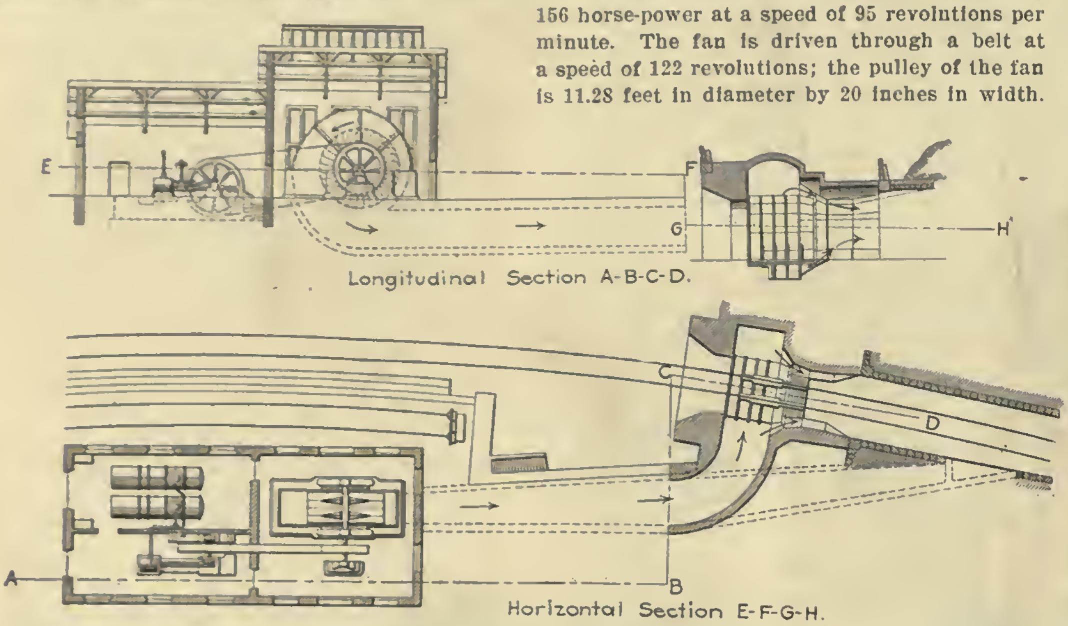
By Dr. Alfred Gradenwitz.

A striking example of the difficulties met with in the aeration of tunnels, as well as of the large size machinery necessary for this purpose, is afforded by the recent installation of a large ventilator built by Mr. Emmanuel Farcot fils, Plaine St. Denis, France, for the Albespeyre tunnel on the Langogne-Alais line, belonging to the Paris-Lyons-Mediterranean Company, between Prévenchères and Villefort stations. This tunnel traverses the parting of waters between the Atlantic and the Mediterranean; it is a single-track tunnel, 258 square feet in cross-section and 4,930 feet in length; its mean gradient is about 25 in 1,000.

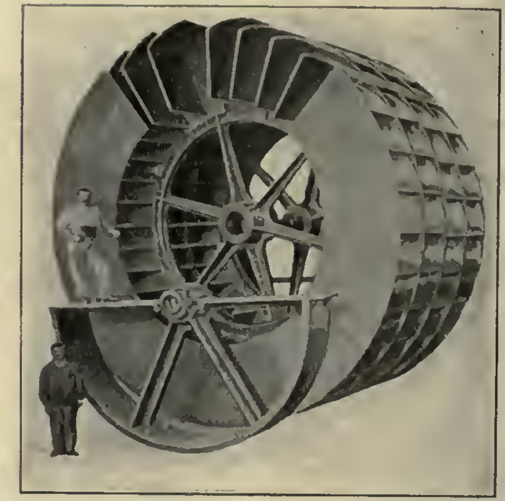


Albespeyre Tunnel: Train before Entering; Train Within; Train Passed Out but Fan in Operation.

The ventilation of this tunnel, which is traversed by a large number of heavy trains, presented special difficulties. While the natural aeration, being frequently acted against by violent winds, proved quite inefficient; three shafts sunk for the purpose, 10.76 square feet in cross-section and 200, 395 and 490 feet in depth, respectively, had but a negligible action. In the beginning the trains going up-hill had to be pushed by an auxiliary engine placed at the rear of the train; moreover, the trains had to stop at Villefort to take on water, clean the grates and make up a good fire. The high gradient, however, resulted in a large consumption of fuel, giving rise to the production of a great amount of toxic gases, which repeatedly caused serious accidents of asphyxia, as well as stoppages within the tunnel. Moreover, the two-locomotive freight trains did not run at a speed above 15¼ to 17 miles per hour on the high gradient. The head locomotive would, accordingly, meet a supply of fresh air on traversing the tunnel. As the steam and smoke escaping from it would be thrown backward, the engineer and fireman of the rear locomotive, situated at about 65 feet distant from the former, would have to pass through a contaminated and rather dangerous atmosphere. This plan was therefore eventually abandoned, and the train divided into two parts; however, the atmosphere of the tunnel would remain in a contaminated condition, sometimes for about 40 minutes after the passage of the train, and this solution did not prove satisfactory.



Arrangement of the Albespeyre Tunnel Plant.



The Fan Wheel.

The Paris-Lyons-Mediterranean Company therefore decided on trying artificial ventilation for the tunnel according to the Saccardo system, used, for instance, in the double-track St. Gothard tunnel, 9⅓ miles in length.. The Saccardo ejector, as is well known, consists of a fan blowing into an annular compartment, which terminates in a pipe fitted to the perimeter of the tunnel, so as to constitute an annular injector of a circular cross-section. The fan, installed at the highest point, throws the air under a definite pressure through the pipe, producing a kind of screen, which retards the speed of the air thrown back by the uphill train and gives rise to a circulation from one end of the tunnel to the other without its being necessary to fit the same with any inconvenient and dangerous doorways.

While the output of the fan installed in the Pracchia tunnel (in the Apennines, 1⅓ miles in length) is 950 to 3,530 cubic feet per second, and that of the two fans in the St. Gothard tunnel double that figure, for a pressure variable between 0.39 and 1 inch, the output required for the Albespeyre tunnel was 5,300 cubic feet per second, the corresponding pressure in the ejector compartment being 1.58 inches, and the annular section of outflow 64.5 square feet. In fact, a much more energetic ventilation than with the two preceding applications was aimed at in the present case.

The Ventilating Plant during Construction.

The Farcot ventilator, a turbine of the reaction type, fulfilling these conditions, is 19.68 feet in diameter by 8.2 feet in breadth, with paddles bent in a direction opposite to the direction of rotation of the wheel; the turbine comprises two symmetrical halves, each of which has 64 sheet-iron paddles. The total weight of the turbine, including the shafts, is about 10 long tons. The spiral casing, consisting half of sheet-iron and half of masonry (at its lower part), is 9.84 feet in breadth; the air issues through a conduit, the cross-section of which increases from 97 to 225 square feet. This conduit terminates in a compartment, surrounding the sheet-iron pipe continuation of the tunnel, whence the annular ejector starts with a cross-section of issue of 64.5 square feet.

The fan is operated by a Corliss-Garnier-Faure-Beaulieu engine, with a cylinder of 18.1x 37.5 inches in size, non-condensing, developing 156 horse-power at a speed of 95 revolutions per minute. The fan is driven through a belt at a speed of 122 revolutions; the pulley of the fan is 11.28 feet in diameter by 20 inches in width. Though the angular speed of the fan is not much above that of the motor, the operation by means of a belt was preferred to a direct coupling, lest the steam engine obstruct the access of air to the fan inlets.

With an output of 5,300 cubic feet per second, as measured at the ejector, a mean speed as high as 34.4 feet per second is obtained throughout the tunnel, corresponding with an output of 6,500 cubic feet due to the carrying along of the air entering at the mouth of the tunnel. This speed, however, discommodes the workmen occupied in the tunnel and puts out the torches. The speed of 16.4 feet per second, corresponding with a total output of 4,250 cubic feet, is still too great, and 10 feet per second should not be exceeded during the time the men are working.

The service is performed in the following way: As long as no uphill train is signaled, the fan runs at low speed, viz., 50 turns per minute. As soon as a train approaches, the speed is raised to 150 revolutions, this speed being maintained for about 8 minutes; 4 minutes are required for the passage of the train through the tunnel, and a further 4 minutes are necessary for clearing away the smoke.

As trains running uphill will go in a direction opposite to the air current at a speed of 15½ to 18½ miles per hour, or 26¼ feet per second, being equivalent in absolute value to that of the air in the tunnel before the train enters the latter, the air current is practically stopped during the time the train traverses the tunnel, the air being thrown back to the northern end. As a certain amount of air still surrounds the train, the atmosphere will remain respirable for the occupants. It has been possible to revert to the former use of the rear locomotive. As the atmosphere is renewed after the passage of each train, the front engine does not contaminate the air in such a way as to affect the men on the second.

Tests made on delivery have shown that the conditions stipulated have been fulfilled. The fan should give for five hours outputs of 4,250 to 5,300 cubic feet per second, the speeds of the motor varying between 95 and 98 revolutions per minute.

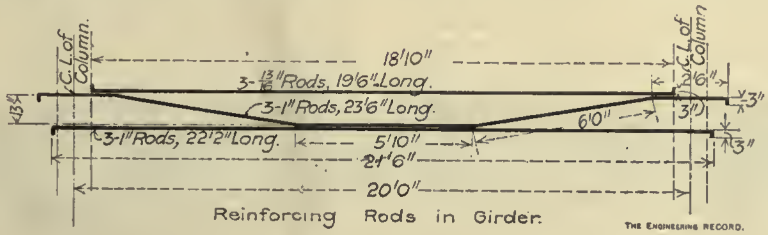
In a communication by Mr. Farcot to the Society for the Encouragement of National Industry, Paris, some experiments were reported on mechanical ventilation recently made in Paris on the Metropolitan Railway between the Vincennes and La Bastille stations. A fan 8.2 feet in diameter, giving an output of 1,770 to 1,950 cubic feet per second and being susceptible both of aspiring and blowing actions, had been installed at Vincennes, with a view to ventilating this tunnel as far as La Bastille, where the tunnel terminates into the open air. As this fan was started during the hours of service, at the moment that the doors of either the Vincennes or the neighboring Place de la Nation station were opened, a most violent air current was produced that was absolutely unbearable, whereas the regular air current did not go as far as La Bastille, on account of the frequent passages of trains running in an opposite direction. By night, however, the air current would be established regularly throughout the length of the tunnel at a speed of 4.9 feet per second, corresponding to 175 cubic feet per second.

A Reinforced Concrete Store Building in Chicago.

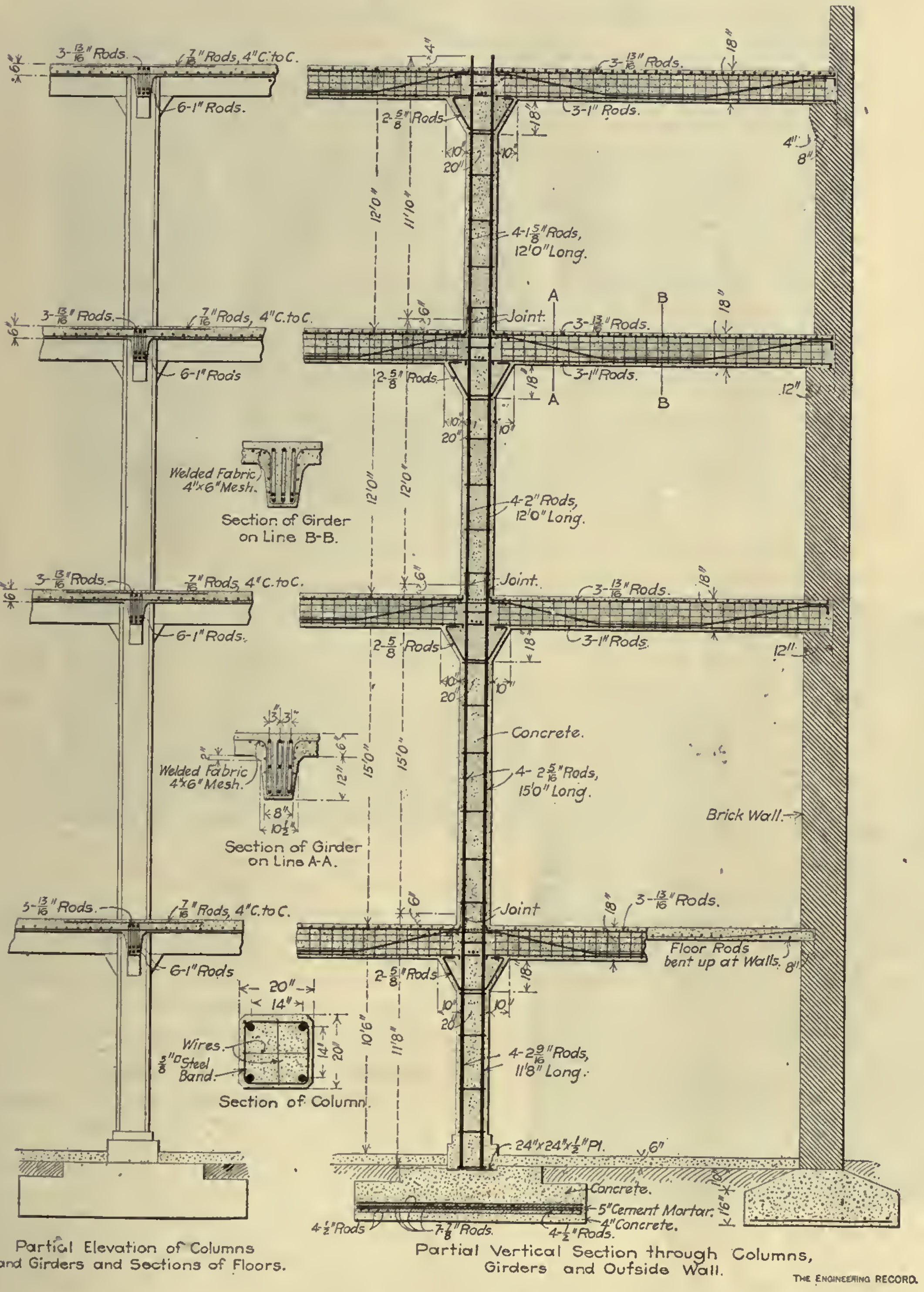
An interesting embodiment of advanced ideas in reinforced concrete construction is the store building now being erected in Chicago at the northeast corner of Thirteenth Street and Michigan Avenue. This building is 100x130 feet, seven stories in height, with brick outer walls. The basement is 10 feet 6 inches high; the first story is 15 feet high, and the remaining stories are 12 feet high. Each floor, with its supporting girders and columns, is a concrete monolith reinforced with round steel rods of an elastic limit of 36,000 pounds. The rods are of widely varying sizes to suit their locations. The general scheme and some of the details of the construction are shown by accompanying drawings. The columns are spaced 15 feet 6 inches by 20 feet, and have bases 11 feet square, so as to reduce the load to 4,000 pounds per square foot on the fine sand in which the foundations are laid.

The construction of the column bases is shown by some of the drawings. A layer of 1:2:3 Portland cement concrete 4 inches thick was first laid in the bottom of each pit, and then four ½-inch rods were placed side by side, near and parallel to each edge of the square pier. Next came two sets of ⅞-inch rods, seven in each set, spaced 6 inches apart and laid both ways at right angles, across the central portion of the footing, as seen in the drawing. Lastly, two sets of diagonal 1-inch rods, seven in each set, were laid on and parallel to the diagonals of the square. The rods were then tied together at their intersections, and 1:4 mortar was poured on to and around the rods to a depth of 5 inches above the first layer of concrete, the rods being shaken to settle the mass, which was then thoroughly tamped. Above this second layer 1:2:3 concrete was placed in forms to finish the pier as shown. The bending moment was plotted as the dotted parabolic curve shown in the transverse section of the footing, and at its highest point there was embedded in the pier a ½-inch steel plate, 2 feet square, upon which stand the four vertical column rods.

These vertical rods in the corners of the columns extend only from floor to floor, with joints 6 inches above the floor level in each story. Each joint is made with a sleeve of gas pipe, into which the ends of the two sections

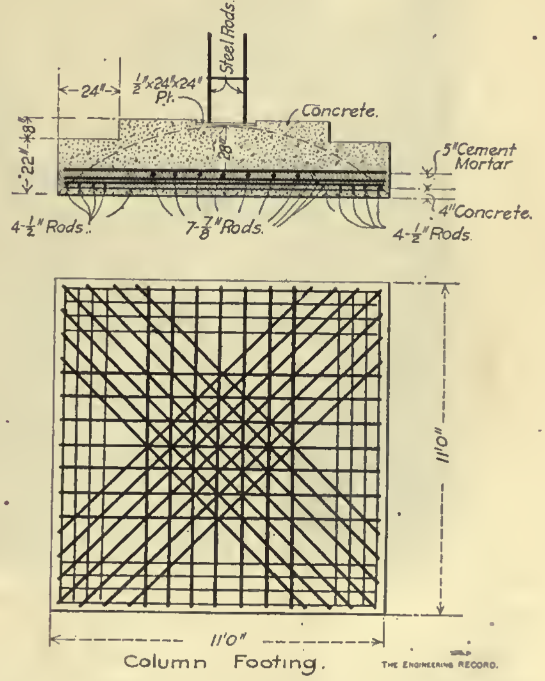


Reinforcing Rods in Girder.



Partial Elevation of Columns and Girders and Sections of Floors.

Partial Vertical Section through Columns, Girders and Outside Wall.

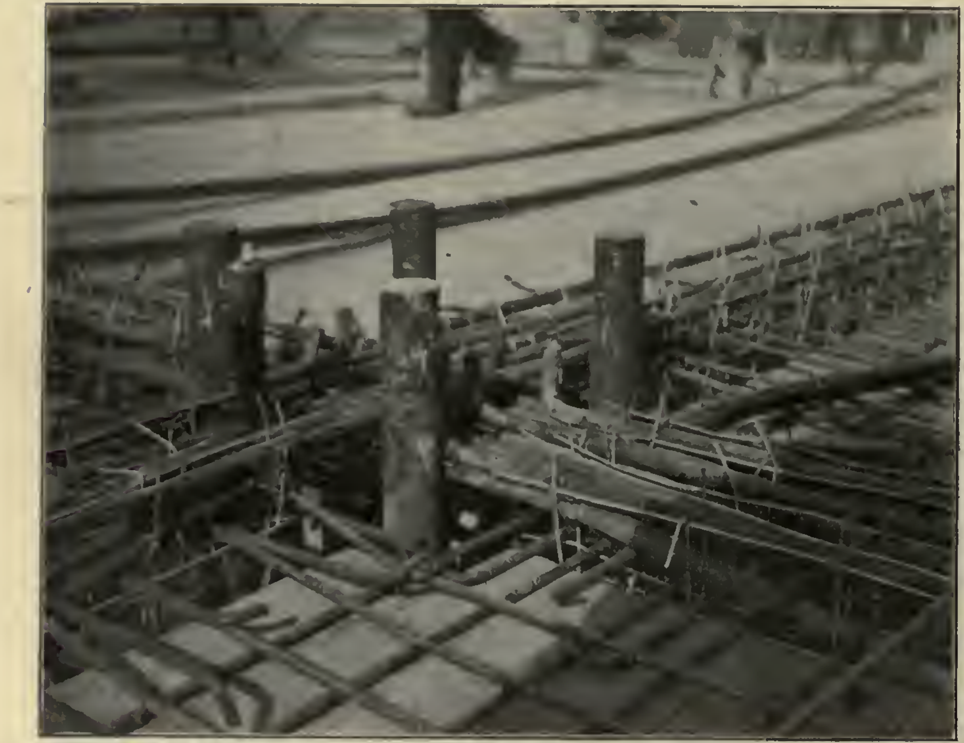


Column Footing.

Structural Details of a Reinforced Concrete Store Building in Chicago.

of a rod are wedged. The rods are 2 7/16 inches in diameter for the first story, and decrease to 1 inch diameter for the top story. Bars of ⅝-inch square steel, at intervals of about 24 inches, bind all four vertical rods together. These bands have loops of wire twisted tightly, connecting the centers of the opposite sides and offering additional resistance to the tendency of the vertical rods to spread.

One of the detail drawings shows the design of the reinforcement in a girder, the rods forming a sort of truss. The average girder contains three of these trusses, thus having three 1-inch tension rods at its bottom, three 1-inch shear rods, and three ¾-inch top rods in compression. The design limited the floor thickness to 6 inches, with a girder depth below this of 12 inches. The girder trusses were designed to come within 1 inch of the top of the floor, in order to gain the fullest advantage possible. The three girder rods of each truss are connected by means of electrically-welded fabric, one net enveloping each girder at each end for one-third of the span and being securely tied to the rods at the intersections. The three trusses are tied together by means of another net extending across the center third of the span only. These details are plainly shown in some of the sections reproduced among the drawings. This mode of application of the stirrups connects the latter horizontally every 4 inches of the depth of the girder. One of the views shows the intersection and interlocking of the girders at a column, also the ends of the four column rods, the conduit for electric wires, which is carried inside the concrete among the rods, and the ends of the electrically-welded fabric mentioned above. The corbels under the ends of the girders at each column are reinforced, as shown, by bent ⅝-inch rods fastened to the girder rods.


Intersection of Girders and Column, Showing Steel Rods in Position.

Reinforced Concrete Building: Floor Rods in Position.

The main floor rods are 7/16 inch in diameter, are spaced 4 inches apart in both directions, and are carried through the girder trusses. Additional floor rods, as can be seen in one of the photographs, as well as in the drawings, are run over the trusses, extending 3 to 5 feet on either side, with hooked ends fastened to the bottom floor rods. These additional rods are intended to take care of the negative bending moments developed. The ends of each girder and floor rod are bent at right angles to the body of the rod to act as anchors. These anchors are 3 inches long on the girder rods and 1½ inches on the floor rods. The outer or brick side walls are not built above the levels of the girder trusses until the latter are put in place. Thus the ends of the girders are built into the walls as they go up.

As the weight of the floors is 75 pounds per square foot, the molds for them are strongly made and securely fastened together. An accompanying view gives a good idea of the arrangement of the molds and bracing. For the columns 1¾-inch material is held every 30 inches by wedges in reinforcing clamps of 2x6-inch stuff. The girder bottom molds are supported on 4x6-inch posts, each resting upon a double wedge by means of which a precise alignment is obtained, thus preventing the sagging of these bottom girder strips, which might place the tension reinforcing rods too near to the neutral axis, a thing which has been known to happen in reinforced concrete work. These girder mold planks also carry the molds for the floor. The floor molds are in the form of inverted boxes 4 feet 7 inches by 15 feet, and four of them are laid and bolted together to form a section, the outer exposed ends and sides forming the sides of the girder molds.

The cement used is Vulcanite, and the concrete is being mixed in a Smith machine of 60 cubic yards capacity per day of eight hours. The proportion of voids in the materials is measured every morning and the concrete is mixed accordingly, the desired ratio being 1:2:2 of cement, sharp torpedo sand and clean screened roofing gravel of a size to pass through a ⅝-inch mesh.

The concreting is carried on by two eight-hour shifts, the interval of no work between 1 A. M. and 7 A. M. not being deleterious to the result. One of the views also shows the trestle adopted to carry the barrows of concrete over the floor rods. The concrete is mixed very wet, and after being poured on, is puddled with small rods to work the air out. The mixtures used in the floors, columns and girders have proven practically watertight. After one floor has set ten days the molds are dropped, leaving in place girder and panel supports. The molds are then carried up one story, re-erected, and the next floor put in. About fifteen days per floor are required for this building. All the work of bending the ends of the rods, building up and tying the girders, etc., is done on the spot by two men and two helpers.

Mr. E. Lee Heidenreich is the engineer for the armored concrete construction; Mr. James Gamble Rogers, the architect for the building, and Mr. James O. Heyworth is the contractor.

The Siberian Railway is 4,100 miles long from the frontier to Vladivostok and has many bridges. The aggregate length of the bridges is estimated to be more than 30 miles. Among the most important, according to "Indian Engineering," are those over the Irtish, 2,250 feet long; the Tobol bridge, 1,540 feet in length; the bridge over the Yenessei, 3,000 feet long, and the Obi bridge of 2,600 feet length, all single-track structures.

Air-Lift Pumping Machinery at the Inverted Siphon of the New Croton Aqueduct, New York City.—II.

In connection with the old bailing apparatus 6x8-inch vertical hard-pine guides had been set for the buckets to travel on. There were four of these guides, two attached to the cast-iron lining and two fastened to a number of cast-iron I-beams placed at intervals on diameters of the pump well. All the guides are set in a diametral plane of the well. Advantage was taken of these guides as an aid in keeping each pair of tanks in alignment as they were lowered. Two guides were available for each pair of tanks, but it was decided to use only one, the one in each half of the well farther from the aqueduct shaft, because if the two guides of a pair were not truly in the same plane or if the tanks should cant slightly during the lowering, with the great weight of the moving mass a serious binding or jamming might occur, which, with the tanks at a great depth under water, might have been very difficult to overcome. It was desired to have the four tanks when in their final position as far as practicable from the connection to the aqueduct shaft so as to leave as much free space as possible around the opening.

Reinforced Concrete Building: Erecting Molds for a Floor.

For the pair of tanks farther from the aqueduct shaft, the southerly pair, the guide attached to the cast-iron lining was used, and for the other pair the guide on its side of the I-beams. Guide grooves about 2 feet high were formed on the outside of one of the special pipe castings just above the tanks, and for the south pair of tanks this groove and another of the same height riveted to a plate connected to the tanks near the bottom were used. For the north tanks the groove on the special pipe casting could not be used, as it was on the wrong side, and so its sides were planed off, and two grooves riveted to connecting plates near the top and the bottom of the tanks were used. A long piece of steel angle was also riveted to the top and down the side of each tank of the north pair so that its edge would touch the flanges of the I-beams, to aid in guiding the tanks.

Further use was made of these old guides to hold the air and discharge rising pipes from buckling out of line. This was accomplished by means of clamps, each of which was made in two pieces bolted together so as to hold all three pipes from one pair of tanks. Each clamp has a groove at each end and engages the two guides in one side of the pump well. These guide clamps were spaced about 60 feet apart vertically, being clamped to the discharge pipe just above a flange as the successive lengths of pipes were added as the tanks were lowered. The pipe fittings and flanges, the tank heads and all other important castings are of steel and were made by the Chester Steel Casting Company, of Chester, Pa. The tanks were made by the International Boiler Company, of Stroudsburg, Pa. The pipes are extra-heavy lap-welded steel tubes manufactured by the National Tube Company, of Pittsburg.

The faces of the pipe flanges as furnished were not absolutely true, and in all cases the end of the pipe projected slightly through the flange. While such small discrepancies might be passed in ordinary piping, they were deemed unsafe in pipe columns 330 feet or more in height. This made it necessary to face the ends of the pipes, and as there was no machine shop within several miles which was equipped suitably for the job, the erecting engineer, after some loss of sleep over the predicament, devised an ingenious and simple apparatus for doing the work. This was made mostly of materials and tools at hand and proved not only very economical, but efficient and rapid also. An accompanying view shows this improvised machine, which is described below. After being faced, the flange joints of the pipes under water were made up with red gasket paper about 1-32 inch thick, furnished by Messrs. C. B. Hewitt & Brothers, of New York, and known as grade K.

Two 10-inch I-beams 20 feet long, several pieces of old cut granite 10 inches thick and some cast-iron floor gratings were the crude materials from which a very respectable lathe was evolved. First, four of the stones were leveled up on the ground with some of the gratings below them to act as washers. On the stones were placed the beam and two pieces of 12x12-inch timber, near one end to carry the boxes for the facing bar. The facing bar was obtained from the company's shop, together with a small engine to drive it. Two cradle castings were made to fit the pipes and also the I-beams and were held on by long eye-bolts which passed down between the stones and through the gratings, with nuts below. Four hook bolts engage the eyes to swing up to two wooden clamps with slotted ends for holding the pipes in the cradles while being faced. The bar was carefully lined up to one of the pipes. The engine was set on two planks, lined up, lag-screwed down to them and held in position by piling stones on the planks. A 6-inch pulley on the engine shaft and a 24-inch pulley on a short piece of shaft at right angles to the bar and geared to it in a 1 to 3 drive completed the outfit.

The pipes were run along the ground on rollers, rolled up planks into the cradles and made fast. To turn the pipe end for end an hydraulic jack came in handy. This was placed on a steel plate on the ground and had a wooden V-block on top recessed to fit the jack and prevent slip. With one man to steady the pipe and one to pump, the pipe was raised, swung around and lowered in about three minutes. Various rates of progress were made, one day six pipes or twelve flanges in eight hours, another day one flange in four hours, but this latter was very hard and badly out. The average was ahead of most jobbing shops, cramped for room and with poor crane facilities. The facing was well up to the average shop work.

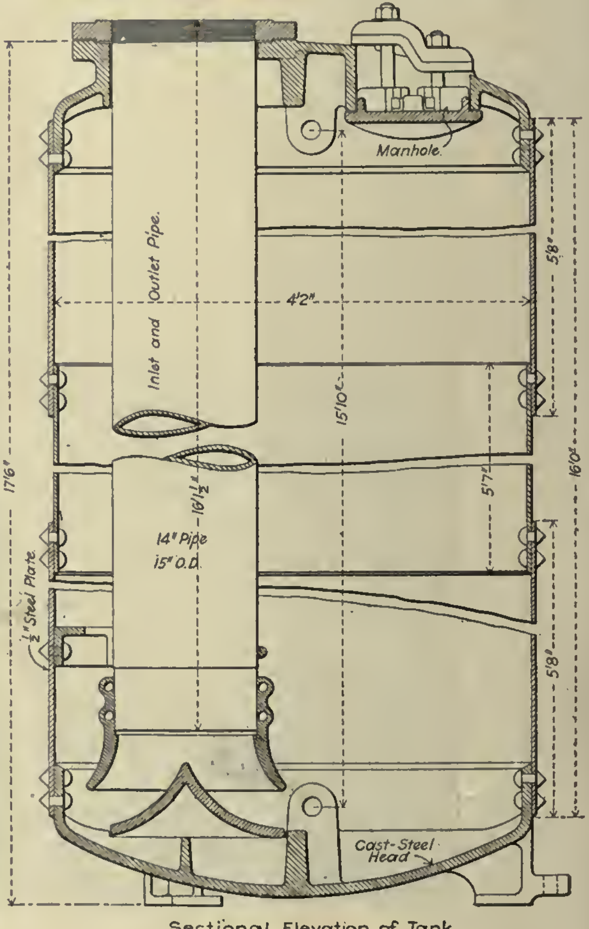
The two 14-inch discharge risers after the two pairs of tanks had been seated at the bottom of the well, were united 3 feet above the erecting platform by a special Y-branch flange connected to a tee set vertically in each line. Above these tees the risers were extended about 22 feet as open-top standpipes, which were used only during the tests as a sort of safety valve for the meter. To the special Y-branch a 21-inch S-curve was bolted in order to direct the discharge into a cast-iron box or catchbasin, from which the water flows into the 48-inch cast-iron blow-off pipe leading to the Harlem River. During the efficiency tests of the apparatus a 20-inch Gem meter, made by the National Meter Company, of New York, was substituted for the S-curve, with its end projecting into the 48-inch pipe.

The four air pipe risers were carried up vertically from the connections on the tops of the tanks to and just through the erecting platform; then they were all deflected into one plane near the south side of the shaft and extended vertically to the machinery room. This necessitated their passing through the two-brick diaphragms built across the shaft. It was not convenient to pass these pipes through the manholes, and, besides, the manholes have heavy iron covers which it is necessary to bolt down, because the water in the well might otherwise rise into the working chamber above, since the aqueduct is under pressure here sufficient to raise the water to elevation 130, or about 35 feet above the floor of the machinery-room. The eight pipe holes through the brickwork of the diaphragms were cut by means of a 9-inch Davis Calyx drill, which removed clean cores of brick and mortar, like small pillars, and also cut disks from the 1½-inch cast-iron plates on which the brickwork rested. The holes for the various pipes through the manhole plates and the diaphragms were fitted with stuffing boxes and made watertight.

Into each hole a heavy cast-iron pipe was inserted and made tight in the following manner: Each pipe had one end flanged and one end spigot-shaped. Four of the pipes were put in from below the lower diaphragm and bolted to the cast-iron lining under this diaphragm; the other four went in from above and met the first four between the diaphragms, where all were connected by heavy sleeves leaded and calked, after which all were grouted solid. These pipes were 7½ inches inside diameter, or large enough to pass the 5-inch pipes and couplings easily. Their upper ends carried the glands, which were also made to pass the pipe couplings by the removal of a loose ring in the bottom of the stuffing box. Each of the air lines had a section of brass pipe jointed in where it passed through the gland, which was also lined with brass to prevent corrosion.

It will be seen that the pumps are in duplicate, each pump consisting of two tanks with their independent pipe connections. Each tank has in its top head an air inlet and outlet opening, a water inlet and outlet opening and a manhole. The two water openings of the pair of tanks are connected, through two check valves, to one water intake pipe, as indicated in the illustrations. The intake pipe extends down beside the tanks to a level about 5 feet below the check valves, or about 12 feet above the bottom of the well, and has a flaring end. A pipe also extends down inside of each tank from the inlet and outlet connection, nearly to the bottom, as shown in the detailed drawing of the tank. The pipes from the two water openings of the pair of tanks are extended above the inlet connection and united through two other check valves and a Y-branch to the discharge riser. Near this point, also, an air chamber is connected to the side outlet of a tee inserted in the riser just above the Y-branch.

The four air pipes from the four tanks are led up to the two manifolds at the top of the shaft, from the top of which 8-inch pipes lead to the air switch. It will be readily seen that each 8-inch pipe, and consequently each manifold, acts alternately as the pressure side and as the return. The compressor forces the air in one direction, or always through one of the four connections to the switch; the return is also unchangeable, hence, the two 8-inch pipes leading to the manifold are, during one cycle, connected to pressure and the next to the intake of the compressor, through the switch. The manifolds serve the further purpose of making it possible to pump with any two tanks, no matter which two. This is accomplished by one by-pass from each manifold to one of the pipes on the other manifold. The advantage of this is apparent, for if it should become necessary to pump alone from the two tanks on one manifold, one of the tanks would have to be connected to the opposite port on the switch in such a case. The pipes lead from the manifolds to the tanks in such a way that but one tank of each side is discharging at any time. The air from the compressor passes through an after-cooler on its way to the switch, and in the pipe between the after-cooler and the switch there is a tee from which an 8-inch pipe leads to the 42 inch by 10 foot receiver.



Sectional Elevation of Tank.

THE ENGINEERING RECORD.

Air-Lift Pumping Machinery: Lathe for Facing Pipe Flanges; Details of One of the Tanks at Bottom of Pump Well.

The operation of pumping or ejecting the water may be briefly described as follows: Water under the pressure due to its depth in the pump well enters an empty tank through the inlet pipe. When the tank is filled the automatic air switch directs air from the compressor into this tank, which forces the water through the discharge riser to the outlet, the check valve in the inlet connection to this tank closing when the air under pressure is admitted. The tank having been emptied of water, the air is diverted by the switch to the other tank of the pair, which, meanwhile, had been filled with water. This alternating process is continued by the two pairs of tanks until the water is reduced to the desired level. It will be perceived that it is necessary to set the tanks so that their tops are slightly below the level down to which the water is to be pumped, and that a portion of the air-pressure is recovered as the water fills the tank. This recovery of air under partial pressure is due to the use of a constant working pressure from the compressor and the return of the air to the compressor under the pressure due to the depth of water above the tanks, instead of exhausting the air to the atmosphere. Of course, as the water is lowered in the well, the pressure on the air returned to the compressor drops, and it becomes nil when the well is empty.

The automatic air switch is made to operate and is controlled by the difference between the return pressure and that due to the head of water in the pump well. This pump well pressure is obtained by running a ⅜-inch galvanized iron pipe to within 6 feet of the bottom of the well. A branch from this pipe runs to a gauge reading in pounds pressure and the corresponding feet of water. A small regulating cock connects it to the main air line and keeps it charged; as the water falls air leaves the bottom of the pipe and the gauge at once gives the water level. A connection from this pipe runs to one side of a 5-inch diaphragm in the switch, and the opposite side of the diaphragm is connected to the return pressure-pipe from the switch to the compressor.

The diaphragm has a movement of 3/32-inch and controls a valve which admits or exhausts air from a 2-inch vertical cylinder with a piston movement of 1½ inches, which in turn moves a valve that admits and exhausts air from an 8-inch diameter by 6¾-inch stroke cylinder, the piston of which moves the switch. Air for this purpose is reduced to 50 pounds and stored in a small receiver. The object of all this is to cause the switch to operate the instant a tank is full. The movement is governed by, and takes advantage of, the pressure due to the head returning to the compressor and prevents its being drawn down below that required to fill the tanks.

The operation during one cycle is as follows: The switch having just moved, the return pressure on one side of the diaphragm, being greater than the pump-well pressure, causes the diaphragm to move and this closes the valve operating the small cylinder, previously referred to, causing it to exhaust and the piston to return to its lower position by means of a weighted lever. The tension on the diaphragm can be varied by a spring on the side opposite to the valve so that when the return pressure falls 5 pounds below the pump-well pressure, or that due to the difference in length of the pump-well gauge pipe and the depth to the top of the tank, then the pump-well pressure, being the greatest, moves the diaphragm and thereby the switch. This may seem cumbersome and somewhat roundabout, but no other scheme presented itself which could be made sufficiently sensitive. In practice it worked out very nicely. The 5-pound difference in pressure available on the two sides of the diaphragm made it possible to follow the filling exactly, since the diaphragm could be made to start its movement just before the filling of a tank was completed and timed to meet it.

The work at shaft No. 25, as on other parts of the new Croton aqueduct, is in charge of the Aqueduct Commissioners, for whom Mr. J. Waldo Smith is chief engineer, Mr. F. S. Cook, assistant engineer, and Major F. W. Watkins, the division engineer in local charge. The pumping apparatus was designed and installed by the Pneumatic Engineering Company, of New York, for which Mr. E. L. Mills is the designing and erecting engineer. In the efficiency test of the apparatus Mr. Will J. Sando was the expert representing the Commissioners.

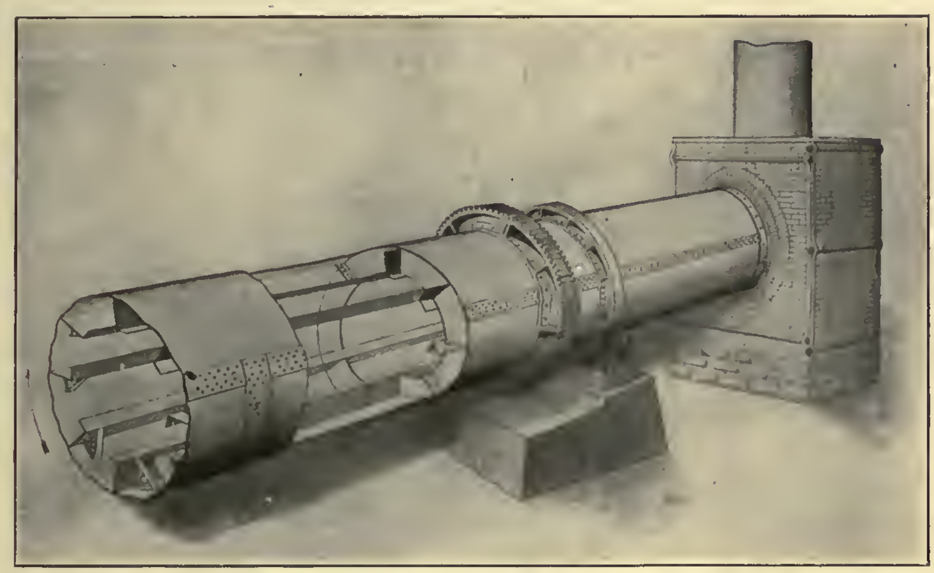
A Reheating System for Steam Turbines is described in a recent issue of the "Mechanical Engineer." The superheated steam is led partly to the turbine proper and partly to the reheaters, one for each stage.

Efficiency of Rotary Cement Kilns.

By Dr. W. Michaelis, Jr., Consulting Engineer.

In reviewing the articles that have appeared in The Engineering Record during recent months on the subject of the efficiency of rotary cement kilns, I see that the time has come when American cement manufacturers also realize the importance of the highest fuel economy possible. The efforts that have been made in this country in saving fuel have been divided into two classes. One consists in enlarging the diameter of the kilns and using double burners. More heat is thus produced, which will drive off the carbonic acid from a greater amount of raw material. This process results in great waste of heat at the upper end of the kiln, part of which is utilized under boilers and saved this way. The other method aims to utilize the heat within the kiln. The material is exposed to the heat for a longer time, as in the 150-foot kiln of the Edison plant. The article describing these different methods ends with this remark: "At the present time the second method of increasing the utilization of the heat is undoubtedly considered the better."

The last article that The Engineering Record published on this subject, on May 14, discussed again the possibilities of reducing the fuel consumption and suggested different methods for this purpose, for instance, reducing the amount of air admitted to the kilns. The writer of the article regards this as a "proposition worthy of careful consideration by experienced manufacturers," and calls attention to the low percentage of fuel required in the burning in upright kilns. The last aim in the improvement of rotary kilns seems to be to him to make the fuel consumption as low as that of dome-kilns. Then the only advantage that may be claimed for upright kilns at places where the cost of fuel is high will disappear and the rotary kiln will be superior in all cases.


Rotary Cement Kiln for Wet Process Works.

Being familiar with the progress that has been made in rotary kiln practice not only in the United States but all over the world, I can assure the writer that this question has been settled. On account of the higher price of coal in Europe, German cement manufacturers had from the beginning to pay more attention to the saving of fuel than Americans. They succeeded in gradually lowering the consumption of fuel by devices that make the coal feed and the feeding of raw material as uniform as can be imagined, and especially by making better use of the heat of the flame. All their endeavors went along the line of utilizing the heat within the kiln, the method above referred to as "undoubtedly the better." With a 90-foot kiln of the same design as used by American manufacturers, German cement makers at present turn out daily 300 barrels of clinker per kiln in the dry process, with an expense of only from 15 to 18 per cent. of fuel, or from 60 to 75 pounds of powdered coal for a barrel (400 pounds) of cement. This comes very near to the low fuel consumption of upright kilns, and is about half as much as is generally used by American cement manufacturers. All that is required for this purpose is some inexpensive additional machinery that regulates the amount of air and fuel at the lower end of the kiln and a raw material feeding device that takes care of regulating the feeding of the kiln.

From this it will be seen that it is unnecessary to make a kiln 150 feet long, if a 90-foot kiln can be run so that there is no waste of heat at the upper end of the kiln, and so little as 15 to 18 per cent. of fuel is required for the burning.

The Engineering Record points out that the trouble in the wet process is even greater, which is true, and declares that the only direction in which any improvements have been suggested, regarding the kiln itself, is the lengthening of it. Referring to this latter remark, I wish to call attention to a patent of mine, U. S. Patent No. 743538, that was secured with a view of increasing especially the capacity of a rotary kiln under the wet process. It belongs to the methods that aim to utilize the heat within the kiln and yet does not require the lengthening of the kiln beyond practicability.

The idea of this patent is to hold back the material, especially the slurry in the wet process, in the upper part of the kiln, by means of spiral partitions that discharge the material only gradually toward the lower end of the kiln. Thus the material is kept a longer time in the upper part of the kiln, has more time to give off its moisture, and arrives sufficiently dried and calcined at the burning zone, while up to this time it usually happens that the material rushes down in the kiln undried and uncalcined, and that part of the heat of the burning zone that should serve to vitrify the material is still needed for drying the slurry and driving off the carbonic acid. The result is that the heat of the flame is better utilized and that more material can be taken care of at the same time and with the same amount of fuel as before, thus resulting in a great saving of fuel.

The lengthening of the rotary kiln resulted from the experience that there is plenty of heat at the lower end of the kiln to vitrify twice as much material, if it should have been sufficiently prepared, dried and calcined in the upper part of the kiln.

The slurry that in Michigan contains from 50 to 75 per cent. of water, according to the state of the marl and its physical properties, passes in too short a time through the upper part of the kiln, because there has been nothing, so far, to hold it back. A 150-foot kiln would probably be required to dry and calcine in the upper 120 feet the material that can easily be clinkered in the lower 30 feet of the kiln. With partitions to hold the slurry back, to retard its downward movement, it is not necessary to build a kiln longer than 90 or 100 feet.

It may be said against this that the same can be obtained by rotating the kiln more slowly; then the material will be exposed to the waste heat in the upper part of the kiln for a longer time. But in this case the drying will be imperfect, because the material necessarily has to be turned over and over in order to give off its moisture. The speed of the kiln cannot be decreased, and yet the material has to be retained in the upper part of the rotating cylinder, in order to give off its moisture. The speed of the kilns cannot be increased, and yet the material has to be retained in the upper part of the rotating cylinder.

Further, it may be said against this patented device that if the speed of the kiln cannot be decreased, the downward movement of the raw material can be retarded by making the rotary kiln less inclined. But this, in my opinion, would be a very poor suggestion. On the contrary, I regard it as one of the greatest advantages of these spiral partitions, that they make possible a greater inclination of a rotary kiln. So far, there has been much trouble on account of the lack of draft, especially in the wet process, where an enormous back pressure is caused by the superheated steam in the upper part of the almost horizontal cylinder. Blowers have been used at the rear end of the kiln in order to suck the air out of the kiln into the stack. This is easily explained by the insufficient inclination of the present kiln. The large body of hot air inside the kiln has no tendency to leave it in a horizontal direction, but would readily escape if the kiln were more inclined.

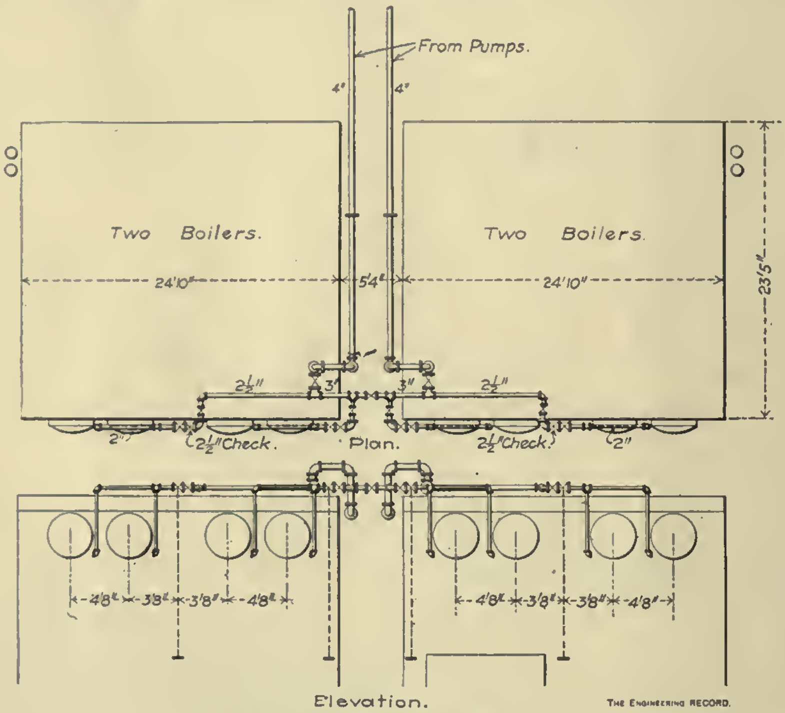
The accompanying illustration shows a set of shelves of L shape extending along the inside of the upper part of the kiln parallel to its axis. At several points, say, 10, 20 and 30 feet from the upper end of the kiln, small partitions between these shelves form a spiral dam of the height of the shelves. These spiral dams each have but a single turn around the inside of the kiln, and the pitch is moderate, 12 to 24 inches. Thus the spiral partitions divide the upper part of the kiln into several compartments. By the rotation of the kiln the slurry is lifted up and drops back through the hot air current, most of it remaining in the same compartment. A small quantity, however, is discharged through the opening of the spiral toward the lower end of the kiln at each revolution.

In the upper part of the kiln these longitudinal shelves and radial partitions are made of boiler steel; farther down toward the middle of the kiln they consist of firebrick. The lower half of the kiln is free of shelves and partitions. In the dry process fire-brick is used exclusively in the building of these shelves and spiral partitions.

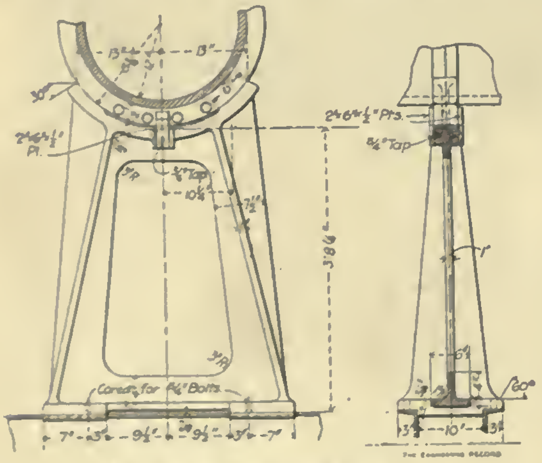
One feature generally neglected is that for drying moist materials not only heat is required, but at the same time sufficient space for the evaporated moisture, for the steam. The last article of The Engineering Record again points out that a large surplus of air must be introduced into a rotary kiln run on wet material, in order to carry off the moisture of the slurry. This shows once more how this point is generally understood. It is not so much a question of a surplus of air as a question of space at the upper end of the kiln, or rather of both. They have to be well balanced, and neither must be neglected. Rotary kilns run on wet material are generally not wide enough at the upper end, where much space is required for the steam created by evaporation.

Some Details of the Service Plant of the Louisiana Purchase Exposition.

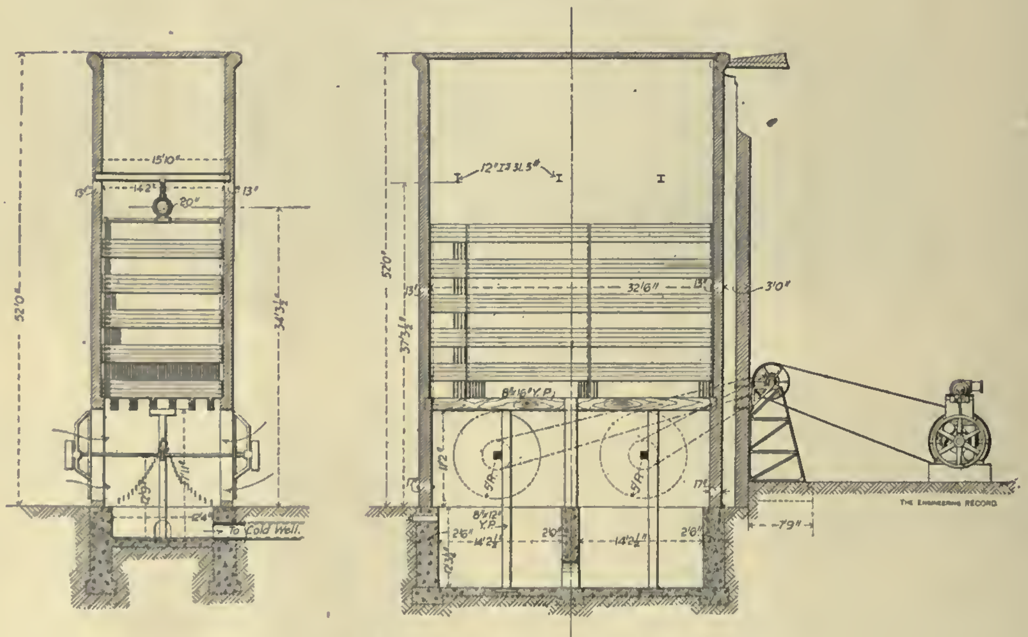
It will doubtless be remembered that in The Engineering Record of February 27 the service power plant for the Louisiana Purchase Exposition was described at some length, with special reference to some of the more interesting details of the work. It is intended to supplement that account at this time with further details, these covering chiefly the supporting and anchoring of pipe lines, but also the cooling towers for the condensing installation. As stated in the former article, the general engineering work in connection with the service power plant was entrusted to Westinghouse, Church, Kerr & Co., of New York, who also installed the plant.



Typical Arrangement of Feed Piping.



Support for Exhaust Main.



Elevations of Cooling Tower.

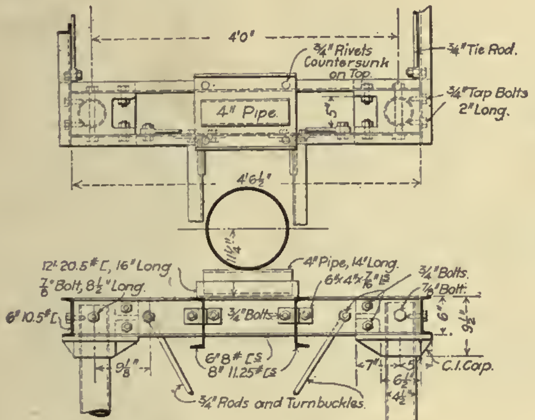
Among the accompanying illustrations is one showing the run of the steam mains in the boiler house, which, it will be recalled, is the Steam and Fuels Building. The boiler plant is arranged in two independent groups, each group consisting of eight boilers in two rows of four each, the two rows being set back-to-back with a flue between them. This makes three firing floors for the sixteen boilers, the center floor having eight boilers facing on it and each of the outside floors having four boilers facing on it. Each group of boilers feeds into a separate ring steam main. From each of these ring mains a 12-inch pipe is carried through a tunnel to the service plant in the Machinery Building. In the boiler house these mains are supported by towers, as the buildings were not designed for carrying the pipe loads. The location and general dimensions of these towers is shown in the drawings in question. It will be seen that each tower has four vertical posts. These are made up of 4-inch piping screwed at the bottom into an extra heavy flange. Every 6 or 7 feet these verticals are tied together by a rectangle of 3x3x5/16-inch angle iron, and are also braced by ¾-inch diagonal rods. At the top the rectangle is formed of channel bars, but the details of the connections are shown. One of the interesting things to which attention may be called is the arrangement for longitudinal movements of the pipes for expansion and contraction. The main rests on a short length of 4-inch pipe which serves as a roll, set in a similarly short piece of 12-inch channel iron, this limiting the travel of the roll. At the top the 4-inch verticals fit into cast-iron caps. At the intermediate points the verticals are fixed to the angle iron horizontals by bolts bent into a semi-circle and pulled tight against the angle bar by nuts. The pipes are anchored at the point indicated by a similar arrangement, shown in one of the details.

The tunnel piping is supported by pipe rolls in the manner shown in the former article, but that illustration did not indicate the method of anchoring the tunnel piping. The pipe is clasped by a pair of straps or clamps, each encircling half of the pipe, and the two are brought together by ¾-inch bolts. The clamps are 8 inches wide and of ⅜-inch metal. Where the tunnel is constructed of timber, the clamp is bolted to a 4x6x⅜-inch angle iron, which is 4 feet long. This in turn is lag-screwed through two thicknesses of 2x8-inch yellow pine planks, each 10 feet long, which are spiked and lag-screwed to the side planking of the tunnel. Where the tunnel is of concrete, the clamps are fastened to a ⅜-inch plate, which, in turn, is bolted to a 4x6x⅜-inch angle iron 4 feet long. The last is anchored directly to the concrete.

In Machinery Hall an interesting form of support for the main exhaust pipes has been provided, and this is shown in an accompanying illustration. It is fixed to the top of a pipe-tower, which tower, in this case, is built up of 6-inch pipes, and it is designed to carry cast-iron saddles in which the pipes rest. As the lengths of exhaust piping between engines and condensers are not very great, no elaborate provisions had to be made for expansion and contraction, but the support shown serves more or less as an anchor to restrict the movements of the pipes at the points where they are fixed and to transfer such movements over the other supports. These are of the same general design as that shown, but they are proportioned to receive the pipe itself and not its flanges. To make the support shown act as an anchor a 2x6x½-inch plate is bolted to each side of the support lapping over the sides of the flanges, as indicated.

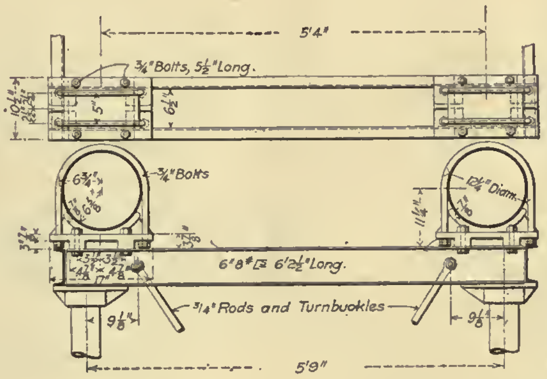
The distribution of feed water to the boilers is also one of the interesting points in connection with the service plant, which was not illustrated in the article of February 27. There are two main water lines running from the feed pumps, these two pipes carried across both groups of boilers at a central line. They are supported partly from pipe hangers of an A-frame structure, which was shown among the illustrations of the former description. The piping connections, typical of each pair of batteries, is given in the present connection. It will be seen that each pipe feeds independently into the two sub-mains, and these in turn feed the corresponding pair of boilers. The two sub-mains can be connected together, so that either feed main or both may be employed to deliver the water. The arrangement of check and other valves is clearly shown.

The general construction of the cooling towers is the subject of the remaining illustrations. It will be remembered that there are four of these grouped together immediately outside of the Steam and Fuels Building. Each of them is a rectangular brick stack 52 feet in height, containing ten tiers of wooden gratings occupying 20 feet of the height of the tower. These gratings are constructed of ¾x6-inch pine timber set on edge four deep, with uniform side spacing. This construction forms a horizontal grating 24 inches in height and filling the entire area of the tower, the ten tiers of grating being at right angles, in order to break up more completely descending streams of water and secure maximum effectiveness of the cooling surface. The dimensions of the cooling towers should be considered in connection with the capacity of the condensing plant. There are two condensers, each intended to serve one-half of the plant, that is, two 2,000-kilowatt units. Each of these is of the elevated jet type, and the water is finally discharged into a well underneath the cooling towers. Water from this is ordinarily delivered to the top of the cooling towers by means of one Worthington centrifugal pump of the turbine pattern, which has a capacity of 17,000 gallons per minute under a head of 50 feet, including equivalent friction head. The operating head is approximately 45 feet, including suction. The pump may be regulated according to the water required by means of the hand wheels at the end of the engine shafts. By these the speed of the engine driving the pump is regulated.



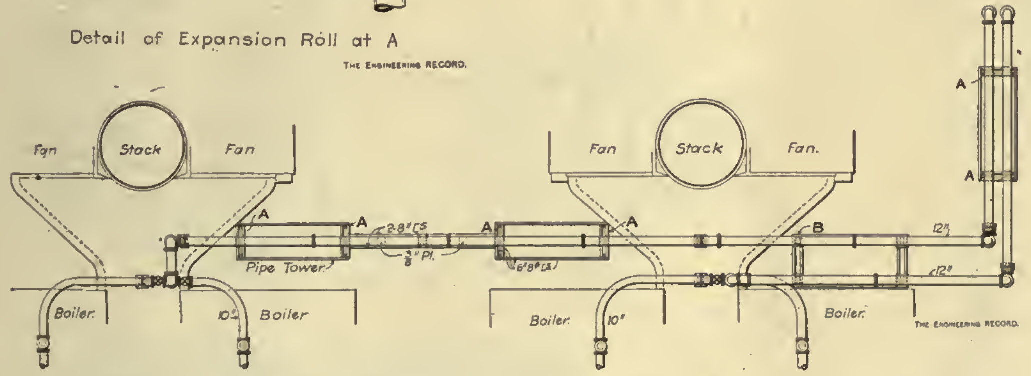
Detail of Expansion Roll at A

THE ENGINEERING RECORD.



Detail of Anchor at B

THE ENGINEERING RECORD.



THE ENGINEERING RECORD.

Louisiana Purchase Exposition Service Plant: Steam Piping in Boiler Room.

A space of 12½ feet beneath the gratings of the water tower provides for the introduction of fans, of which there are four, two on each side. These are of the Seymour pattern. The horizontal discharge from the fans is turned upward by curved vanes formed by wooden strips set on edge so as to allow a clear descent of water to the settling well beneath. Above the gratings there is space of 20 feet which conducts the vapor above the adjacent building roof and provides some natural draft in addition to that furnished by the fans. The water-distributing system of each tower comprises a 20-inch cast-iron supply pipe extending through the walls of the pump-room, against which the tower is located. This pipe runs the full length of the tower and supplies thirty transverse pipes 4 inches in diameter. These are drilled with numerous holes from which the water falls upon the gratings. The entire piping system is suspended from steel cross-beams anchored in the walls. The 20-inch cast-iron main in each tower is run from a 24-inch main from the circulating pumps. Each branch is controlled by a gate valve. The arrangement of the pumping equipment for the condensers and the cooling tower was shown in the former article.

The New York Times Building.

PART IV.—ARRANGEMENT AND CONNECTIONS OF BEAMS AND GIRDERS.

In the second sub-basement story there is a mezzanine floor which forms a gallery extending across the middle of the building and along the east and west walls. It has transverse floorbeams from 10 to 15 inches deep, which are supported at the outer ends on cast-iron wall plates and at the inner ends are framed to longitudinal beams carried by light one-story vertical columns made with pairs of 6x4-inch angles. The section of this floor which crosses the building is entirely independent of the main columns, which it encloses, and is made with long-span 20-inch girders.

The first sub-basement floor, inside the building lines, is framed similarly to the upper floors. Outside the building lines the floor is supported on 15 and 20-inch I-beams transverse to the vault retaining walls, which carry their outer ends on cast-iron bearing plates. The inner ends of these beams are web-connected to plate-girders in the planes of the wall columns. The basement floor plan corresponds to that of the sub-basement, except that it is smaller, because a large portion of the east side and north end of the building at this level is occupied by the subway, and the floorbeams are made to clear its walls.

At the first floor level the exterior walls of the superstructure are carried by plate-girders connected to the wall columns. Bracketed to these girders there are horizontal I-beams, usually 15 inches in depth, which are set out beyond the exterior faces of the columns and are built solidly into the brickwork. Parallel I-beams, generally 12 inches deep, are bracketed out from the inner sides of the girder-webs, and carry the adjacent portions of the floor. These girders and beams are set at different levels and are connected by riveted transverse diaphragms in the same vertical planes on both sides of the girder, as indicated in the cross-section detail, which is typical of the construction at this story.

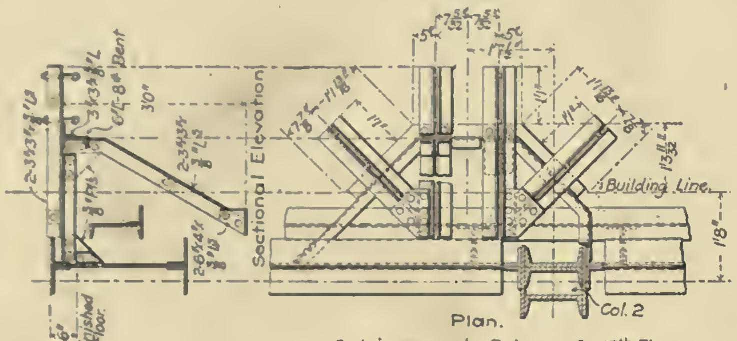
In the upper stories the walls are not so thick and heavy, and are carried in some cases by the girders only, but generally are supported on 12-inch channels bracketed out from them, as shown in the third floor section between columns 1 and 8. A continuous 3x4 or 3x3-inch angle is, in many cases, riveted to the back of the channel web, as there shown, with its horizontal flange entering the joint between the courses of face masonry. In other cases the masonry is grooved to clear the flange of the girder and the channel is omitted, as shown in the second floor section between columns 2 and 3.

From the fourth to the twelfth floor, inclusive, the wall girders support the adjacent portions of the floors directly from skewback angles riveted to the inner sides of their webs, as indicated in the cross-section between columns 4 and 8 in the tenth story. At the thirteenth floor there is a wide projecting terra cotta belt course with buttresses projecting about 3 feet beyond the building line opposite each wall column. Here the heavy terra cotta blocks are seated directly on the top flanges of the wall girders, and beams and channels are bracketed out from both sides of them to carry the masonry and the floor loads, as indicated in the section between columns 2 and 3. At the fourteenth and fifteenth floors the exterior buttresses are carried on 15-inch channels bracketed out from the 20-inch I-beam wall-girders so as to enclose the column sections, as shown in the diagram plans of intermediate wall column 11 and corner column 9, and by the cross-section at ZZ.

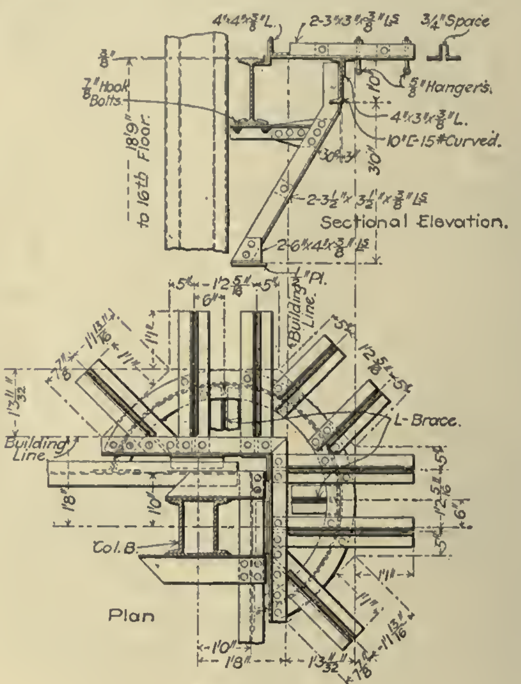
At the sixteenth floor there is a very wide projecting terra cotta cornice course which is carried by a 15-inch beam and a 15-inch channel supported on gusset plates riveted to the flanges of the columns. The channel has an outside flange angle fillered out from its web so as to leave a space through which suspension bolts are passed to carry the terra cotta. At the Forty-second Street corners of the building, columns 1 and 16 have gusset plates riveted to them to support the ends of the wall girders cantilevering beyond them so as to carry a light horizontal platform of 15-inch channels which circumscribe a circle about 6 feet in diameter and support the foot of the tower pier starting at this level. In the sixteenth story there is a mezzanine floor or gallery which extends around all sides of the building and across the central part. It is framed chiefly with 12-inch channels parallel to the walls, which are bracketed out from the columns and serve as girders for 6-inch I-beams nearly perpendicular to them, about 3 feet apart.

The seventeenth floor framing corresponds with that of the other upper floors in most respects, except that there is a deep transverse plate-girder extending through the full width of the building from column 4 to column 13. It is made in two pieces, with their adjacent ends supported on column 21. Between columns 4 and 21 this girder carries tower column 21A, and between columns 21 and 13 it carries tower column 21B. Girder 13-4 is made continuous through the building by the rigid connections of both pieces above column 21. Both parts of the girder resemble the piece 21-4, which is here illustrated. The wall ends of the girder are web-spliced to the kneebrace plates on the columns which are engaged between their projecting flange angles. The adjacent ends of the girders are field-riveted together through their end vertical web-stiffener angles, and are seated on the cap of column 21, to which girder 21-4 only is kneebraced. The base plates of tower columns 21-A and 21-B are seated on the top flange cover-plates of the girders, and are field-riveted to them with solid-web gusset-plates engaging the connection angles shown in the accompanying illustration.

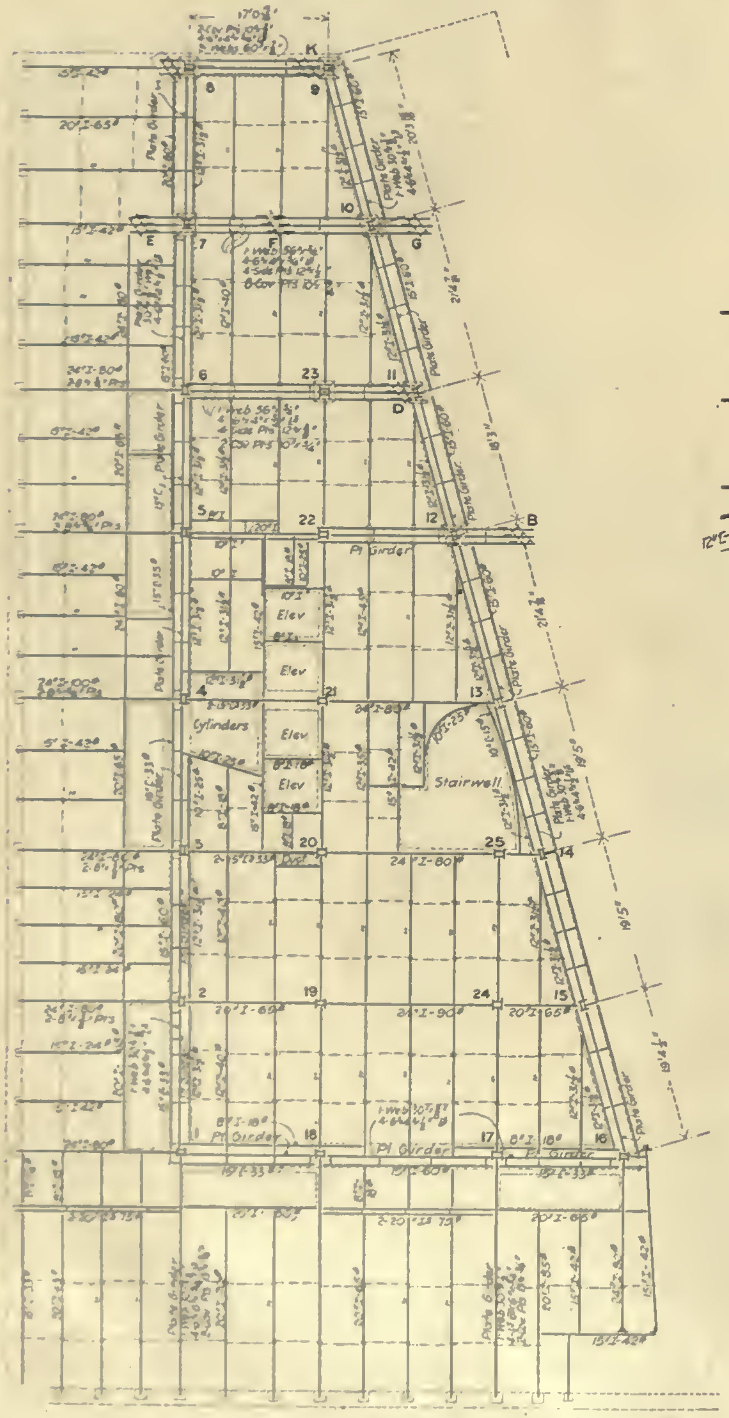
North of this girder, 13-4, in the narrow end of the building, the seventeenth tier of beams serves as the roof of the sixteenh story, except



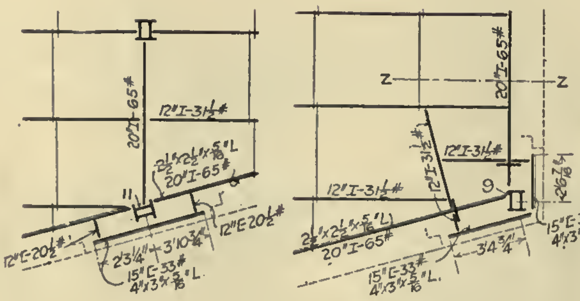
Outrigger at Column 2, 17th Floor.



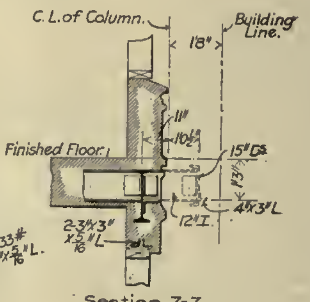
Outrigger at Column B, 17th Floor.



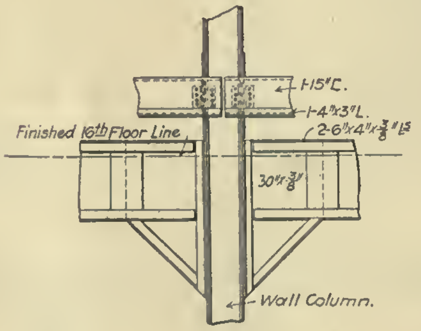
First Floor Beam Plan



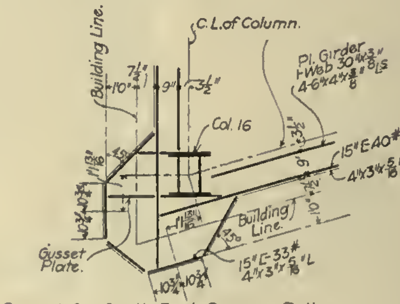
Plan Diagrams
14th and 15th Floor Supports for Outer Pilasters.



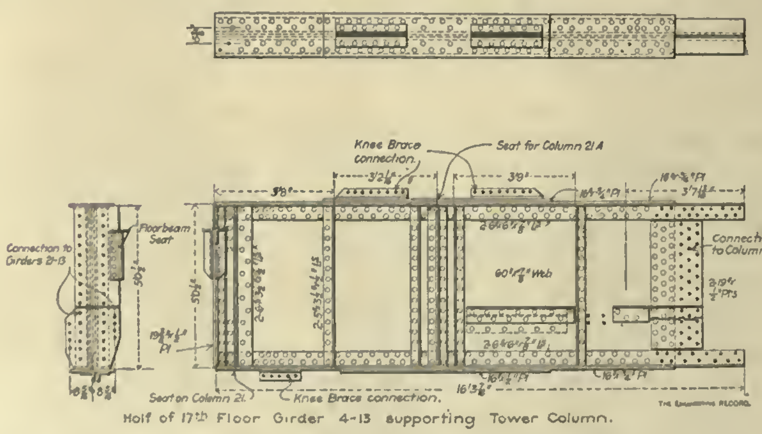
Section Z-Z.



Wall Column and Girder connection.

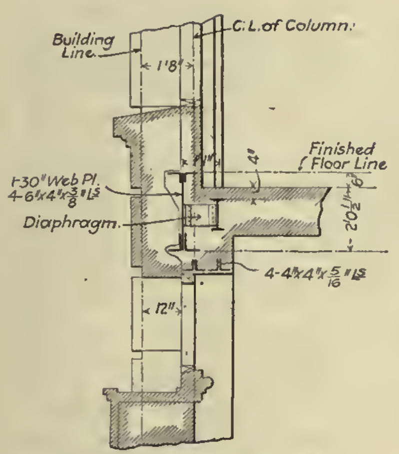


Support for South-East Corner Buttress, 16th Floor.

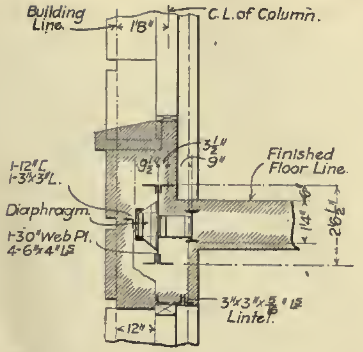


Half of 17th Floor Girder 4-13 supporting Tower Column.

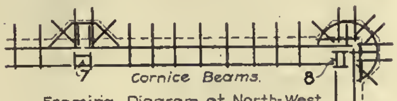
THE TIMES BUILDING, NEW YORK: FIRST FLOOR BEAM PLAN; COLUMN, GIRDER AND WALL DETAILS.



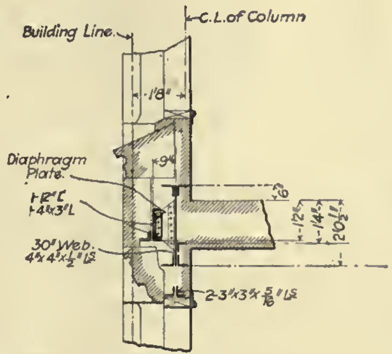
Section between Columns 2 and 3
2nd and 3rd Floors.



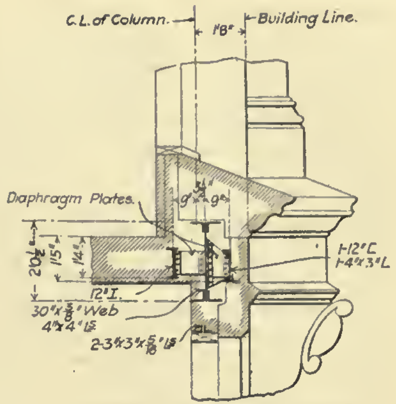
Section between Columns 1 and 8
2nd and 3rd Floors.



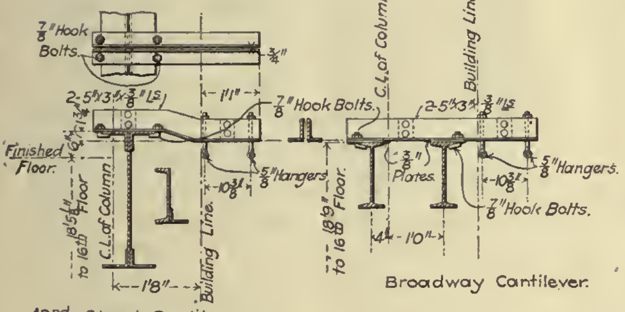
Framing Diagram at North-West Corner of Seventeenth Floor



Section between Columns 4 and 8
8th to 12th Floors inclusive.



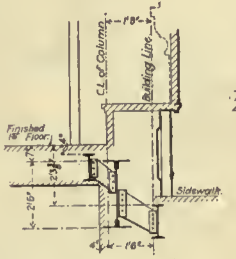
Section between Columns. 2 and 3. 13th Floor.



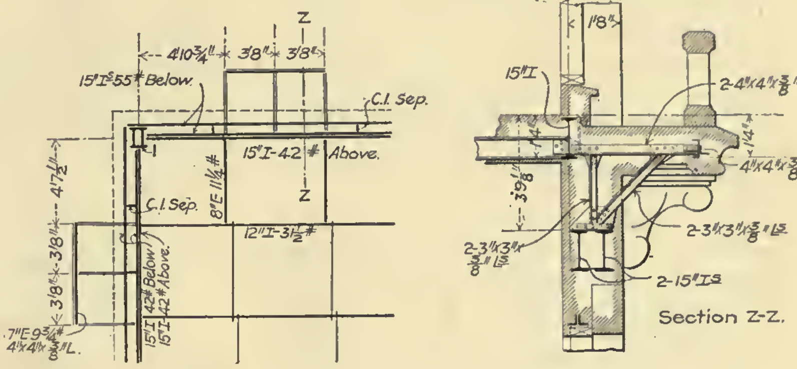
42nd Street Cantilever.

Broadway Cantilever.

Supports for Main Cornice 17th Floor.

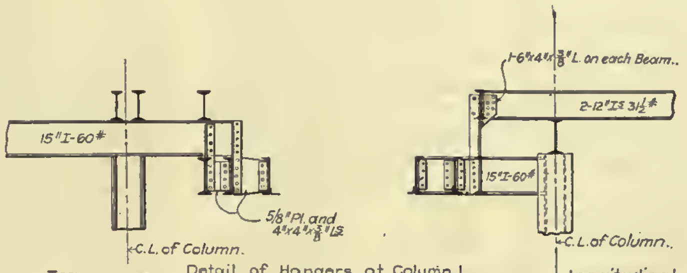


Cross-Section through Wall Girder at First Floor.

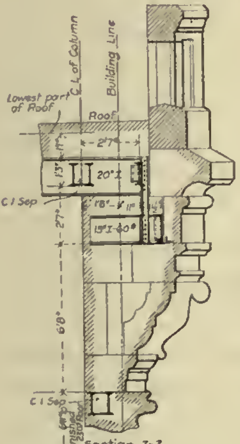


Plan

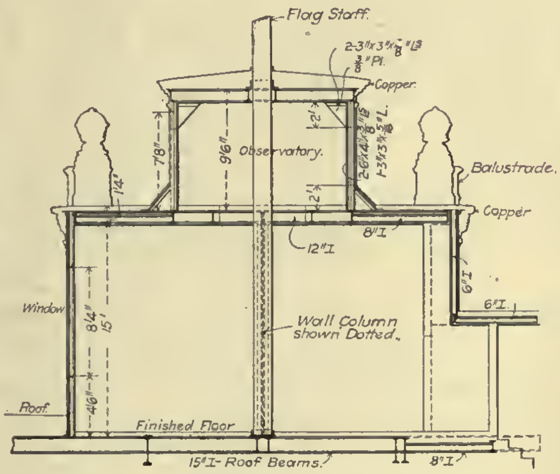
22nd Floor of Tower, Cornice Framing.



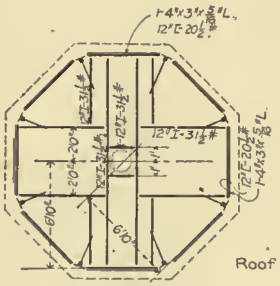
Transverse. Detail of Hangers at Column 1. Longitudinal.
Main Roof of Tower.



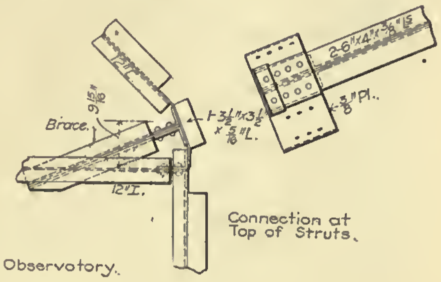
Balustrade and Cornice of Tower.



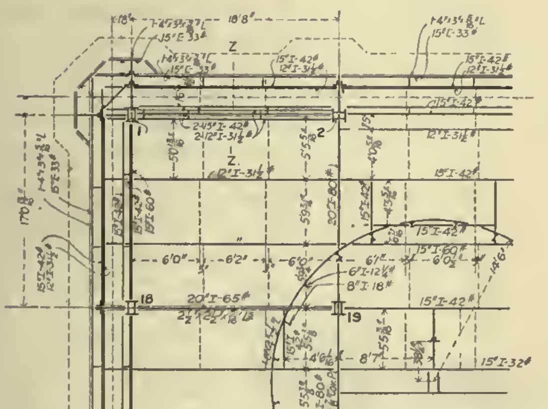
Observatory on Tower Roof.



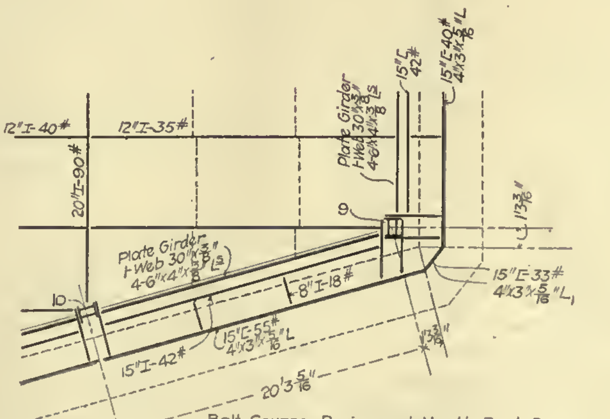
Roof of Observatory.



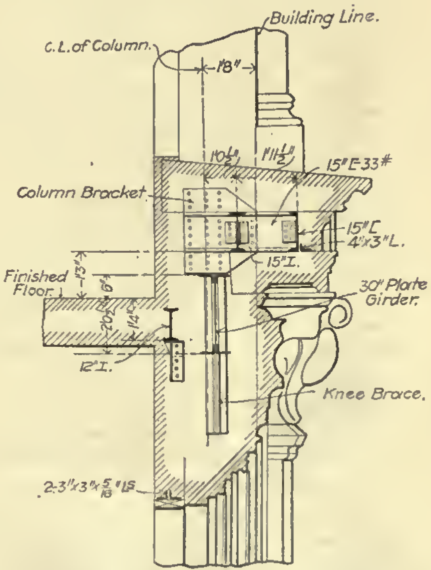
Connection at Top of Struts.



Quarter Plan of Tower Roof Framing.


12" I-40#
12" I-35#
20" I-90#
Plate Girder 1-Web 30"x3/8" 4-6"x4"x3/8" Ls.
9
Plate Girder 1-Web 30"x3/8" 4-6"x4"x3/8" Ls.
10
8" I-18#
15" I-42#
15" E-33#
4"x3"x5/16" L
20'3 5/8"

Belt Course Beams at North-East Corner, 16th Floor.



Section between Columns 2 and 3, 16th Floor.

THE TIMES BUILDING, NEW YORK: TOWER ROOF FRAMING; WALL AND CORNICE DETAILS.

in the middle portion, where there is a monitor and the transverse beams cross the open space between its walls. The flat roof over the monitor is made with transverse I-beams from 4½ to 5½ feet apart, which are supported on the 10-inch channels forming the upper part of the monitor wall framing, and carried by vertical T-bars about 6 feet apart.

The first tower floor, which corresponds with the eighteenth floor of the building, is made with 12-inch transverse I-beams about 5½ feet apart, framed to 20-inch longitudinal I-beams about 18½ feet apart. The walls are carried directly on the outer 20-inch I-beams, which have 12-inch channels bracketed out from them to carry the column buttresses, as in the fourteenth and fifteenth stories. The beam plans for the nineteenth, twentieth, twenty-first, twenty-second and twenty-third stories are similar, except that at the twenty-second-floor balconies project about 5 feet from the face of the wall and are carried, as shown in the plan diagram and cross-section detail, by braced cantilever brackets seated on pairs of wall girders and anchored to the floorbeams 3 feet above them.

The tower has a flat roof and cornice, as shown by the perspective view published in The Engineering Record of May 14. This will be framed with longitudinal and transverse beams and girders corresponding with those in the lower floors, except for the provision made to support the cornice and to carry the central circular observatory, which stands on a cylindrical base 29 feet in diameter. The wall girders overhang the column tops and carry cornice beams suspended from their cantilever extremities by stiff riveted angle connections, as shown in the details of column 1, which is similar to the other three corner columns. The outline of the cornice and parapet is shown by the detail at intermediate cross-section GG, looking toward column 1.

The walls of the circular story below the observatory are framed with 6-inch vertical I-beams 4 feet apart, connected by horizontal curved 6-inch intermediate channels and by a vertical-web circular 12-inch channel and 3x3-inch angle at the top. The octagonal observatory roof 12 feet in diameter is framed with 12-inch longitudinal and transverse I-beams with 12-inch channels across the corners and an outer line of 4x3-inch angles in the cornice. The connections are made with bent riveted web-plates, as shown in the detail at the top of one of the observatory columns. These columns are made with pairs of 6x4-inch angles, back to back, stiffened by top and bottom kneebraces. The former are made with solid web plates and the latter with pairs of bent angles. A steel-pipe flagpole 60 feet long and 10 inches in diameter at the foot, passes through the observatory roof and floor, and is seated in a flanged cast-iron shoe on the main roof of the tower.

The main-roof cornice at the seventeenth floor level, is carried by independent cantilevers about 2 feet apart between the columns, and by framed outriggers at column points which support the tops of the buttresses or pilasters in the ornamental facade. The arrangement of the outriggers and cantilevers adjacent to columns 7 and 8, as shown in the diagram, is typical of the others. The cantilevers are all made with pairs of 3x5-inch angles about 3 feet long, which are riveted together back to back with filler plates between their vertical flanges, enabling eye-bolt hangers to pass between them and take nut bearings on their upper edge, so as to support the terra cotta blocks. Where these cantilevers are supported by the wall girders only, they are hook-bolted to their top flanges, as shown in the detail of the Forty-second Street hanger. On the Broadway side they are supported by two wall beams and are not bent as in the previous case. The outriggers at intermediate columns are composed of four intersecting cantilevers framed together and riveted to the plate-girder wall girders, as shown at column 2, or they are hook-bolted to the top flanges of the I-beam well girders, as shown in column 5, which, in plan, corresponds substantially with the outrigger at column 2. At corner columns 8 and 9 the outriggers are similar in principle to those of the intermediate columns, but are more elaborate and provide a platform covering 270 degrees of a circular area about 8 feet in diameter. In all cases the outrigger cantilevers are braced by inclined struts with horizontal flanges on the lower ends, which are built solidly into the masonry walls.

Messrs. Cyrus L. W. Eidlitz and Andrew C. McKenzie are the architects, and Mr. W. B. Bamford and Mr. Paul Gemelin, of their staff, are respectively general superintendent in charge of the building and chief draftsman. The designing of the structural steel was done in the New York office of Purdy & Henderson.

(To be continued.)

The Use of Superheated Steam and of Reheaters in Compound Engines of Large Size.

Abstract of a paper presented by Prof. Lionel S. Marks, of Harvard University, before the American Society of Mechanical Engineers.

The object of this paper is to present the results of a number of unpublished tests made during the past five years on several high-speed, two-cylinder compound engines, all built by the same makers, and all of the same type. The engines tested differ from one another only in size, in cylinder proportions, and in their working conditions. The investigations were made to determine the performance of the engines under different loads, both with and without jacketing and reheating. A comparison of the results for the different tests throws some light on the influence of the thermal efficiency of large size four-valve compound engines of the following factors: (*a*) The use of a reheater. (*b*) The use of moderately superheated admission steam. (*c*) The load. (*d*) The size of the engine. (*e*) The cylinder proportions.

The results recorded here are for tests made on nine separate engines and for 28 different tests.

Engine A is at the L Street station, South Boston, of the Edison Electric Illuminating Company. The tests at this station were conducted by the author.

Engines B, C, D, E and F are at the Atlantic Avenue station of that company. Messrs C. H. Parker and H. Cook, both members of this Society, were in charge of most of the tests, but in some tests their places were taken by Messrs. C. R. Brown and S. G. Colt.

Engines G, H and K are at the new plant of the Cambridge Electric Light Company, and were tested by the author. The first two stations were described in the "Electrical World and Engineer" of May 27, 1899, and May 18, 1901, respectively, and the last in The Engineering Record of November 1, 1902.

The engines tested vary from 750 to 2,500 rated horse-power, and were all built by McIntosh, Seymour & Co., of Auburn, N. Y. Each high-pressure cylinder is jacketed on the barrel, and both heads and the jackets are piped in series; the steam enters the jacket on the top head, passes into the barrel jacket, goes to the jacket on the lower head and then to the reheater coils. In this way a very active circulation in the jackets is insured. As there is no separate steam supply to the reheater coils, nor any separate drain from the high-pressure jackets, it is not possible to use either jackets or reheater alone. The low-pressure cylinder is unjacketed.

Tests of Engine A.—This engine is rated to develop 2,400 indicated horse-power at 0.23 cut-off, 4,128 indicated horse-power at 0.6 cut-off, and has a maximum cut-off at 0.8 stroke. Its piston speed is 960 feet per minute. It is direct connected to a 1,500 kilowatt, three-phase General Electric generator delivering current at 2,250 volts. The ratio of low-pressure to high-pressure piston displacements is 4.3 to 1. The reheater coil has 777 square feet of heating surface, but the steam supply to it was too small.

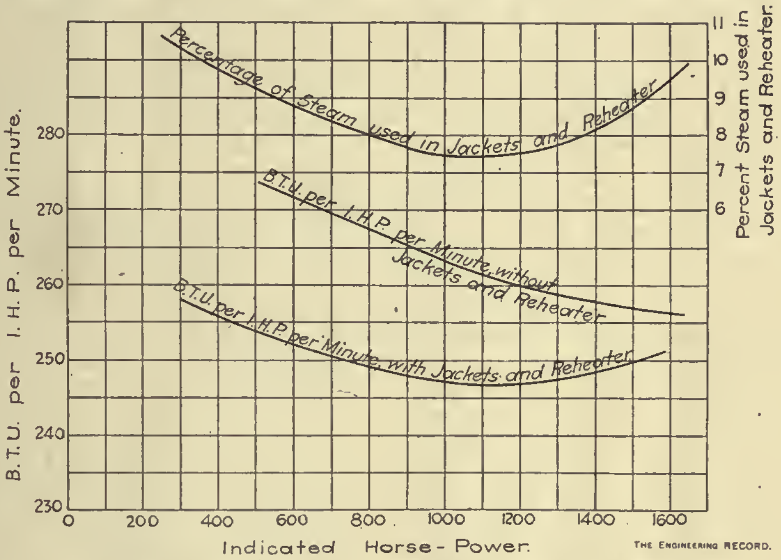
Two full load tests were made: one with the jackets and reheater in use, the other with both out of use. The principal results of the test are given in the accompanying table. The reheater was not very effective owing to the deficient steam supply; it superheated the receiver steam 35 degrees Fahr. The economic results as indicated by the steam consumption in line 13 shows practically no saving at all by the use of the high-pressure jackets and the reheater. The steam consumption, however, is not a fair quantity by which to judge the performance of the engine, since in Test 1 about 7 per cent. of the total steam is rejected as condensation at about the boiler temperature, whereas in Test 2 all is rejected at the condenser temperature.

The heat units per indicated horse-power, measured above the ideal feed temperature (which is obtained by mixing the condensations in the reheater and receiver, each at its own proper temperature, with the condensation water in the condenser supposed to be at the exhaust pipe temperature), necessary to form steam such as exists at the throttle, is an accurate measure of the performance of the engine, and it is this quantity which is given in line 20, and from which the calculation in line 23 of the saving by jacketing and reheating has been made. Lines 16 and 17 show that the high-pressure jackets have been moderately effective, raising the quality of the steam in the high-pressure cylinder 6 per cent. throughout the expansion. The small total gain by both jackets and reheater indicate then that the reheater is of small value, or may even be a source of loss when it superheats only 35 degrees.

Test of Engine B.—The engines C, D, E and F are all of the same size and are rated at about 2,400 indicated horse-power. Engine B develops only about one-half the power of the other engines; it is also the only one of these engines fitted with a surface condenser. The engine is intended to run at 100 revolutions per minute and to develop 1,200 indicated horse-power at 0.22 cut-off with 160 pounds steam pressure and 26 inches vacuum. At 0.6 cut-off it develops 2,200 indicated horse-power. It drives an 800-kilowatt General Electric direct-current generator. The reheater consists of coils of brass pipe aggregating 440 square feet total heating surface.

Ten separate tests were made on this engine in order to determine its economy at different loads, both with and without the jackets and reheater in use. The principal results are given in the table. The superheat was slight in all cases, but was greater during the series of tests without jackets and reheater. The vacuum was not constant, but fell at the higher loads; it averaged higher than in the tests of any of the other engines. In order to eliminate the effect of variation in the vacuum on the economy of the engine a correction has been applied reducing all the results to an effective vacuum of 26 inches. The corrected heat consumptions per indicated horse-power per minute, and the method of variation with the engine load, are shown graphically in the accompanying chart of curves; the same figure shows also the percentage of the total steam used in the jackets and reheater. The most striking feature of the curves is the small variation of the efficiency of the engine when jackets and reheater are used throughout the range of load from one-half load to one-quarter overload. Within this range the total variation of economy did not exceed 2 per cent., and the economy was greatest at about the rated load. It should also be noted that the percentage of the total steam used in the jacket and reheaters is lowest when the efficiency is greatest.

Without the jackets and reheater in use the economy increases with increase of load, and in such way as to indicate that there would be but little advantage in the use of jackets and reheater when the engine is much overloaded. With light loads up to full load the saving by jackets and reheater ranges from 9 to 4 per cent. and is obtained by using from 10 to 7 per cent. of the total steam in the jackcts and reheater. The increase in economy with the load and the reheater in use would have been greater had the reheater been of greater capacity. As is seen in line 10, the superheat of the steam entering the low-pressure cylinder decreased from 100 degrees to 46 degrees as the amount of steam used increased. This is probably the reason for the close approach of the two heat consumption curves. The steam qualities tabulated in lines 16 to 19 show that the qualities during expansion in the high-pressure cylinder are but slightly affected by the steam jackets. On the other hand, the qualities during expansion in the low-pressure cylinder show very clearly the beneficial results of reheating, especially in the low load tests where the superheat in the receiver was greatest.



THE ENGINEERING RECORD.

Chart Showing Value of Jackets and Reheater.

Tests of Engines C, D, E and F.—Each of these engines is direct connected to a 1,600-kilowatt direct-current General Electric generator. Engines C and D have each 740 square feet of reheating surface in the receiver; the other two engines have each 800 square feet. All four exhaust into a central condensing plant consisting of jet condensers and Blake twin vertical air pumps.

The tests on engine C show the efficiency of the engine to change very slightly with change of load—the better economy at half load being principally due to the better vacuum, though this is offset in part by the lower superheat of the admission steam. The saving by jacketing and reheating at full load is only 3 per cent. The jacketing is shown by the steam qualities in the high-pressure cylinder to be of no value with 80 degrees admission superheat, and the reheater is of but small value when it superheats only 60 degrees.

The economic results of engine D are better than on engine C, as a result of higher superheat of the admission steam and a better vacuum. The effect of the higher superheat is most plainly shown by the very high steam qualities during expansion in the high-pressure cylinder. The saving in this engine by the use of jackets and reheater is 4.5 per cent.—a little greater than in engine C. The full load tests on engines E and F give results agreeing very closely with those obtained on engine D—the running conditions were very similar in all three cases. The half load test on engine E gives the same economic result as the full load test on the same engine.

Tests of Engines G, H and K.—Engines G and H are exactly similar units, developing 760 indicated horse-power at 0.24 cut-off with 135 pounds initial steam pressure and 26 inches effective vacuum, and direct connected to 600-kilowatt, 60-cycle alternating generators built by the General Electric Company. Engine K develops 2,320 indicated horse-power at 0.24 cut-off with 135 pounds in initial steam pressure and 26 inches effective vacuum, and is direct connected to a 1,500-kilowatt General Electric generator.

The engines G and H are the smallest of the whole series tested. The results of the two full load tests of G agree very closely with the results of tests of engine B under full load, although this latter engine is 50 per cent. larger than G. The reheaters gave practically the same superheat in both cases; the steam pressures in the high pressure cylinders were practically the same, so that the disadvantage of smaller size and poorer vacuum in engine G is just about offset by the greater superheat of its admission steam. The gain by the use of jackets and reheater was about 7 per cent. in both cases. It will be seen by an examination of the steam qualities in the high-pressure cylinder that the jacket is effective in this comparatively small cylinder even with moderate superheat at the throttle. The performance of engine H at 20 per cent. overload is considerably better than that of engine B under approximately similar conditions. That the superheat of the admission steam is probably responsible for this is suggested by the higher quality of steam in the high-pressure cylinder. This particular engine, H, was known to be in better condition than G, its pistons were tighter, and it had run with unusual smoothness from the beginning.

The tests on K again emphasize the fact brought out on tests of C and E that the efficiency throughout the ordinary range of loads is practically constant in these engines, though it naturally falls off when the load is reduced to one-quarter. The advantage of jacketing and reheating is again found to be about 7 per cent.

High-Pressure Jackets and Reheating.—There are certain facts which the author believes may be postulated with reference to the effectiveness of jacketing and reheating, and which are supported by the results of these tests.

The saving by jacketing varies with the following factors: (*a*) It increases as the cut-off becomes earlier. (*b*) It decreases as the superheat of the entering steam increases. (*c*) It decreases with increase in size of the engine.

There is no saving by reheating when the reheater does no more than to dry the steam. If there is any advantage in using dry and saturated steam in the low-pressure cylinder over the use of wet steam, it can be obtained by the use of a separator between the cylinders. In tests 2, 7, 9 and 24, when the reheater was not in use, the receiver acted as an almost perfect separator, taking away all the condensation which calculations showed to have occurred in the high-pressure cylinder. If the reheater merely vaporizes the condensed steam at the expense of a practically equal quantity of high-pressure steam it is not only non-effective but is also, probably, a source of actual loss, since more work could have been obtained from the total steam used if it had all gone into the high-pressure cylinder. The reheater then should be regarded merely as a superheating device for the steam entering the low-pressure cylinder, and it may be expected to be more effective the greater the amount of superheat it gives the receiver of steam. It is probable that the reheater would be more effective if the only work were superheating, as it might be if the wet steam exhausting from the high-pressure cylinder passed through a good separator before reaching the reheater. As the reheater will have less to do when the engine is running at low loads it may be expected to give a higher superheat at low loads, and consequently to be more effective. With the above in mind, an examination of the tests already described throws some light on the conditions under which the jacketing of the high-pressure cylinder and the practice of reheating are desirable, and shows the saving to be expected from them in large size engines.

In engine A, where saturated steam is used, the jackets at full load keep the steam about 6 per cent. dryer in the high-pressure cylinder, and the reheater superheats 35 degrees. As the greater part of the 6.8 per cent. of the total steam which is condensed in the jackets and reheater must have been condensed in the latter place, it is obvious that the reheater cannot have contributed anything to the small total saving of 1.3 per cent. The conditions in engine B are much more satisfactory for effective action of jackets on reheater, especially at the lower loads. The engine is smaller, and its reheater is more effective. At half load, with 75 degrees superheat of the receiver steam, the saving was 9 per cent.; at three-quarter load, with 60 degrees superheat, there was 7 per cent. saving; at full load, with 46 degrees superheat, there was still 7 per cent. saving, and even at one-quarter overload with 26 degrees superheat there was 4 per cent. saving.

The larger engines C and D, with 80 degrees and 98 degrees initial superheat and 60 degrees superheat by the reheater, show but 3 per cent. and 4.5 per cent. saving respectively. The engine G is only one-third the power of engines C and D, consequently the jackets are much more effective (raising the steam quality 10 per cent. in the high-pressure cylinder), so that with 49 degrees superheat going to the low-pressure cylinder the saving is 7.5 per cent. The tests on engine K at half load, with 59 degrees superheat by the reheater, show 7.2 per cent. saving. The engines C, D and K have sufficient initial superheat and are of such size as to make the high-pressure jackets of but little value, so that the savings shown are due principally to the action of the reheater.

A study of the above results appears to indicate that the reheater will not justify its use (except as a separator) unless it superheats the low-pressure admission steam at least 30 degrees. An examination of the qualities at release in the low-pressure cylinders indicates that 100 degrees superheat of the receiver steam will probably be enough to make the steam dry and saturated at release. As it is not desirable to have superheated steam at release, this suggests the probable desirable limit to the amount of superheat to be given by the reheater.

PRINCIPAL RESULTS OF ALL THE TESTS.

1. Number of test	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2. Engine	A	A	B	B	B	B	B	B	B	B	B	B	C	C
3. Nominal load	1	1	¼	½	½	¾	¾	1	1	1¼	1¼	1	1	1
4. Jackets and reheater	With	Without	With	With	Without	With	Without	With	Without	With	Without	With	With	Without
5. H. P. cylinder diameter, in	28	28	23	23	23	23	23	23	23	23	23	23	29	29
6. L. P. cylinder diameter, in	58	58	48	48	48	48	48	48	48	48	48	48	60	60
7. Stroke, inches	48	48	48	48	48	48	48	48	48	48	48	48	56	56
8. Pressure at throttle, lbs	159	161	152.6	151.5	155.3	150	155.1	149.5	155.9	152.6	155.2	161.8	168.6	167
9. Superheat at throttle, deg. Fahr	Wet	Wet	.8	4.8	21.8	10.7	17.5	9.2	14.6	8	13.8	18.6	80.2	78.5
10. Superheat entering L. P. cylinder	35.5	Wet	99.8	75.4	Wet	60.5	Wet	46.6	Wet	52.9	Wet	49.4	60.3	Wet
11. Vacuum in exhaust, in	25	24.5	28.2	28.0	27.25	28.3	27.1	27.7	28.0	25.2	26.8	27.0	24.9	24.7
12. Indicated horse-power	1,994	1,984	309	552	548	845	831	1,047	1,105	1,498	1,516	1,104	2,267	2,240
13. Total steam per I. h.-p. per hr	13.59	13.68	14.04	13.71	15.11	13.63	14.72	13.59	14.41	14.57	15.16	13.58	12.72	12.98
14. Per cent. used in jackets and reheat	6.8	....	10.2	8.95	....	7.91	....	7.49	....	8.9	....	6.9	6.5	....
15. P. C. of cyl. steam drained from rec.	1.6	6.0	....	....	3.7	....	6.7	....	5.97	....	4.97	....	....	2.3
16. Quality at cut-off h.-p. cyl	81.6	75.5	61	58	60	68	72	68	60	79	74	65	86	86
17. Quality at release h.-p. cyl	85.6	79.6	85	85	88	80	74	78	75	83	78	81	83	88
18. Quality at cut-off l.-p. cyl	92.4	87	95	90	65	88	78	90	76	94	88	90	99	84
19. Quality at release l.-p. cyl	95.5	93	95	95	91	88	90	91	83	98	89	93	96	91
20. B. T. U. per I. h. p. per min	245	248	258	252	277	251	270	248	267	255	265	241	236	244
21. Thermodynamic efficiency, per cent.	17.3	17.1	16.5	16.9	15.4	17.0	15.8	17.2	15.9	16.7	16.1	17.6	18.0	17.4
22. Ther. effi. compared with ideal cycle	65.4	65	58	60	58	60.5	59	62.5	58	66.1	61.5	64.5	68.3	65.6
23. Per cent. saving by jack. and reheat	1.3	....	....	9.0	....	8.0	....	7.0	....	4.0	....	....	3.0	....
24. Engine friction at no load, I. h. p.	118	....	....	....	....	....	....	70.5	....	....	....	....	159	....
25. Mechanical efficiency at rated load	94.1	....	....	....	....	....	....	94	....	....	....	....	93.2	....

1. Number of test	15	16	17	18	19	20	21	22	23	24	25	26	27	28
2. Engine	C	C	D	D	E	E	F	G	G	H	K	K	K	K
3. Nominal load	¾	½	1	1	1	½	1	1	1	1¼	1	½	¼	½
4. Jackets and reheater	With	With	With	Without	With	With	With	Without	With	Without	With	With	With	Without
5. H. P. cylinder diameter, in	29	29	29	29	29	29	29	18	18	18	31	31	31	31
6. L. P. cylinder diameter, in	60	60	60	60	60	66	60	38	38	38	64	64	64	64
7. Stroke, inches	56	56	56	56	56	56	56	42	42	42	48	48	48	48
8. Pressure at throttle, lbs	167	169.4	162.8	163.1	159.2	160.4	158.7	186	137	131	136	132	136	135
9. Superheat at throttle, deg. Fahr	64.5	48.3	98.4	98.4	72.4	70.4	92.7	72.2	75	55.5	64.2	70.3	55.3	73.5
10. Superheat entering L. P. cylinder	67	84.8	60.5	Wet	60.9	86.0	61.7	Wet	49.1	Wet	40.3	59	79.1	Wet
11. Vacuum in exhaust, in	25.6	26.1	25.6	25.7	25.3	25.4	26.1	26.2	26.3	26.1	25.4	26.4	26.4	25.8
12. Indicated horse-power	1,831	1,239	2,202	2,215	2,230	1,259	2,171	715	716	858	2,184	1,196	716	1,198
13. Total steam per I. h.-p. per hr	12.71	12.38	11.57	11.88	11.67	11.78	11.67	14.13	13.21	13.13	12.50	12.22	12.95	12.90
14. Per cent. used in jackets and reheat	7.2	9.3	7.4	....	7.1	9.3	5.6	....	6.45	....	4.89	7.28	9.05	....
15. P. C. of cyl. steam drained from rec.	....	....	....	....	....	....	....	3.35	.69	6.12	.93	.67	....	2.75
16. Quality at cut-off h.-p. cyl	77	65	99	93	93	82	89	76	85	86	92	83	81	80.5
17. Quality at release h.-p. cyl	82	80	94	87	94	92	84	75	88.5	83	93	82.5	88	92
18. Quality at cut-off l.-p. cyl	93	99	100	86	93	85	100	84	89	84	93	92	97.4	80.5
19. Quality at release l.-p. cyl	98.5	99	96	84	93	92	100	87	93.2	82	97	96	100	94
20. B. T. U. per I. h. p. per min	235	227	217	226.5	217	217	221	264.9	245.5	243.3	227.3	226.6	241.5	244
21. Thermodynamic efficiency, per cent.	18.1	18.7	19.6	18.7	19.6	19.0	19.2	16.0	17.3	17.4	18.7	18.7	17.6	17.4
22. Ther. effi. compared with ideal cycle	67.3	67.7	75.4	72.3	72.6	73	70.7	62.8	67.4	68.5	74.2	73.3	66.8	67.5
23. Per cent. saving by jack. and reheat	....	....	4.5	....	....	....	....	....	7.5	....	....	7.2	....	....
24. Engine friction at no load, I. h. p.	....	....	169	....	164	....	197	....	50	50	....	....	....	....
25. Mechanical efficiency at rated load	....	....	92.7	....	93	....	91.4	....	93.4	93.4	....	....	....	....

Value of Moderate Superheating.—The engines C, D, E, F, G, H and K were all supplied with steam from Babcock and Wilcox boilers, fitted with superheaters giving from 100 degrees to 125 degrees superheat at the boiler when running at the rated power. The amount of superheat at the engine depends on the load at which the engine is running; (*a*) because the superheat at the boiler decreases as its load is decreased, and (*b*) because the fall of temperature in the steam pipe increases as the weight of steam passing through it diminishes. For these two reasons the superheat was less at low loads than at higher loads, except in some cases where the number of boilers used could be decreased as the load decreased. As the superheat going to the low-pressure cylinder when the reheaters were in use varied in the opposite way; that is, increased with decrease of load, these two variations tended to offset one another in their influence on the engine efficiency. The tests without the reheaters in use will then be the most valuable for showing the influence of the superheat of the high-pressure steam. The tests at full load show that engine A uses 248 British thermal units per indicated horse-power per minute with no superheat; engine C, of about the same size, with 78 degrees superheat, uses 239 British thermal units, and engine D, with 98 degrees superheat, uses 226 British thermal units, a saving of about 9 per cent.; some of which, however, is also due to a better vacuum and better cylinder proportions. Engine B, a smaller engine, uses 267 British thermal units with 15 degrees superheat—which is practically the same result as that obtained from G, a still smaller engine, with a poorer vacuum but with 72 degrees superheat. In the test of D with 98 degrees superheat the quality of the steam at release is 87 per cent., so that it is evident that when the jackets are not used a much greater superheat is desirable in order to prevent condensation in the high pressure cylinder—probably at least 150 degrees will be necessary. An even greater superheat will be necessary to keep the steam dry in both cylinders. With the jackets in use and with 98 degrees superheat, the quality in the high pressure cylinder at cut-off is 99 per cent., and at release is 94 per cent. The advantage gained by superheating is, of course, greater in the smaller engines.

Variation of Economy with Engine Load.—The engines B, C, E and K were all tested at several loads so as to determine the effect of variation of engine load on the efficiency of the engine. In engines C, E and K, where moderately superheated steam was admitted to both cylinders, the important fact was brought out that the heat consumption per indicated horse-power is practically constant through a range of load varying from one-half load to full load, and probably even to a considerable overload. The apparent exception in the better performance of engine C at half load is probably due to a better vacuum at that load. The general result was to be expected, because the effect of superheat is to reduce the amount of heat disappearing during admission, and, consequently, to permit the increased expansion at low loads to occur without excessive cylinder condensation. In engine B, with very small superheat of the admission steam, there is a slight decrease in economy as the load decreases from full load, and in the tests without reheater, and consequently with no superheat going to the low-pressure cylinder this decrease in economy is very marked.

It is, perhaps, hardly necessary to emphasize the fact that the constancy of heat consumption referred to above is in terms of the indicated horse-power. In all these engines the friction horse-power is low, and the mechanical efficiencies at the rated loads are high, varying (line 25) from 91.4 to 94 per cent. and averaging 93.2 per cent. The friction horse-powers were determined by taking cards with no load on the engine, but they really represent more than the friction of the engine power, since they include some losses properly chargeable to the generator—such as the brush friction, the armature windage, the bearing friction of the armature and, in some cases, a low excitation of the field. Consequently, tho real mechanical efficiencies of the engines are somewhat higher than the quantities given in the table.

Conclusions.—The following conclusions appear to the author to be justified when applied to large size, high-speed, compound, four-valve engines of common proportions.

The jacketing of the high-pressure cylinder is of but little value when moderately superheated steam (100 degrees Fahr.) is used.

Reheating is probably a source of loss unless it superheats the receiver steam at least 30 degrees Fahr., and is not fully effective unless it superheats about 100 degrees. In the latter case it may be expected to effect a saving of 6 to 8 per cent. of the total heat used per indicated horse-power.

Jacketing the low-pressure cylinder is shown by the steam qualities during expansion in the low-pressure cylinder to be unnecessary and therefore undesirable when the reheating is effective. The effect of admitting moderately superheated steam to both the high-pressure and low-pressure cylinders is to keep the heat consumption per indicated horse-power practically constant throughout a considerable range of loads—from half load to about one-quarter overload.

The variation within the ordinary limits of the ratio of stroke to diameter in large size engines of the same power when using moderately superheated steam, does not have any marked effect upon the economy of the engine. The size of the engine is an important factor in determining its efficiency. The engine G has about 10 per cent. greater heat consumption per indicated horse-power than K, which is three times larger.

Power-Plant Papers at the Meeting of the American Society of Mechanical Engineers.

At the meeting this week in Chicago of the American Society of Mechanical Engineers, a number of papers were presented on power-plant subjects. These included contributions on the steam turbine, the use of superheated steam and of reheaters in compound engines, the power-plants in tall office buildings, refuse destructors, the description of a plant in England, and commercial gas testing. On account of their general relation to the question of power generation, as many as possible of them are discussed in the following reviews under the above title.

The Power-Plant in Tall Office Buildings.

There were two papers read on "The Power-Plant in Tall Office Buildings," by Mr. J. Hollis Wells and Mr. Reginald Pelham Bolton, both of New York City. Mr. Wells paid chief attention to the steam plant, including the heating installation, and to the electric plant and wiring, introducing an instructive analysis of the latter, based on actual experience. Mr. Bolton's paper treated especially of the elevator equipment of the lofty office structure, publishing the typical plans of a considerable number of buildings in that connection, but it gave a general review of the current practice in respect to the mechanical apparatus of this type of building. The following is an abstract of both papers:

As to the proportions of the elevator plant as based on the floor-space of the building, Mr. Wells gave some figures of actual installations in New York City, reproduced in the accompanying table. The first five buildings named in the table are equipped with hydraulic elevators and the remaining three with electric elevators. The third column gives the total floor area in square feet that there is throughout the building, including rentable area and halls and corridors, for each elevator. The fourth column has been added to the author's table to give the number of square feet of total floor area there are on each floor for each elevator. These figures show a variation from 242 to 2,000 square feet to be served by one elevator, with an average of 1,175. The author stated, however, that in most cases the service in the buildings cited is satisfactory, and that the number of elevators depends on the class of the building and its location, and on the nature of the business to be transacted.

Floor Area Ratios for Office Building Elevators.

Building.	No. of Stories.	No. of Cars.	Area per Car.	Area Per Car per Floor.
Broad Exchange	20	18	25,860	1,293
Amer. Exchange Bank.	16	3	24,000	1,500
Bank of Commerce...	19	7	4,600	242
Wall St. Exchange...	25	10	22,500	900
Sixty Wall St.......	26	8	21,500	827
Park Row...........	25	10	31,500	1,260
Bishop	12	4	24,000	2,000
Beaver	15	4	21,000	1,400

Compound pumps, he stated, generally require 70 pounds of steam per water horse-power hour, triple expansion pumps about 36 pounds, and fly wheel pumps slightly less. High-speed, single-cylinder engines are guaranteed at 36 pounds of steam per horse-power-hour, compound engines, 26 pounds, and steam-jacketed, four-valve, compound engines, 20 pounds. An average of 6½ water horse-power per car-mile per hour is required for hydraulic elevators, and for electric elevators an average of 3½ kilowatts.

In regard to the steam plant he made the following observations: In designing the boiler plant it is customary to allow about 50 per cent. reserve over the estimated peak loads. Superheaters of sufficient capacity to allow the steam produced by the boilers to receive a superheat of from 75 to 100 degrees Fahr. have been used with excellent results. Van Stone joints, or joints somewhat similar in design, for pressure piping exceeding 5 inches in diameter, have given very satisfactory results. In designing the mains and risers for steam distribution to the steam heating system, the sizes of pipes are determined by the amount of the condensation of the radiating surfaces and the velocity of the steam flowing through the pipes. In mains this velocity is assumed to be from 60 to 80 feet per second, and in risers from 25 to 50 feet per second.

To illustrate the method of designing the electric plant, he took a specific case, explaining, however, that the figures are average results of tests and records of perhaps fifty of the tall buildings of New York City. The building in question is designed for banking rooms on the first and second floors; above for offices. Three boilers of 350 horse-power each are located in the cellar and the plant in the basement. The electric portion of this plant consists of two 125-kilowatt, one 100-kilowatt, and one 50-kilowatt generators, two fan motors of 15 horse-power each, and engine plant of sufficient horse-power to operate the entire electrical installation. These engines will be of the four-valve tandem compound type and the dynamos, direct current, 120-volt machines. The total floor area to be lighted is 196,700 square feet, and taking the average rate at one light for each 37 square feet of floor area, the number of lights as laid out on the plans is 5,316 plus 250 lights allowed for decorative effect in banking rooms; the total number of lights to be wired for is 5,566. Lamps are guaranteed at 50 watts per 16 candle-power, but this is when they are new; we therefore assume an average of 55 watts; this, therefore, means that with all the lights burning the total output would be 306 kilowatts.

From his experience he finds the absolute peak load is 70 per cent. of the connected load; the average peak and running load for dark days, 60 per cent.; the average day load for eight months, 30 per cent.; the average low load for twelve months, 16 per cent.; and the average of nights, Sundays and holidays, 50 kilowatts. In addition, an increase of 10 per cent. over the above running loads is made on account of the desires of tenants. Under ordinary conditions it is customary to allow 1.6 horse-power in engine for each kilowatt output of the generator and 1.8 horse-power in boilers for each kilowatt in generators.

To operate under the load conditions enumerated we have selected the following plant:

Two generators of 125 kilowatts capacity each, either of which will carry the average peak running load, or both connected in multiple will carry the absolute peak loads which are on for short isolated periods only. One generator of 100 kilowatts capacity to carry early running and low average loads for 12 months, and one generator of 50 kilowatts capacity as an auxiliary unit for nights, holidays, Sundays and odd times.

The cost of operating this electric plant may be estimated from the accompanying table, allowing in addition for motor operation for 304 days at 10 hours per day and 20 kilowatts per hour, amounting to 60,800 kilowatt-hours per year. The table shows the percentages of connected load, so that the number of kilowatt-hours for each period and for all of the working days can be calculated. Such a calculation gives a total day load of 292,850 kilowatt-hours. To this is added a night load of 5 per cent., which for 365 nights and 12 hours per night amounts to 70,080 kilowatt-hours for the year. The average Sunday and holiday loads is taken at 10 kilowatts, and for 61 days of 12 hours each amounts to 7,320 kilowatt-hours. These, added to the motor consumption of 60,800 kilowatt-hours, gives a grand total of 431,050 kilowatt-hours.

Distribution of Lighting Loads over the Working Day.

	Per cent. of connected load for the different periods.			
Winter Schedule......	7 to 8	8 to 3	3 to 6	6 to 7
January	20	25	60	50
February	18	24	50	40
March	17	23	33	20
October	17	24	34	21
November	19	30	60	50
December	21	34	70	60
Summer Schedule....	7 to 8	8 to 4	4 to 6	6 to 7
April	14	21	30	20
May	14	19	29	19
June	11	18	28	18
July	10	17	27	17
August	10	17	27	17
September	12	19	29	19

With the ratios already stated, of 1.6 and 1.8, the engines would generate 689,680 horse-power-hours, and the boilers, 775,890 horse-power-hours. The author assumes an engine guarantee of 24 pounds of steam per horse-power per hour and a direct evaporation of 8 pounds per pound of coal. This is equivalent to 3 pounds of coal per engine horse-power-hour. He evidently based his further calculations on the boiler horse-power-hours, though it would appear that a typographical error existed in the paper as printed for distribution. The ratio of 1.6 to 1 between the horse-power of the engines and the kilowatts of the generator would indicate an efficiency of the generating units of about 83.5 per cent., while the ratio of 1.8 to 1, in comparing boiler horse-power to kilowatts output would seem to provide steaming capacity in excess of the direct requirements of the generating unit, or to provide for auxiliary steam machinery and any losses from condensation and the like. If the 3 pounds is charged to each boiler horse-power-hour, the total coal consumption will be about 1,164 short tons, and at 8 pounds of steam per pound of coal, the total evaporation will approximate 299,000 cubic feet. It is safe to assume, he says, that only 50 per cent. of this water is wasted and that the remainder is returned to the boilers. His summary of cost is made up as follows: Taking the cost of good grade of coal at $3.75 per ton, water at 10 cents per 100 cubic feet, oil and waste at $400, interest and depreciation of $3,000, ash removal at $225 (5 per cent. of the cost of the coal), and charging one-half the cost of the force in the fire and engine rooms to this account, or $2,500, would make the total cost of operating the electric plant $10,642.80, or a little less than 2½ cents per kilowatt-hour.

Mr. Bolton's paper is in abstract as follows: The present practice in tall office building construction has settled down to a general adoption of a height affording space for 16 to 20 stories. The limitation of height has come about in a natural manner by realization of the disadvantages of the remoteness of such lofty floors from the street, and the excessive expense of maintaining a suitable elevator travel schedule on such long runs.

The proportioning of the number and travel of elevators to the area, character, and height of these buildings has, so far, proceeded in a very haphazard manner. Mere increase of the area of the cars is the cause of delay in handling the passengers, and the speed of travel is practically limited to 600 feet per minute for stopping or way cars, and to 750 feet for express cars, beyond which speeds more time is lost than gained by over-running the landings. A basis for the due proportioning of elevator service may be found in the provision of an elevator to an area of 1,000 square feet of rented space repeated on 16 floors. For heights exceeding 16, the basis of calculation should be the above, plus a provision for an average number of opportunities of access to cars at the average or medium traveling floors.

In New York, the general traveling public has learned to make use of the signal system. The importance of satisfactory signal systems between floors and cars, announcing the proximate arrival of cars to waiting passengers, and of the presence of the latter to the operators, has had a more important bearing on the economy of operation than any economic improvement in operative machinery. Where elevator employes have been placed under the orders and directions of the operating engineer, remarkable improvements have resulted, particularly in the operation of electric elevators, in which the operators get into habits of continually fidgeting with the little levers of some types of control.

Indicator cards were exhibited to show the varying loads on a simple engine operating electric elevators. Ten cards taken at one-minute intervals indicated an average of 108 horse-power, with the largest 154 horse-power and the smallest 54 horse-power. As to the use of a storage battery with an electric elevator, he referred to the experience in the Dun Building, New York. The battery stands for a capital cost of $18,000, representing annual maintenance and interest of $2,150, the equivalent of nearly 20 per cent. of the coal bill. In addition, one engineer is employed to attend to the operating mechanism of the five elevator machines, a further cost of $1,000 per annum.

The following extracts from the paper give information regarding other parts of a building plant. The exhaust of elevator power is the main source of heat supply during the cold season. This exhaust in heavy schedule service is nearly always in excess of heat requirements during the business hours. The feed system is in summer a direct cold feed from outside supply, the entire exhaust being wasted, except in those cases where an open heater is used, by which about 20 per cent. of the feed water is returned as condensed exhaust. The compound engine has not made much headway, more for similar reasons of space, than of disregard of its economy. The four-valve engine is a type well adapted to the conditions, and has found some favor recently.

In the Dun Building, 15 stories high, the author found a sufficient supply to justify sinking a tube well 30 feet deep below cellar floor, whence a pump discharges the supply, which is fairly clear but chemically impure surface water, over the coils of the refrigerating plant, thence to the eleventh floor to a tank. From this tank the air supply of an Adams sewage lift is compressed, and by it all sewage of the kitchen, of the restaurant, as well as that of the basement toilets, is lifted to the sewer. The water, after compressing the air, descends to another tank on the fourth level, whence it supplies the flushes of the fixtures below, and is thus used three times over, reducing the water bill, he stated, of the building by $1,100 per annum.

THE POWER REQUIREMENTS OF CRANES AND CAPSTANS.

One of the papers read at the meeting, presented by a member of the Institution of Mechanical Engineers, described the Middlesbrough dock electric and hydraulic power plant of the North Eastern Railway. It was contributed by Mr. Vincent L. Raven, chief assistant mechanical engineer. At this dock there are hydraulic and electric appliances working side by side, on which some detail tests were made. It will be out of the question to describe without illustrations the details of the cranes and capstans, but reference may here be made to the results of the tests.

The figures will be given first for the hydraulic apparatus and second for the electric, in every case. The total number of lifts made were 825 and 834, the latter figure relating, as stated, to the electric appliances. The total weight of rails lifted were 1,210.4 and 1224.9 long tons. The time occupied for loading was 7 hours and 5 hours 15 minutes, respectively, showing a gain effected by the electric cranes of 1 hour 45 minutes. The total coal burned at the power station during the test was 3,584 and 2,912 pounds, showing a saving effected by the electric cranes of 672 pounds. The savings, it may be stated, were all on the side of the electric apparatus. The total costs of working at the power station during the test was $3.35 and $3.03, showing a saving of 32 cents. The cost of working, including capital, interest and repairs, was $8.73 and $7.03, effecting a saving of $1.70. When the total cost of men's wages was included, the cost per 100 long tons is $6.55 and $4.89, showing a saving of $1.65. The total saving effected by the electric cranes was given as 25 per cent.

As to the performance of the capstans, a number of hauls of 100 feet were made, with a load varying from 29 to 174 long tons. In every case the electric capstans consumed less time than the hydraulic, with the exception of the 29-ton load, when the hydraulic apparatus required less ime. The speed per minute was in general higher, for the electric the ratio being greater, the heavier the load hauled. For the total of the six runs that were made the electric capstan required 226 seconds, as against 691½ seconds; the mean speed was 161 feet per minute with the electric and 96 with the hydraulic, while the actual power used by the machines was calculated as 5,600,000 foot-pounds in the case of the electric machine and 6,100,000 for the hydraulic.

COMMERCIAL GAS ENGINE TESTING.

Another one of the papers which can be referred to under the foregoing general head of power-plant papers, was one on "Commercial Gas-Engine Testing," by Mr. William P. Flint, of East Pittsburg. While the paper starts out with general directions covering the testing of gas engines, it is mainly devoted to a proposed standard of comparison between gas engines.

The maximum power of a given gas engine depends on the number of British thermal units it can take in per minute, and on the percentage of this heat which it can turn into brake horse-power. With engines of about 10 brake-horse-power per cylinder and larger, there is but little variation in the efficiency of similar engines, which may be attributed to the size. The consequence of this is that the power of gas engines of the four-stroke cycle type varies almost in proportion to their suction displacement, and some one size of engine may be taken as a standard to which to reduce the figures obtained on other engines. The curves thus obtained from the results of tests on many sizes of engines are mutually comparable. They furnish a basis for predicting what still other sizes of engines, not yet tested, may be expected to do.

The results of tests on a large number of similar engines using natural gas for fuel have shown that every 345 cubic feet mixture displacement per minute will give in the neighborhood of 115 maximum brake horse-power, or 100 rated brake horse-power. The above displacement is figured from the area of the piston, length of stroke, and the greatest number of charges per minute at full load speed, and furnishes the data upon which it is proposed herein to establish a basis of comparison.

Comparisons of the engine are made on the 100-horse-power basis in the following way: The number 345, being the number of cubic feet mixture displacement that will give about 100 horse-power, is divided by the suction displacement of the engine in question, and the quotient gives a reduction factor by which both the brake horse-power and the British thermal units used per hour are multiplied to bring the engine on a 100-horse-power basis. By plotting in this manner the results of a large number of tests of gas engines, a manufacturer may, the author says, ascertain the characteristic British thermal units brake-horse-power curve for each size and type, and from these can predict what new sizes should do. Experience teaches that when reduced to a common basis there is but little more variation between the curves for similar engines of different sizes than between individual engines of the same size. There are so many factors influencing the exact location of the curves in question, that under commercial conditions a good many tests have to be run before safe average curves can be drawn. For this reason it is most helpful to be able to readily and intelligently compare the results of different sizes, to the end that the experience gained on a size which many engines have been built may be utilized in criticizing the performance of a new size.

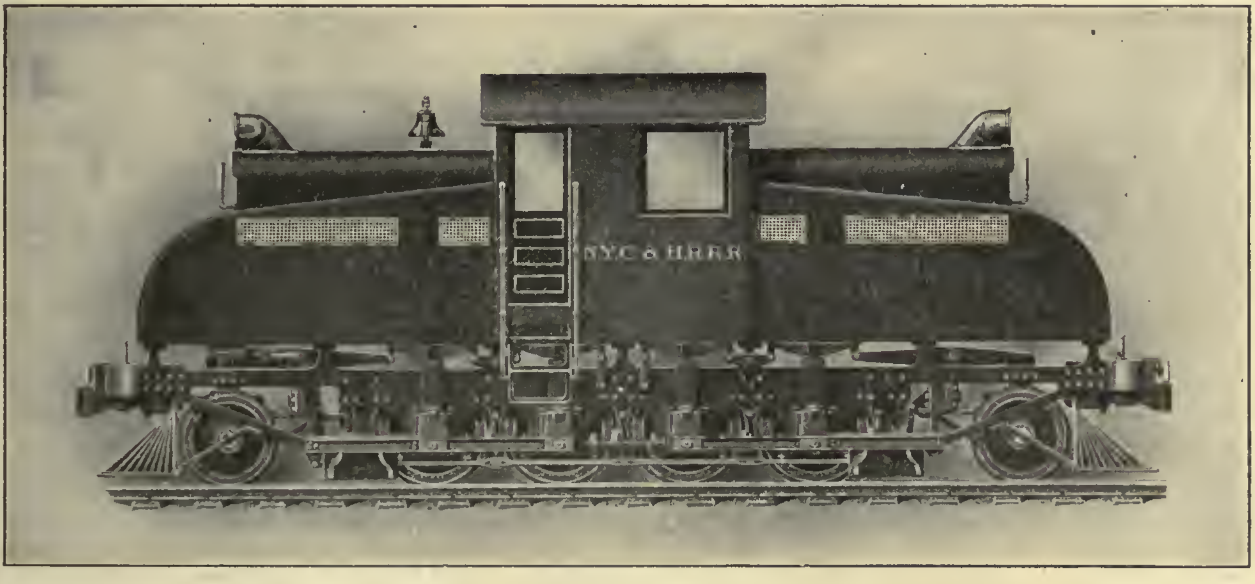
The Cost of Thawing Water Pipes by electricity, according to figures given at the recent meeting of the National Electric Light Association, was as follows on the basis of 125 house services thawed in Rutland, Vt., during February: On the average, 17 amperes alternating current at 2,200 volts were required and the average time consumed was 27 minutes. At 10 cents per kilowatt-hour the current cost was $1.68; and the cost of labor was $1.85 and of teams and drivers 58 cents, making the total cost per service, $4.11.

St. Petersburg Disposes of Its Wastes by antiquated methods. The street drainage and the partial drainage of the properties in the central parts of the city is accomplished by means of pipes discharging into the nearest canal or the river. This system has been in use since 1770; consequently, all the waterways are seriously polluted. Furthermore, according to "Public Works," house sewage and other refuse are removed by night carts and river barges, which deposit their loads on suburban fields. Much foul matter also percolates into the soil. The capital of Russia is thus shown to be several generations behind the progress of civilization. On the other hand, the majority of the inhabitants are said to indulge in a steam bath once a week, and there are 350 establishments leased by the municipality where such baths can be taken.

The Electric Locomotives of the New York Central Railroad.

The readers of this journal have been kept informed of the general progress of the New York Central & Hudson River Railroad Company in equipping its lines near New York with electricity for both suburban and through trains. In a number of respects it is the most important application of electricity to traction which has yet been considered, and particular interest has attached to the design of locomotive adopted for hauling the heavy express trains which run into the Grand Central Station. The importance of handling such trains as promptly as by steam locomotives, and more promptly if possible, was so recently pointed out in The Engineering Record that it need not be discussed again. The General Electric Company and the American Locomotive Company, the joint builders of the new motive power equipment, believe that it will excel the best records of steam. With a light train the electric locomotive is expected to give a speed of 75 miles an hour, if desired, while heavier trains can be hauled at this rate by coupling together two locomotives and working them as a single unit.

The locomotive has been designed in accordance with specifications prepared by the Electric Traction Commission appointed by the railroad company, the members being Messrs. W. J. Wilgus, John F. Deems, B. J. Arnold, Frank J. Sprague, and George Gibbs. The secretary to the commission is Mr. Edwin B. Katte. The locomotives are to handle trains to Croton, on the Hudson division, and North White Plains, on the Harlem division, 34 and 24 miles, respectively, from the Grand Central Station. The conditions which the commission determined must be fulfilled by the locomotive were that it must be capable of making two regular successive trips of one hour each between Grand Central Station and Croton with a total weight of 550 tons, a single stop in each direction and a lay-over not to exceed 20 minutes. In addition to this it was provided that a similar schedule should be maintained with somewhat lighter trains making more frequent stops. Finally, it was provided that with a total train weight of '35 tons the electric locomotive should be able to run from Grand Central Station to Croton without stop in 44 minutes, and, with one hour lay-over, be able to keep up this service continuously. This last schedule is the equivalent of the present timing of the Empire State Express, though the latter has a lighter train.



Electric Locomotive for the New York Central Railroad's Passenger Service at New York.

Specifications embodying these conditions were prepared by the Commission and sent to all the principal electrical manufacturing companies, both here and abroad. It will be observed that no restriction was placed on bidders as to whether direct or alternating current was to be used. The successful bidders were the General Electric Company in conjunction with the American Locomotive Company, as announced some time ago. The choice of a direct current type of locomotive was dictated largely by its known reliability of service, owing to the amount of experience which had been accumulated with the direct current motor.

The new electric locomotive will be 37 feet in length over all. The wheel base will consist of four pairs of motor wheels and two pairs of pony truck wheels, the length of the total wheel base being 27 feet, and of the rigid wheel base, consisting of the four pairs of motor wheels, 13 feet. The diameter of the driving wheels will be 44 inches and of the truck wheels 36 inches. The driving axles will be 8½ inches in diameter. It will be what is known as a double ender and will weigh approximately 190,000 pounds.

The weight which will rest upon each of the driving wheels will be about 17,000 pounds.

Proper distribution and division of the weight among axles will be accomplished by swinging the main frames from a system of elliptical springs and equalizing levers of forged steel, the whole being so arranged as to cross equalize the load and furnish three points of support.

The frame will be of cast steel, the side and end frames being bolted together at machined surfaces and stiffened by cast-steel cross transoms. The journal boxes and axles will be designed to permit sufficient lateral play to enable the locomotive to pass easily around curves of 230-foot radius. The superstructure of the locomotive is to be of steeple form, so designed as to offer the least practicable wind resistance consistent with the adequate housing of the apparatus and its convenient operation. The cab is designed so as to afford a clear view of the track. The whole of the superstructure is to be of sheet steel with angle iron framing, and the doors and windows of the cab are to be fireproof.

The driving power of the locomotive will be furnished by four 600-volt direct-current gearless motors, each of 550 horse-power. This will make the normal rating of the locomotive 2,200 horse-power, with a maximum rating of about 2,800 horse-power, or about 50 per cent. greater than that of the largest steam passenger locomotives now in service.

The armatures will be mounted directly on the axles and will be centered between the poles by the journal boxes, sliding within finished ways in the side frames. The armature core will be of the iron-clad type, the laminations being assembled on a quill which will be pressed on the axle. The commutator will be supported on the quill. Unlike the ordinary four-pole motor where the magnetic circuit is made through a separate box casting, the magnetic circuits in this type of electric locomotive are completed through the side and end frames. The pole pieces are cast in the end frames and there are also double pole pieces between the armatures carried by bars which act as part of the magnetic circuit. The pole pieces will be shaped so that the armature is free to move between them with ample clearance on the sides. As the poles move up and down with the riding of the frame on the springs, they will always clear the armature, and provision is made so that the armature will not strike the pole pieces, even if the springs are broken.

The Sprague-General Electric multiple unit control will be used on this type of electric locomotive. There will be two master controllers in the cab, so placed that the operating engineer looking ahead will always have one of these under his hand. The control system will permit two or three locomotives to be coupled together in any order in which they happen to come and to be operated as one unit by the engineer in the leading cab. The control system will also be semi-automatic in its action, as it will provide a check on the rate of acceleration of the train, which the engineer cannot exceed, while he may accelerate at any slower rate if he so desires. Should two locomotives break apart the control current will be automatically and instantly cut off from the second locomotive without affecting the ability of the engineer in charge to control the front locomotive under his charge. The control system is designed for a minimum of 300 volts and a maximum of 750.

The locomotive will be provided with all the usual accessories of a steam locomotive, including an electric air compressor to furnish air for the brakes; it will have whistles, a bell, and an electro-pneumatic sanding device, and electric headlights at each end. The interior of the cab will also be heated by electric coils.

The Austrian Government is investigating the probable cost and the feasibility of operating its Alpine railways by electricity, according to European contemporaries. The principal objection to the present operation by locomotives is the difficulty experienced in ventilating the twenty-seven long tunnels on the line.

The Length of Russian Railways at the beginning of this year is officially reported to have been 36,673 miles, of which 31,493 miles were in Europe and 5,180 in Asia. These figures do not include 1,944 miles in Finland and 1,555 miles of the Eastern Chinese line. Of the European lines nearly two-thirds of the mileage are operated by the Government.

Book Notes.

The seventeenth annual report of the Interstate Commerce Commission is a most interesting book of 382 pages, giving a full account of the work done during the year ending June 30, 1903. Those familiar with previous reports do not need to be told that this one gives a comprehensive view of many of the most important financial, operating and construction problems of the present time. Abstracts are given of all decisions made during the year by the Commission and there are valuable sections describing the progress made in introducing various appliances and methods to insure the greater security of employes and travelers.

The Connecticut Society of Civil Engineers, the secretary of which is Mr. J. F. Jackson, of New Haven, has issued a volume containing its papers and proceedings for 1903. Among the papers may be mentioned descriptions of the water power development at New Milford and the new storage reservoir at New London, and a valuable discussion by Prof. H. S. Graves of the relation which forestry work may be made to bear to city water supplies. There are also a large number of short papers, mostly on municipal engineering subjects, which contain valuable practical information.

Any one who has had to figure discounts, particularly those involving three deductions before getting the final result, knows well the advantage of a well arranged table of such figures, giving at a glance the value of $1.00 after the total discount has been subtracted. For example, to figure the value of $1.00 after taking off discounts of 55, 7½, 5 and 2½ per cent. is a time-absorbing task, but a book which will give the result, $0.3585, at a glance, is worth a great deal. Moreover, if this book also gives this discount for every unit from 1 to 50, inclusive, still more figuring is saved, and the whole process of taking off the discount and obtaining the final amount is simply the addition of a few figures. Such a book, "The Thomas Discount Book," has been compiled by M. T. Thomas, of Williamsport, Pa., who publishes it in cloth covers at $1.00 and in leather at $1.25. It contains 81 pages, giving all the discounts in general use, and is arranged with a thumb index on the side of the page so as to be used with the utmost facility.

National Iron and Steel, Coal and Coke Blue Book. Edited by B. H. Morwood. Pittsburg: R. L. Polk & Co.; cloth, 9x6 in.; 890 pages; $7.50.

The second edition of this well known directory of the iron, steel, coal and coke industry in the United States retains the features of the first edition and has a number of new ones. The first half of the work is devoted to iron and steel, and begins with an index of products, so that any one desirous of ascertaining the makers of an article can readily find their names. This is followed by a general grouping of the works under Bessemer steel plants, crucible steel plants, merchant mills, plate mills, sheet mills, skelp mills, blast furnaces, open-hearth steel works, rail mills, structural mills and steel casting works. The next section is an alphabetical list of companies and firms, giving so far as possible the date of incorporation, capital stock, board of directors, purchasing and sales managers, superintendents, shipping facilities and equipment of works. After this comes an alphabetical index of directors, officers, managers and superintendents, and then geographical lists of blast furnaces and steel mills. The part of the book devoted to coal and coke producers is arranged with similar thoroughness and regard to the convenience of the user.

Hendrick's Commercial Register of the United States. Thirteenth edition. New York: Samuel E. Hendricks Co.; cloth, 10x7½ ins.; 1,226 pages; $6.

This directory is a carefully compiled directory of the architectural, mechanical, engineering, contracting, electrical, railroad, iron, steel, mining, mill, quarrying and kindred industries. It contains over 350,000 names, classified and cross-indexed with much skill, and readily consulted by means of an elaborate index. The manufacturers and dealers in the machinery used in these industries, their products and the purchasers of the products are all covered by the book, which is revised annually. The book is compiled with care, and no one accustomed to using it will care to be without it, for it is a unique and valuable publication.

General Index to the Street Railway Journal. Arranged by subjects and authors. October, 1884, to December, 1903. New York: McGraw Publishing Co.; cloth, 10x7 ins.; 162 pages; $5.

The information given in a really good class publication is invaluable for any one interested in the subjects it covers, but this material is often only partially available because of the lack of a suitable index to the volumes. The "Street Railway Journal" covers so thoroughly the entire field of city, suburban and interurban railways that a really good index, such as this, is invaluable to those who wish to investigate any feature of such roads. The unique position of this publication, the manner in which it covers every part of its field, and the accuracy of its information are everywhere acknowledged. The index has been prepared with evident care and thoroughness and is arranged in a typographical form very easy to use.

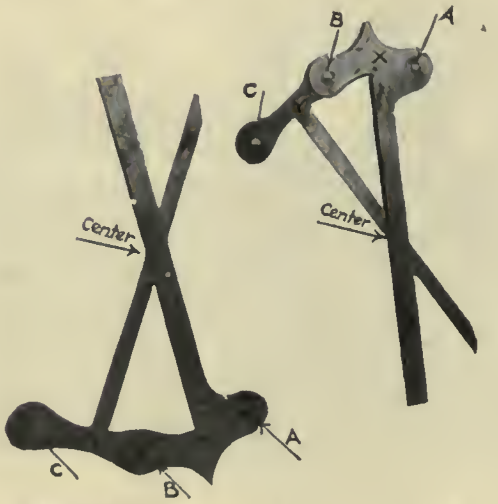
Directory of American Cement Industries. Third edition. Edited by Charles Carroll Brown. Indianapolis: Municipal Engineering Co.; cloth, 9x6 ins.; 734 pages; $5.

The new edition of this directory has been much improved by a marked expansion of the real directory parts of the earlier editions, and the omission of the sections on the uses of cement and concrete. The combination of a technical manual and trade lists is rarely a happy one. The growth of the cement industry in recent years is well shown by the largely increased number of cement manufacturers which are reported. Brief descriptions of most of the leading works are given, and these have been largely rewritten for this edition. The directors, capital stock, nominal output and shipping facilities of the companies are given, together with lists of brands and sales agents. An interesting feature is the statement of companies' names not now in use, a compilation very difficult to carry out. It might be stated that the note concerning the sale of the Warners plant to the Mohawk Portland Cement Company and its reconstruction by the latter is incorrect, for the plant has been idle for several years and can be bought for two-thirds or half the money actually invested in it. The artificial stone and concrete block business has increased so rapidly that a section of the book has been set aside solely for it. The lists of dealers in cement, contractors using the material, engineers and testing laboratories are very full, while the directory of manufacturers of machinery used in cement mills has been much enlarged in comparison with previous editions.

Letter to the Editor.

An Instrument for Bridge Shop Inspectors.

Sir:—We send you herewith a photograph of a small instrument, which can be made by any careful mechanic, and one which is extremely handy in shop inspection work where pin-connected truss members are to be measured. It was devised by us for use during our shop inspection of the Fraser River Bridge, recently erected at New Westminster, B. C., in which structure there are several heavy pin-connected spans. (See recent numbers of The Engineering Record.)



Instrument for Finding Pinhole Centers.

The principle of the instrument is simply this: the perpendicular bisector of the chord of a circle passes through the circle's center, and the intersection of two such perpendiculars determines the center. The material used is thin saw blade steel. Arm X is composed of two such plates, and arm Y, which is a single plate, slides between them, rotating about the rigid pin B. The left-hand edge (as shown) of arm Y is a perpendicular bisector of the line joining the centers of the pins C and B. Similarly, the left-hand edge of arm X bisects perpendicularly the center line of pins A and B. The instruments shown in the cut are two inches center to center of pins, with arms six and one-half inches long. This will cover a range of pinholes from 3 to 11½ inches in diameter.

When the three pins, A, B, C, are brought to bear against the circumference of any pinhole, the intersection of the edges of the arms X and Y determines the center of that pinhole.

The more care taken in their manufacture, the more accurate they become, and may be used in determining the overall lengths of truss members, and make this part of the work very much easier, especially if the holes be of different diameters expressed in fractions or decimals of inches. Very truly yours, G. B. Ashcroft.

The DeLano-Osborn Eng. Co.
Toronto, May 29.

A System of Street Grades has been established at Havre, Mont., by an ordnance drawn by City Engineer C. W. Swearingen which contains many interesting features. A U. S. Geological Survey bench mark, carefully described in the ordinance, is made the official bench mark for all the streets. Grades are established at each block corner in the city, and other points are determined as follows: "Curb grades at all points shall be at an elevation determined by a fall of 2½ per cent. from the property line grade to the top of the curb." This ordinance not only fixes all grades, but enables any surveyor to run them out for a property owner. It is too often the case that the notes concerning such work are considered private property by surveyors.

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The Utilization of Inferior Timber.

Engineers and architects have had occasion many times during the last few years to feel considerable uneasiness regarding estimates of the cost of timber structures. For years they were accustomed to call for certain grades of material and could estimate within a comparatively narrow range what these grades would cost. In times of plenty the best is none too good for everybody and so specifications were cast in a certain mold, as regards the requirements for timber, from which it is high time they should be freed. Not only is the best timber much more costly than it was when these specifications were drawn, but it is occasionally impossible to obtain it at any reasonable figure. The day has come when it is the duty of the engineer and architect to investigate this whole subject afresh and ascertain the possibility of utilizing for many of their purposes woods which were considered unserviceable no longer than ten years ago. In fact, it is perfectly well known by those acquainted with the lumber trade that a large amount of these so-called inferior timbers are sold under the old-time specifications for the highest-grade species. The dealers know that they look much the same, answer the purpose just as well, and can be secured at lower cost and in ample quantity.

The good work that the Bureau of Forestry is doing in making known the valuable properties of many timbers deserves the hearty support of all users of wood in any form. The engineer and architect are particularly assisted by these investigations, because they furnish information that will not only enable them to use the cheaper species of wood with the same facility as the expensive pines, but will also enable these users to draw good specifications for such timber. At the present time very few are in possession of such information, but its value is evident from some data presented before the National Lumber Manufacturers' Association a short time ago by Dr. Hermann von Schrenk. A brief summary of these statements will illustrate their importance.

In Washington and Norfolk there is sold a "Virginia" pine in sticks up to ten inches square, almost entirely sapwood of such rapid growth that sometimes only four rings occur in three inches. It is a second growth timber, usually very knotty. Farther south, at Charleston, considerable "North Carolina" pine is produced which is shipped north. It gives large-size lumber, fairly free from knots, somewhat close-ringed and of much structural merit. Both these timbers are the same species, the loblolly pine, but of different grades. The loblolly pine has a bad name among users of timber because, doubtless, the published information regarding it is based on the results of tests of the poorer grades, like that sold as "Virginia" pine. The better grades, the "North Carolina" pine, are favorably known, and there is no reason why the name loblolly should be regarded any longer as denoting a material fit only for chicken coops. The species grows easily and rapidly, and lends itself readily to good forestry management. Although it decays rapidly under certain conditions, it may be treated very successfully by preservative processes.

Another species which should receive more attention is known as red fir, Douglas spruce, Oregon pine and Oregon fir. It forms nine-tenths of the timber from southern Oregon to Vancouver and from the Cascade Mountains to the coast. It differs very much in its hardness and other properties, and can be obtained in very long sticks of large cross-section. It is common in the Chicago market and some of it has been used for special purposes in the Atlantic States.

The western hemlock is another species that has suffered from its name. Hemlock does not sound well to the Eastern builder, and the vigorous western species, which grows to a height of 250 feet and a diameter of 15 feet, is misjudged on its mere name.

These three species of timber can be obtained in large quantities and two of them in very large sticks. Their availability for many purposes for which long-leaf pine is specified is manifest from their strength. Taking 8x14-inch joists on a 16-foot span, the long-leaf pine will carry a center load of 44,500 pounds and deflect 2¼ inches before breaking, the loblolly pine will carry 32,500 pounds and deflect 3 inches, the red fir will carry 30,500 pounds and deflect 5 inches, and the western hemlock will carry 28,300 pounds and deflect 1½ inches. These figures, which Dr. Schrenk gives as representative of merchantable timber, can also be stated in another way. For the same strength, in beams 8 inches wide and of 16 feet span, the long-leaf pine will be 14 inches deep, the loblolly pine and red fir 16 inches and the western hemlock 18 inches. These figures show that while the long-leaf pine unquestionably deserves its reputation for strength, the other species are good. Before long, enough information will doubtless be gathered by the Bureau of Forestry to enable anyone to write a good specification for all these woods, so that advantage can be taken of the condition of the market and that species used which will be to the best advantage of the owner of the structure.

One feature of the timber market which ought to be mentioned in this connection is the desirability of specifying so far as possible merchantable sizes of timber. On large work this is particularly necessary and every builder of large structures has had occasion to deplore the readiness of mill architects and others to call for timber that must be cut to order. This practice often delays the time of completion of the structures and leads to the use of wood which is only nominally dried.

These notes refer to the use of so-called inferior woods for structural purposes. This is an important subject because many of these woods are in no way inferior to long-leaf pine provided they are properly used. Timber is employed for many other purposes, however, where cheaper grades than those now used would be equally serviceable. An inspection of the packing cases of German and American manufacturers will show how securely the former put up their goods with boxing material that would be immediately rejected in the United States. The subject of cross-ties has been discussed so recently in this paper that it is unnecessary to do more than refer to it again as a great field for utilizing other timbers than those previously employed. In short, the more carefully the whole subject of our timber supplies is considered the more evident becomes the value of this work of the Bureau of Forestry to timber producers and users.

The Education of an Engineer.

In this season of graduation of young engineers from the many engineering schools of the country it is well to give a little careful thought to the education of an engineer. The practical side of the profession of engineering is too immanent a matter in the affairs of the community ever to fail of most thorough consideration, but the educational training of an engineer is far differently circumstanced. There is, however, no lack of expressions of opinion on this subject from a great variety of sources, nor has there ever been such lack. Great professional organizations like the American Society of Civil Engineers and the Institution of Civil Engineers of Great Britain have discussed it at length, and individual engineers without number not only have expressed a corresponding diversity of opinion as to the proper education of an engineer, but are doing so still, and will continue to do so. The most positive judgment has been recorded in favor of a "practical" character for the work of the professional school meaning a comparatively small amount of "theory," if anyone really knows what that is. Others would have a "judicious balance" between "theory" and "practice," while a few modestly insist upon the value of a training nearly wholly "theoretical." Again, another party believes that the nearest approach to perfection will be attained by taking the Military

Academy, at West Point, as a model for a school of civil engineering; and so on to the end of the list.

The Engineering Record is not a partisan of any of these views on engineering education, nor of any other special views of the subject. It recognizes any excellence found in such critical observations as those cited, but it goes somewhat farther than that. It has been found that experience usually conveys a reasonable amount of information regarding that special field of activity covered by it. This general rule is seldom controverted in connection with the practice of the engineering profession. Occasionally the mental caliber and quality of the practitioner may be small or defective, so that the results of experience in such cases are not satisfactory, but that in no way militates against the general rule. Critics of engineering education too frequently forget this general but simple principle.

Few who prescribe a sure panacea for all the ills of professional training have ever enjoyed even a day's experience in the work of instruction. As a matter of fact, in all the wide field of engineering activity there are nowhere found problems of so great difficulty or so urgently needing extended experience for their best solution as in the work of educational training. The question is not one of relative amounts of "practice" and "theory," and therein the ordinary critic commonly fails, and most radically. Confusion "worse confounded" has been introduced into the consideration of this question by that imaginary and false distinction between practice and theory. What in reality is usually covered by those words is mal-developed knowledge on the one hand and unbalanced knowledge on the other. In the best and only true educational training of the engineer there is no such distinction; they are harmonious and absolutely essential parts of a well-rounded whole. If correct views of engineering education are ever to be attained in the profession, that fundamental, simple fact must be recognized as the corner-stone of the educational structure.

It is the business of the professional school to impart to its students that particular class of knowledge—and the use of it—required in their subsequent professional careers, and it is of exceptional importance that they should acquire that kind of training which the school can most efficiently give and which the pressing duties of active life subsequently render essentially impossible to secure. There are few men so resolute in their pursuit of knowledge as to persist in that line of work after graduation from the professional school, even though the knowledge thus gained be of the highest value to them. Again, there is a certain mental and individual development, a well-rounded shaping of personality, gained by educational training that is rarely possible of accomplishment in after life, yet of distinct value to the professional man. The engineering school must confer on its graduates this educational finish and also supply the best quality of technical knowledge afforded by advanced engineering science and practice.

The broad, general principles of every branch of the philosophy of engineering should be thoroughly taught, for in no other way can the student acquire a comprehensive view of his profession or an intelligent control of its practice. There can be no greater educational error than the narrowing restriction of a student's work to special demonstrations and their applications. If a student possesses a thorough grasp of general principles illustrated by their applications to larger engineering works, the whole mass of special applications become self-evidently clear, and much time devoted to them is essentially wasted.

Memorized mathematical demonstrations insisted upon under the old régime are largely useless, but judicious applications of intelligently derived formulæ to typical engineering problems constitute the essence of the highest grade of instruction. There is no better test of a student's knowledge than his capacity to use it. The real question is not as to the relative amounts of "theory" and "practice" that the student should have, but as to the most efficient methods of imparting to him a thorough knowledge of the fundamental principles of his profession and the power to use them. The completion of such a course of professional study will not make a young man a ripe and finished practitioner, but it is the best, if not the only initiative leading to that end.

Pensions for Disabled Workmen.

The unrest among machinists, railway employes and others whose work is more or less dangerous has long been attracting the attention of some of the leading men in public life as well as that of employers who feel their responsibility toward their men. This feeling has found expression in the compulsory old-age and disability pension system of Germany, and the accident pensions of railways in many countries. It has been investigated by students of social economy of many nationalities, and a great number of papers on the subject have been written. A defect of most discussions of the subject has been a prejudiced point of view, preventing an equitable weighing of all the relations of such pensions to employers, employes and the community. Hence it is not at all surprising that the eminent manufacturers who attended the graduating exercises at Bryn Mawr College on June 2 paid a degree of attention to the commencement address of Dr. Carroll D. Wright which such speeches seldom receive. It was one of the clearest explanations of the pension proposition that has ever been made, and is particularly marked by its frank avowal that a really good system of pensions cannot be worked out in detail until more comprehensive data are available. This statement, from the conservative director of the Government's Bureau of Labor, was coupled with an equally important assertion that the time had come when a pension system must be inaugurated as a matter of justice to a great proportion of the community.

The argument advanced to support this claim deserves careful consideration. The owner of an industrial establishment lays aside a certain sum each year, so that by the time his machinery is worn out he has funds for replacing it. This is considered good business; anyone who fails to do it is regarded with suspicion, and the community makes no objection to the additional charge for the products which this course entails. It is the public which pays for this conservation of capital, not the manufacturer, and the justness of the system is everywhere recognized to rest on the fact that the capital is employed for purposes of general service to the community.

The men whose labor is just as essential as capital to carry on these enterprises are to-day generally without any sinking fund system within their comprehension. According to Dr. Wright, during the year of the Spanish war the number of railway employes killed and injured in this country greatly exceeded the number of soldiers who were killed and wounded. Statistics of injuries in other callings might be given to show their hazards to efficiency and even to life. When these data of injury and death are taken into careful consideration, there is reason for asserting that the community should pay to workmen the same insurance and sinking fund contributions that it already pays to capital. The moderate wages of these men leave them little money for their old age, and few of them have any training or knowledge which aids them to invest their scanty savings to the best advantage. It is true that there are savings banks and insurance companies always ready to assist them, but the existence of these companies does not lead the men to utilize their advantages as much as they should.

The men are entitled, according to Dr. Wright, to the same protection against depreciation that the community has willingly given to capital for many generations. The man's skill and strength are his capital. The trouble in endeavoring to introduce any such project lies in the lack of information concerning the hazards of the various callings. To learn these thoroughly it will be necessary to compile a great mass of statistics and to investigate them by the same methods that actuaries employ in computing their tables of the expectancy of life. Having such tables, the machinery for caring for workmen would be little more complicated than that now in force in Germany. In that country the funds for the purpose are partly contributed by the employers and partly by the government. In the United States the funds would probably be provided by the companies, as in this way the money would most easily be raised indirectly from the community by a very slight increase in the prices charged for the products. The cost of supervising such a system by the government would not necessarily be great.

It is important to observe that such a proposal is not a government charity in any sense and has none of the poor-house features that are sometimes asserted against it. The proposition is merely to extend to skilled labor the same privileges that capital alone enjoys to-day. It must be studied and discussed a long time before a fairly just solution can be reached, and it may be questioned if it will do much to allay the social unrest which is now more marked than ever before. It cannot be regarded as a remedy for existing conditions, but merely as one more step forward in the evolution of the skilled workman. He has passed from a slave to a serf and from a serf to a freeman. It now remains to be seen whether society can find some way to guarantee to his skill the same protection that it has long and willingly given to capital. This is Dr. Wright's view. In his official capacity as United States Commissioner of Labor he has made a careful study of the subject, abroad as well as in this country, and his belief that a good system of pensions is possible—and is warranted by logical deductions from the pensions paid to mechanical equipment—is certainly deserving of more than passing attention.

Municipal Improvements in New York.

One of the most interesting reports on municipal engineering that has appeared in a long time is by Mr. Nelson P. Lewis, chief engineer of the Board of Estimate and Apportionment of New York, for the last two years. Greater New York is one of the few municipalities that has no city engineer. Under the revised charter, which went into effect on the first day of 1902, a large part of the public improvements are brought up by the local boards of the different boroughs, but must be reviewed and authorized by the Board of Estimate and Apportionment before they become accepted projects, as they may be called for lack of a better term. The position of engineer to the board had no precedents to govern it, and it has developed into the nearest equivalent to the office of city engineer that there is in the city's organization. The work is very comprehensive in character, for the conditions in lower Manhattan Island are as different from those of the market gardens of Queens or the suburban communities north of the Harlem River as it is possible to conceive. For this reason alone, the city engineering work of Greater New York is of interest, but there are other causes as well for its particular novelty.

The sewerage problems of the city offer a good example of the peculiar features that can be observed. All things considered Broadway may safely be considered the most important thoroughfare in America, and yet there are many blocks of it which are without public sewers of any description. The reason for this is the fact that in the lower part of Manhattan Island Broadway occupies a ridge from which the side streets fall away in both directions, and many of the buildings fronting on it drain through side streets or reach the sewers by private connections. But this is simply an unusual condition, and not a serious problem, such as that of some of the old sewers in the lower part of the island. Some of these are very old, of a type now obsolete, and of a capacity inadequate to serve the great population which throngs the lofty office buildings of the district every working day. The design of a system of sewers for this part of the city presents problems of a nature never yet undertaken in some of its features. The investigations of Mr. Nicholas S. Hill, Jr., chief engineer of the Water Department of the city, have shown that the water consumption in this part of the city is very high, far above what was estimated at the time his investigations were begun, and the volume of sewage will be correspondingly raised above that which was estimated when the old drains now in service were designed.

The sewerage problems in the other boroughs are no less complicated. In Brooklyn the great growth of the borough inland, by the development of farming lands, has made it necessary to construct very extensive systems of sewers, including two expensive outfall tunnels to tide water, which are now being described in this journal. But such a system of relief is impossible in Queens, because the communities are relatively small and scattered. Mr. Lewis frankly acknowledges that expert advice should be sought in making a comprehensive study of the sewerage of the borough. This recommendation is a thoroughly sound one, which has many precedents. The plans for such work must be drawn with a view to future as well as present conditions. The relative merits of the combined and separate systems for different localities in such an extensive territory must be carefully weighed. These tasks call for an extensive experience and a high degree of specialized knowledge, which only a comparatively few men possess, and the city will doubtless save money in the end by utilizing this knowledge in a careful study of the problems before the growth of the district renders them too complex for really satisfactory solution. It is always well to bear in mind that plans can be changed much more quickly and cheaply than executed works can be reconstructed. The drainage problem in the Borough of the Bronx is also a complicated one, because the picturesque stream which runs through its center is fast approaching the condition of a fetid sewer. The pollution is not only due to New York but also to other communities, and joint action by them all will be needed to bring about a really successful solution of the problem.

Sewerage is only one of the branches of engineering which fall to the supervising province of the engineer of the Board of Estimate and Apportionment. Paving is even more important just now. The most noteworthy feature about it is the Board's refusal, in all but a very few cases, to sanction the use of macadam. This course has been followed because in cities such pavement has a short life, and, while its first cost is small, the expense of maintenance is far greater than that of any other pavement in general use. "The necessity for repairs begins immediately upon the completion of the work, and if the street is subjected to considerable traffic such necessity continues during the life of the pavement, while constant sprinkling is required not only to prolong its life, but to make tolerable the use of and residence upon streets so paved." Under the charter a street once paved by funds raised by assessing the abutting property, must be maintained and renewed out of the general funds, unless the owners of over half of the frontage agree to another local assessment; such an agreement "it it practically impossible to obtain." Hence it is unfair to property owners who have paid for a durable pavement to permit those on adjacent streets not only to escape with a light assessment for macadam, but also to avoid liability for the maintenance of such streets. If it were possible to assess part of the cost of renewals of macadam on abutting property, it would change the aspect of the problem, but up to the present time all attempts to secure legislation to this end has been of no avail. This decision of the Board will receive the approval of most engineers who have tried to maintain macadam pavements in cities.

A feature of Greater New York's municipal engineering which deserves favorable comment is the triangulation of the city, which is being conducted under the supervision of Mr. A. T. Mosman, representing the U. S. Coast & Geodetic Survey, which co-operates in the work. The value of this work to the city can hardly be appreciated now, but later, when more of it is closely built up, the importance of the triangulation will be more evident. Few cities have undertaken triangulation of high accuracy, and in this respect New York sets a good example.

Notes and Comments.

CIVIL SERVICE EXAMINATIONS for New York State and county positions will be held July 9. The examinations of interest to readers of this journal are those for architectural draughtsman, bridge designer, bridge draughtsman, and photographic assistant. Applications for these examinations must be made on or before July 5. Full particulars of the examinations and blank applications may be obtained by addressing the Chief Examiner of the Civil Service Commission at Albany.

CONDENSER CIRCULATING PIPES of ¼-inch riveted steel were adopted for the main railway power house of the New Orleans Railways Company in preference to cast-iron on account of the vibration of the ground, due to the character of the soil and the very frequent passing of steam railroad freight trains immediately above them. There are two 24-inch suction pipes, 287 and 312 feet in length, and one 36-inch discharge, 324 feet in length. All three in their run into the Mississippi River are carried on a framework on 65-foot piles. The strainers of the foot-valves on the suction lines are of the form of an inverted truncated cone, with the idea that fish clogging the perforations will fall off when the use of the pipe is discontinued. The outlet of the discharge pipe, which is turned down stream, is fitted with a clapper valve. This is a large check to prevent a backflow during high water, and consists essentially of a ½-inch steel plate hinged at the top and seating against a 3/16-inch leather ring.

THE IMPORTANCE OF THE VACUUM in steam turbine operation is generally recognized, but some figures on the subject given by the Hon. Charles A. Parsons will surprise those who have not followed the turbine situation. He states that the amount of cooling water generally allowed is about fifty times the full-load steam consumption, which will increase the vacuum under the normal conditions about three-fourths to one inch above that with the usual circulating allowance of thirty times the steam used. In other words, the output of the turbine can be increased four or five per cent. by increasing the power needed for circulating water from six-tenths to one per cent., about four-tenths of one per cent. of the total power being required to produce this additional vacuum. This need of a high vacuum has led to the design of a vacuum augmenter. A pipe is led from near the bottom of the main condenser to an auxiliary condenser of about one-twentieth of its cooling surface. In this pipe a small steam jet is placed which sucks nearly all the residual air and vapor from the condenser and delivers it to the air pump. With an expenditure of steam amounting to about one and a half per cent. of that used by the turbine the vacuum can be raised from 26 to 27½ or 28 inches. The air pump need not be of large size, because the jet compresses the air and vapor mixture to about half its original volume.

INDUSTRIAL PLANT PROMOTION, not for the purpost of legitimate manufacturing but to dicker in stocks and other alleged securities, has received another setback in the situation of the investors in a New England steel plant. A few years ago the leading magazines had advertisements of the great prospects of these works, describing the fine character of the plant and the high character of its product. The shares of the company were offered as a desirable investment of the savings of people in moderate circumstances. The works are now proved to be unprofitable and the stockholders recently met to devise some way of obtaining at least a part of the sums they sunk. The only purpose in mentioning this incident of high finance in these pages is to point out the minor place engineering really fills in such an enterprise. Probably every statement made in the advertisements of this corporation were true, so far as they related to the plant and product. The works were built from the plans of an eminent engineer, and the character of the product was certainly good for many purposes. The trouble lay in the fact that the location of the works was not a particularly happy one and there was not much demand for the product. It makes no difference whether a cent or a million dollars is spent on such works if there is no demand for the product, and it certainly does not pay to build a plant in a location where freight rates on both raw materials and manufactures are a maximum. There are a number of people always ready to invest money in projects which they have not carefully investigated, and they will always lose their money to promoters in consequence. The effect of their losses ought not to be considered any indication of market conditions, however, for the failure of plants which have little or no legitimate reason for existence is merely an incidental and not an important feature of business conditions.

The City Island Bridge, New York.

The bridge connecting City Island and Pelham Bay Park at Rodman Neck, Borough of Bronx, New York, is about 1,500 feet long, including approaches and 50 feet wide over all. It has a steel superstructure supported on six masonry piers and two abutments all sunk to rock or hard material at a maximum depth of about 40 feet below high water. There are five deck plate-girder spans 80 feet long on centers, and one swing span 168 feet long from center to center of rest piers, which has two openings of 55 feet 3 inches in the clear and is supported on a circular pivot pier. The 80-foot spans have two lines of plate-girders 6½ feet deep and 35 feet apart on centers. They are made with web plates 9/16-inch thick and 6x6x⅞-inch flange angles reinforced with 14-inch cover plates. Riveted shoes are riveted to the ends of the lower flanges and engage the 4½-inch bearing pins through riveted pedestals. At the fixed end the pedestals are seated on bolsters made of channels 2 feet long having 24x38½-inch cover plates top and bottom.

At the shore abutment a nest of 3-inch rollers is inserted between the bolsters and pedestals and only one other expansion joint is provided between this point and the City Island end of the steel superstructure at the draw span. This requires that the webs of each pair of adjacent girders be connected so as to expand and contract together. This connection is made by single 12x½-inch cover plates 5½ feet long which are shop-riveted to one girder and field-riveted to the other girder.

The floorbeams are plate girders 44 inches deep made with a ⅜-inch web and pairs of 5x3½x11/16-inch flange angles. They are web-connected to the main girders with their lower flanges just clearing those of the latter. They are field-riveted through the outstanding flange of the vertical web-stiffener angles in the main girder and through a single vertical web-stiffener angle on the opposite side of the floorbeam web. They carry 9-inch longitudinal I-beams 4 feet 10 inches apart flush with their top flanges, which support steel buckle plates laid in transverse strips with the convex sides upward and 3-inch angles riveted over their transverse joints. The buckle plates are leveled up with bituminous concrete filling covered with a 1½-inch wearing surface sloped 2½ inches from the center to the gutters. The 7-foot sidewalks are carried on cantilever brackets on the outsides of the main girders and have buckle plates and concrete floors similar to those of the carriageway.

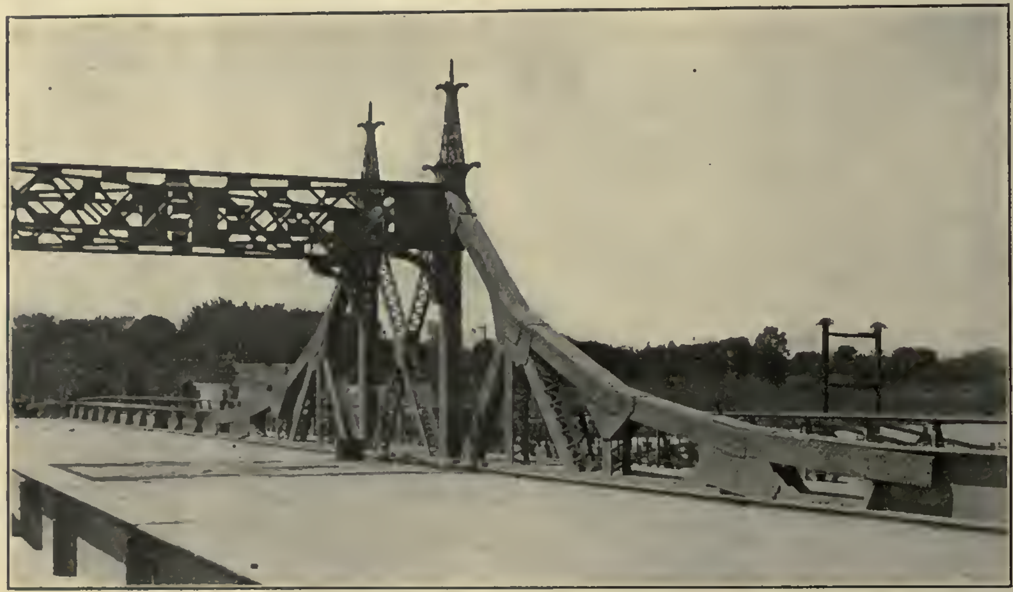
The swing span is mounted on a turntable 28 feet in diameter and is operated by hand power, although provision is made for the future installation of an electric motor. The trusses are interesting on account of the peculiar outline and the combination of separate riveted members with open panels in the center and solid web plate-girders at the ends. The maximum height of the truss is 22 feet and its length is 54 feet from the center of the turntable to the commencement of the plate-girder extremities which are each about 30 feet long and 6½ feet deep. It was the purpose in the design to secure the stiffness and stability of overhead bracing for the trusses of the draw span over the turntable where the depth must necessarily be the greatest. At the ends of the draw span where the girders are shallow the solidity of the adjoining plate girders is gained by using plate webs.

The top chord has a U-shaped section made with vertical side plates and a horizontal cover-flange angle in each channel being much plate connected by two angles with their flanges turned inward. The bottom chord has a rectangular cross-section made with two built channels latticed top and bottom, the upper smaller than the lower flange angle and all of them being turned inward. The buckle-plate floor corresponds with that in the girder spans.

The pivot pier has a maximum diameter of 35 feet and is protected by a longitudinal crib pier 228 feet long and 51 feet wide over all. This pier is built with 45-degree cutwater ends and is sheathed with 4-inch yellow pine vertical planks 14 feet long, extending from 1 foot below mean water level to the top of the crib, 5 feet above mean high water. It is divided by longitudinal and transverse timbers into pockets about 7 feet square, which are filled with stone. The pivot pier occupies a rectangular space 63 feet long and 37 feet wide, each side of which the faces of the crib are continued across the open pocket with horizontal timber trusses 63 feet long and about 7 feet deep. In each end of the crib there is also an open pocket about 21 feet square.

The trusses were built without any adjustable members by which the vertical or horizontal alignment could be perfected after the erection was complete. It was therefore necessary to take unusual pains in assembling the superstructure in order to secure proper bearings and clearances throughout. After the trusses were assembled on the falsework and before any field rivets were driven, the four vertical posts for the central tower were verified for verticality and exact position, instrument readings were taken on the outer ends of the trusses, and they were set with great accuracy and blocked up at intermediate panel points, so as to be at exactly the same level and in perfect vertical and horizontal alignment throughout. The field rivets in the floorbeam and girder connections and in the trusses were then driven, with the exception of those in the adjustment joints of the lower chord. These joints were located just outside the foot of each vertical tower post, and were first assembled with a ¾-inch bolt in each hole.

The bridge was built by the Department of Bridges of New York City, Mr. S. R. Probasco, chief engineer; Prof. W. H. Burr, consulting engineer, who designed both substructure and superstructure. Mr. J. S. Theban was resident engineer. Messrs. Stevens & O'Rourke, succeeded by John F. O'Rourke, were the general contractors and built the substructure, the superstructure being built by the King Bridge Company.



City Island Bridge, New York, Showing Swing-Span Truss.

Water Service at the Baltimore Fire.

Extracts from a paper before the American Water Works Association, by Alfred M. Quick, Water Engineer, Baltimore, Md.

There are three points on which experience connected with the fire of Feb. 7 and 8 suggest something valuable, or at least interesting, to water-works officials: (1) As to the adequacy of any water service to successfully cope with such on emergency. (2) As to the effectiveness of private fire service fixtures in protecting property. (3) As to the possibility of the waste from broken water pipes in buildings destroyed by fire temporarily crippling the water service. [The readers of The Engineering Record were given a general account of the fire and detailed descriptions of many of its features, and in the issue of February 20 there was reproduced a map prepared from official plans. Consequently, this part of the paper may be omitted.]

Baltimore's water supply is derived from two rivers, Jones Falls and the Gunpowder River. From each of the two impounding reservoirs, tunnels convey the water to two clear-water storage reservoirs in the city. The minimum average daily flow of the two sources of supply is about 120,000,000 gallons. The total capacity of the two impounding reservoirs is about 910,000,000 gallons. The delivering capacity of the two tunnels conveying the water to the city is about 200,000,000 gallons a day under the minimum head. The total available capacity of the four storage reservoirs is about 1,240,000,000 gallons. The average daily consumption is about 63,000,000 gallons. For distribution purposes the city is divided into four service areas, designated as low, middle, high, and upper. The low service area, from tide water up to elevation 50, comprising most of the business and manufacturing districts, is supplied from the two Gunpowder storage reservoirs, having an elevation of 163 and a combined capacity of about 760,000,000 gallons, by gravity through two 40-inch main feeds. The middle service area, between elevations 50 and 100, comprising business and residence sections in about equal proportions, is supplied from the two Jones Falls storage reservoirs, having an elevation of 217 and a combined capacity of about 479,000,000 gallons, by gravity through one 40 and two 30-inch main feeds. The high service area, between elevations 100 and 250, entirely a residence section, is supplied by two pumping stations, taking suction from one of the low service storage reservoirs. The east side station, with two 10,000,000-gallon pumps, pumping through the distribution system to a 36,000,000-gallon reservoir at elevation 340. The west side station with two 17,500,000-gallon pumps, pumping through the distribution system to a 22,500,000-gallon reservoir at elevation 348. The upper service area, from elevation 250 to the highest elevation in the city (about 460), is supplied from a pumping station taking suction from one of the middle service reservoirs, with two 4,000,000-gallon pumps, pumping through the distribution system, one to an east side 200,000-gallon standpipe with a high water elevation of 450, and the other to a west side 330,000-gallon standpipe with a high water elevation of 550. There are also connections at both high service pumping stations to the middle service distribution system to sustain the middle service in dry seasons when the flow of Jones Falls is insufficient to keep up the supply.

About seven years ago our distribution system was extremely defective and inadequate. At that time a general plan of improvements was entered upon, involving the laying of miles of additional large mains all over the city, cutting out of service old small pipes that were choked with sediment and corrosion, connecting up dead ends and mains at street intersections, transferring hydrants from old small mains to large mains and increasing pressures generally all over the city by floating the upper, high and middle service down into the higher sections of the high, middle and low service areas. These improvements were planned to give a pressure of not less than 40 pounds at any point, with the maximum domestic consumption drawing, and to allow at least 10,000 gallons a minute to be concentrated for fire service on any block in the closely built up section of the city, without a serious reduction of pressure. This work was practically completed last year and pressures taken all over the city indicate that the desired result has been accomplished so far as the supply for domestic service is concerned.

City Island Bridge, Showing Combined Truss and Girder Span.

With the improvements the distribution system in the burned district was in fairly good shape. The extreme northwestern end of the district is in the middle service area, with 10-inch mains in nearly all of the main streets and these supplied from a 40-inch main running directly from the largest middle service reservoir to a point on Lombard Street about three or four blocks west of the burned district. The rest of the district is in the low service area, with a 40-inch main running through its very center from east to west, feeding directly from the two large low service reservoirs. In that section are also 10-inch mains in Pratt and Lombard Streets, a double line of 10-inch in Baltimore Street, and 10-inch mains also in a number of the north and south streets, all inter-connected. Also in that section is a 12-inch middle service special fire line, making a loop through its center, running down Saint Paul Street, to Light, to German, to South, to Water, to Frederick, and up Frederick Street. In the whole of the burned district are about 130 hydrants, including five with two steamer nozzles, making about fourteen to each mile of main street in the district. There are eleven hydrants within 200 feet of the location of the Hurst building where the fire started, and twenty-two within 400 feet of the building.

The fire started in the middle service area, where the normal pressure is from 55 to 65 pounds. About three hours after the fire started, as soon as it was evident that it had developed into a conflagration, we opened the connection to the middle service distribution system at one of our high service pumping stations, to which I have referred, and by that means increased the pressure in the middle service section of the burned district to 70 or 80 pounds. After the fire had burned out of the middle service district into the low service we opened a 12-inch division stop between the two services, and at intervals thereafter we opened another 12-inch and a 20-inch division stop, at the same time keeping open the connection to the middle service at the pumping station, so as to sustain the pressure in that service. The normal pressure in the low service section of the burned district is from 40 to 55 pounds. The opening of these division stops from the middle service did not increase that pressure because by that time the draught for engine service was at the maximum, and the waste through broken service pipes in the burned buildings had become very great; but it did serve to hold the pressure up to the normal all over the low service district where fire engines were stationed. As the fire progressed employes of the water department went to all fire engines in service at fire hydrants to note the pressure and see if they were getting enough water. At no point was there any complaint of slack supply. If there had been we were prepared to open the middle service to the low at many other points, and, if necessary, to run either one or both of our reserve 10,000,000 and 17,500,000-gallon pumps at the high service stations directly into the middle service system.

We have Venturi meters on all of the five mains leading from the middle and low service reservoirs to the distribution system. Regular weekly readings are taken from these meters every Saturday afternoon. Consequently we know exactly what the excess of consumption was for week of the fire. It was, in round figures, 170,000,000 gallons. We estimate that for the two days of the fire the total consumption of water in the city was about 230,000,000 gallons. With this largely increased consumption and with the outlet gates from our impounding reservoirs remaining as fixed to deliver only the ordinary domestic consumption, our storage reservoirs in the city, which have from 20 to 25 feet available depth, were drawn down only by from 2 to 2½ feet. Even this slight reduction of head could have been prevented, if we had deemed it necessary, by simply opening wider the gates at the impounding reservoirs.

As with an adequate water supply for a fire-engine service, the fire was not stopped until it had practically burned itself out at the water's edge, we are up to the question as to the adequacy of any water service to successfully cope with such an emergency. Certain questions naturally suggest themselves, such as:

Was there a sufficiency of fire apparatus? During the first few hours of the fire, only our own fire department force and apparatus were available for work. There are 438 men, 25 fire-engines, one fire-boat, a water-tower, 11 hook and ladder trucks, some of which have hose and chemical tanks, and 3 chemical wagons. The 25 fire-engines have a combined capacity of about 19,000 gallons a minute. As the hook and ladder and chemical companies took care of all fires in outlying districts, all of the fire-engine companies were available for fighting the main fire. These engines, of course, were not all pumping continuously. It is estimated by the fire department that the average conditions amounted to about two continuous fire streams to each engine, which would make 50 fire streams in constant service. In about three hours after the fire started the first outside fire company was in service, and from that time on other outside companies arrived and got into service very rapidly. By the time the fire was at its height with a maximum front of not over five blocks, the fire fighting force and equipment was augmented to 1,073 men, with 57 fire-engines and 2 fire-boats, having a total capacity of over 50,000 gallons a minute keeping in continuous service over 100 fire streams.

Were the firemen efficient and under intelligent supervision? As to the efficiency of the firemen and apparatus there can be no question. Baltimore's fire department has a well deserved reputation throughout the country for fearlessness and intelligent and effective fire fighting. All of its equipment is first-class in every particular and is kept in perfect condition. Certainly no one who witnessed the work of the companies from other cities could question for a moment their efficiency. As to the management of the men and apparatus there can also be no question. Although our veteran chief was disabled shortly after the fire began, there were in command at various points six experienced district engineers from our own department, in addition to several experienced chiefs or assistant chiefs from other cities.

Would the work of these men have been any more effective in stopping the fire with an independent high pressure fire service system? Assuming such a system to have been installed in Baltimore, completely covering the burned district and embodying all of the most desirable features, the greatest advantages that could have been claimed for it, compared with what our ordinary water supply system offered, it seems to me, would be, that more streams of a somewhat larger diameter and at a somewhat higher pressure would have been available for concentration at any one point, that these streams could have been more quickly brought into play, and that the same force of firemen could have covered a greater area or handled more streams at any one point. In an emergency of such magnitude, involving so many elements of uncertainty, one hesitates to venture a positive opinion as to what would have resulted with a different system or a different method of procedure. Nevertheless, I believe that it is extremely doubtful, in view of the peculiar conditions under which the fire originated and spread, if an independent high-pressure fire service system would have enabled the firemen to stop the fire before it could burn itself out.

The peculiar conditions are as follows: The fire started in the heart of the wholesale business section on Sunday, in the middle of the day, a condition favorable to its gaining considerable headway before discovery. It originated in a building having large floor area with no fire walls, large area of window openings, no automatic fire service, and filled with inflammable materials; a condition favorable to the explosion that caused the building to collapse and scatter flaming debris all over the adjoining property before any fire apparatus could be brought into play. The building was on the northeast corner of a block and consequently the high buildings on the three opposite corners were all directly exposed to its flames, driven by a wind blowing about 12 miles an hour from the southwest; thus in a very few minutes the fire was communicated to three other blocks. Only a few minutes after the explosion of the building where the fire originated, an iron safe full of gunpowder, on the sidewalk in front of a hardware store, directly opposite the Hurst building, on Hopkins Place, exploded with such force as to shatter nearly all the windows in the neighborhood, thus giving the flames an immediate opening into several buildings. The result was that six or more buildings in four different blocks were on fire before any fire apparatus could be brought into effective play, and the flames spread so rapidly that one fire-engine had to be abandoned in the street where the fire started.

Inside of an hour from the start, the wind increased in velocity to about 20 miles an hour, and in three or four hours, before the first outside company was in position to aid our firemen, the fire covered an area about three blocks long and two blocks wide. From noon on Sunday until the fire was over the wind held a velocity of from 15 to 25 miles an hour, with a maximum velocity for short periods of 30 miles an hour.

All Sunday night and Monday morning it frequently occurred that, in attempting to use hydrants a block ahead of the main fire and in line with the wind-driven flames, the firemen and horses would be singed by the heat before they could attach the hose, and would have to move; and at various times single buildings were on fire several blocks ahead of the main body of flame.

Under such conditions one cannot but believe that such advantages as an independent high pressure fire system would have offered would have made very little, if any, difference, either in the rate of progress or the extent of the fire. In stating this conclusion, I wish to emphasize that I have a full appreciation of the value of such a system. I believe that in the great majority of cases, with proper provisions, it would be much more effective than the fire-engine service, and I am frank to say that I believe it would be very much to our advantage to have such a system in Baltimore.

As to the effectiveness of private fire services in protecting property, we have in Baltimore, as there are in all large cities, about every kind of private fire service fixtures, connections and private hydrant lines. We have also nearly every variety of fire service connection from our mains, except that we have no connections used exclusively for fire service that are metered. In the burned district the great majority of fire services were a tap off from the main meter supply to a standpipe of 2 inches or smaller diameter. There were a few buildings having larger standpipes. Nearly all of the larger stores and factories and the tall office buildings had fire pumps and tanks. About half a dozen stores and factories had inside sprinkler systems, and several buildings had outside hose connections. There were no properties with private fire hydrant lines, and none with outside sprinkler systems. In a number of buildings that were burned hose connected to standpipes was used to play on the roofs and walls of adjoining buildings with the sole effect of preventing flaming brands from setting them on fire before the main body of flame reached them.

The notable instances of the effectiveness of private fire services in preventing destruction of property were at buildings on the immediate margin of the burned district. Only a few of the cases given by Mr. Quick can be included in these extracts.

The Lloyd L. Jackson building is a large eight-story warehouse, located on the southeast corner of Lombard and Liberty Streets, on the extreme southwest margin of the burned district. It has a 10-inch fire service connection from a 10-inch main in Lombard Street, supplying the following fire service fixtures: a Grinnell wet-pipe sprinkler system with 4,094 heads; an outside dry-pipe sprinkler system on the east and south sides with 78 heads; a 750-gallon fire pump with three 2½-inch hose outlets on the discharge; three tanks on the roof holding 7,000 gallons each, and two outside Siamese connections for fire engines. As the fire approached this building from the north, employes started the fire pump, forcing water up to the tanks until they overflowed on to the roof, and kept it up until the roof was flooded and the water overflowed the cornice on the exposed north side of the building, thus forming a water curtain which effectually kept the flames from getting a foothold on the cornice or in the windows of the upper floors. A hose pipe was also attached to one of the 2½-inch discharge outlets from the fire pump and run up over the roof to the exposed side of the building, from which a stream was played on the Jackson building itself, on the building across the street, which burned, and on the building adjoining the Jackson building on the east, which was saved. The only damage to the Jackson building was the slight charring of a few window frames and the cracking of some glass on the exposed north side. While it is true that a fire-engine helped to protect the lower floors by playing continuously on the north side, and that the wind was in a direction to blow the flames away from the building, yet there is no question but that this building would have been destroyed if it had not been for the work of the private fire service.

The Baltimore Bargain House is a group of seven four and five-story buildings on the north side of Baltimore Street just west of Liberty Street, next to a lower four-story building on the northwest corner. It was exposed not only to the flames from the lower building, which was partially burned, but also to the showers of sparks and flaming brands from the mass of burning buildings to the south and southeast. These buildings had then two 6-inch fire service connections from a 10-inch main in Garrett Alley in the rear, supplying the following fixtures: a Grinnell wet-pipe sprinkler system with 2,291 heads; two 15,000-gallon roof tanks; a 2½-inch standpipe with a 2½-inch hose outlet on each floor, and two outside Siamese hose connections. Shortly after the fire started, employes of this firm ran a line of hose from one of the standpipe outlets on the top floor to the roof and played continuously on the roofs of these buildings and on the lower four-story building on the corner. By this means they not only saved the Bargain House buildings, but also helped to save the four-story corner building from complete destruction. The only damage to any of the Bargain House buildings was the cracking of some of the most easterly show windows from the heat.

Oppenheim, Obendorf & Company have two large five and six-story buildings on the north side of Fayette Street just west of Charles, at the extreme northwest angle of the burned district. These buildings were exposed to flames from a burning building across the street and one adjoining on the east, and also to showers of sparks from the burning blocks to the south. This property has a 6-inch fire service connection from a 10-inch main in Fayette Street, supplying the following fire service fixtures: a manufacturer's wet-pipe sprinkler system with 1,406 heads; two 4-inch and two 6-inch standpipes with 24 ½-inch hose outlets; two roof tanks, one of 8,000 and one of 10,000 gallons capacity, one tank in the cellar of 28,000 gallons capacity; one Underwriter fire pump with a capacity of 500 gallons a minute, and four outside Siamese hose connections. Soon after the fire started, when sparks began to fall in the vicinity of these buildings, employes started the fire pump, two lines of hose pipe were connected to outlets on the roof supplied from the pump, and two other lines of hose were attached on one of the upper floors to outlets on another standpipe, taking supply direct from the city main. Streams from these four lines of hose were played all over the exposed portions of these buildings and on buildings immediately adjoining and across the street. As the main body of flame drew nearer the tanks were pumped to overflow on to the roofs until water overflowed the roofs at the cornices, forming a water curtain on the exposed sides. When the building adjoining these on the east burned, the flames broke through some doors and windows on the lower floor of one of these buildings and started a few of the sprinkler heads. The water from these sprinklers soon put out the flames. This was the only damage done to these buildings. It is true that all of the numerous windows on the east side walls were protected by fire shutters, but very little, if any, water was thrown on the buildings from fire-engines.

O'Neill & Company have two buildings at the southwest corner of Charles and Lexington Streets, one old four-story building on the corner and a new six-story building adjoining on the south. These buildings were more severely attacked than any others of those I am considering, being directly in the path of the wind-driven flames and exposed to burning buildings adjoining on the south and southwest and across Charles Street on the east. They have an 8-inch fire service connection from a 10-inch main in Lexington Street, supplying the following fire service fixtures: an inside Grinnell wet-pipe sprinkler system with 955 heads; a 15,000-gallon tank on the roof, an outside sprinkler system on the west side with spray heads over each of the eighty-six windows on that side, and two outside Siamese hose connections. When the fire approached the vicinity of these buildings, employes of this firm opened the supply to the outside sprinkler system. Fortunately this property was efficiently protected from the flames on the south side by having on that side a blank fire wall of brick laid in cement. A fire-engine company helped to protect the exposed front of these buildings, but the fire attacked the cornice of the six-story building and ate its way into the roof, where it was put out by the automatic action of 9 sprinkler heads located in the space between the roof and the ceiling at the top floor. The outside sprinkler system saved the buildings from any damage whatever in the rear, and the only damage sustained in addition to the burning of the cornice mentioned, was the partial burning of the roof tank and the cracking of some of the show windows. It is generally conceded that the sprinkler system was the main instrument in saving these buildings from destruction, and that if they had burned a great many other buildings in that vicinity would have been destroyed.

The lessons to be drawn from this experience would therefore seem to warrant the conclusion that private fire services are of great mutual advantage to the owners of property, the insurance companies, and the city in general; also that any water department or water company is justified in granting all reasonable requirements of the Underwriters' Association in regard to such services, that the limitations of the water works system will permit.

Some of the experts who have investigated the experiences of this fire have expressed the opinion that the most instructive suggestion which it affords in relation to water service is as to the possibility of waste from broken water pipes in buildings destroyed by fire temporarily crippling the water service. There were, in round numbers, about 1,400 separate buildings destroyed. The great majority of the buildings were small stores and warehouses, having only small service pipes of one inch or less diameter. As to service pipes over one inch in diameter, there were in the burned district, about 40 1½-inch, 40 2-inch, 165 3-inch, 60 4-inch, and 15 6-inch, but no connections over 6 inches in diameter. It is impossible for me to state exactly how many of these supply pipes were broken during the fire as hundreds of them are completely buried by the debris. In attempting to stop the leakage immediately after the fire it was in many cases even impossible to get at the stops on the service pipes at the curbs, on account of the debris from the burned buildings, and consequently we had to shut off the mains in some streets. We do know from observation, however, that hundreds of the small service pipes and nearly all of the large service pipes were broken, except those in the buildings that were saved from destruction, and those in the banks and office buildings where the walls and floors were left standing.

As we had the great majority of the broken services, including nearly all the larger ones, shut off by the end of the week of the fire, the amount of waste after that was comparatively small, and I will therefore only consider the waste for that week. We know from our Venturi meter readings that the total excess of consumption due to the fire for the week from February 7 to 13, inclusive, was in round numbers 170,000,000 gallons. This was the excess consumption over that of the previous week. To obtain the total amount of water used for fire service and wasted through broken service pipes there should be added to this the normal weekly consumption of the burned district, as there was practically no domestic consumption in that district after the fire started. This amount we estimate from meter records to be about 22,000,000 gallons. Consequently the total amount of water used in fighting the fire and wasted through broken service pipes was about 192,000,000 gallons. Subtracting from this the estimated 70,000,000 gallons used for fire service, we have about 122,000,000 gallons wasted through broken service pipes. Of this quantity we estimate that the maximum amount run to waste in any one day of the week, which was, of course, in the first twenty-four hours after the fire, was about 21,000,000 gallons, or about 33 per cent. of our normal daily consumption at that time. This very large amount of waste, in addition to the amount drawn for fire service and for ordinary domestic consumption, did not seriously affect our water service, simply because of our having such a very great excess of storage, pumping and distributing capacity over what the ordinary domestic consumption would require. It did, however, prevent our being able to increase the pressure above the normal in the low service section of the burned district in the later hours of the fire. It also materially reduced the pressure in some sections of the city adjoining the burned district, immediately after the fire was over.

To summarize, therefore, the deductions which, from the viewpoint of a water-works official, I draw from this experience: (1) There are some fires which no water supply system, no matter how adequate it may be, will put out. (2) Private fire services can do very effective work in protecting property and their installation should therefore be encouraged within reasonable limits. (3) Every water supply system should have a liberal excess of storage, pumping, or delivering capacity over the demands for ordinary domestic consumption to prevent the very large increase in draught for fire service and waste from crippling the service in such emergencies.

Round Hill Dam, Spring Brook, Pennsylvania.

By Marshall O. Leighton, U. S. Geological Survey.

Along the heights bordering the valley of the Lackawanna River and in the mountains forming the perimeter of Wyoming Valley, in the State of Pennsylvania, are exceptional sites for the construction of water supply systems. In fact these localities are excellent examples of that class of lands which in the opinion of hydrographic experts should be forever set aside for the raising of timber and the conservation of water. Indeed, they are good for nothing else, as agriculture is practically an impossibility. The soil is both poor and shallow, and a plowed field in this region after a rain has washed the loose earth from the small stones appears like the waste heap from some quarry. Unfortunately, the entire region has been deforested. Save for scrub thicket and immature trees, the hills are bare. The watersheds, therefore, are quick spilling, but they afford, notwithstanding, excellent reservoir catchment areas. Although the locality generally is populous, settlement along the ridges is sparse. Water of exceeding purity is available almost anywhere.

The Round Hill Masonry Dam at Spring Brook, Pa., Showing Spillway, Wing-Wall and Discharge Pipes.

The water supply of Wilkesbarre and other towns and villages in Wyoming Valley is owned by the Spring Brook Water Supply Company. The system is an extensive one, consisting of many parts which were constructed with respect to the various municipalities to be supplied by separate companies, which were afterward consolidated into the present company. Since consolidation, new reservoirs have been constructed, the most recent of which is Round Hill reservoir, situated upon Spring Brook.

Although the construction of Spring Brook reservoir did not involve any unusual engineering difficulties, it possesses some peculiar features. All operations were performed by the water supply company with its own laborers working by the day. The project was planned and executed by Mr. John Lance, engineer of the company. The stone was quarried upon the drainage area and brought to the site by a specially constructed switchback road, which was also the construction of the company. The whole plant is, therefore, of home manufacture, and as it stands the dam is one of the best pieces of masonry construction in northern Pennsylvania. It is of interest to compare the details with reference to time of construction and cost with similar construction under the usual contract methods.

Round Hill reservoir is situated 6 miles from Moosic station, a small settlement on the Delaware & Hudson Railroad. It is 1.5 miles long, 118.7 acres in area, and has a capacity of 1,322,000,000 gallons. The drainage area above the dam is 36 square miles. At the dam the water is 87 feet deep and is raised at the spillway to 1,155.13 feet above sea level. The dam itself, of which two views are shown, is 500 feet long; 280 feet of this is masonry, and the remainder is an earthen embankment with masonry core walls. Two-foot wing walls, shown in the illustration, retain the embankment at its junction with the masonry. On the west end of the masonry the structure enters the rock, which rises there in a precipitous bluff, overtopping the dam crest about 20 feet. The dam foots in the bedrock, which was excavated to a depth of 15 feet below the surface thereof. The height from foundation to capstones is 104 feet.

The cross-section of the dam, shown by the accompanying drawing, is based upon a right-triangle having its base three-fourths of its altitude. The crest is 9 feet thick and the lower edge along the spillway is appropriately curved. Below this on the lower face of the dam is a batter of 9 inches per foot. The determination of stress showed the necessity of a batter of ½ inch per foot on the back face of the dam, commencing 30 feet below the overflow. On the foot of the spillway a curve of 20-foot radius was introduced for the horizontal deflection of falling water. The spillway channel below the dam is heavily paved for about 100 yards with large cut blocks.

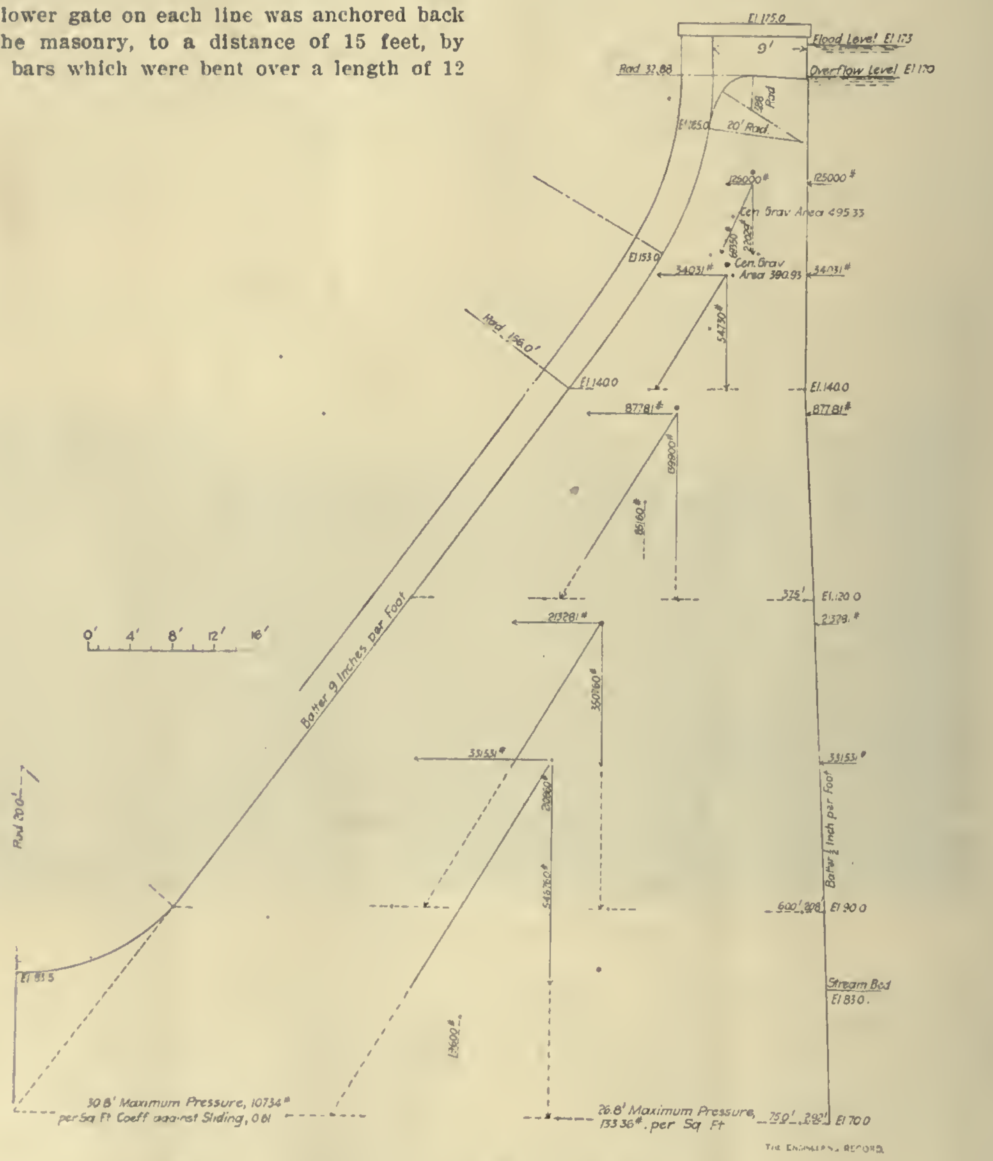
There are 37,710 cubic yards of masonry in the dam; 25,085 barrels of cement were used, which is equivalent to about 1 barrel to 1.26 cubic yards of masonry. The cement mortar was made of Portland cement and sand in proportions by volume of 1 cement to 3 sand; that used for pointing exposed joints and also for filling them was mixed in the proportions of 1 cement to 1 sand. The cements used were Lehigh, Saylor's and Atlas. The stone used in building the dam was Pottsville conglomerate, a tough, gray, heavy stone which dresses roughly, forming an admirable adhering surface for the cement. This conglomerate has a specific gravity of 2.742, and a weight per cubic yard of 165 pounds. The average size of the stones was 0.54 cubic yards, and the largest laid contained 3 cubic yards.

The embankment at the end of the masonry section of the dam rises to a height equal to that of the masonry. Its front and back have slopes of 2½ to 1, and it is paved on the back face to a depth of 18 feet below the spillway crest. The core wall supporting this embankment is 3 feet wide at the top, extending to a height of 3 feet above the spillway. The core is also reinforced by buttresses on its front and back faces, sloping 1 foot in 6.

The discharge pipes are two in number, 30 inches in diameter and 36 inches apart. They were carefully laid on wedges to a true line and a grade of 1 per cent., and then mortar was worked under and around them. When this had set sufficiently the wedges were removed and large blocks of stone of such a height as to reach about 3 inches above the pipes were set on either side and between them, the space between these blocks and the pipes being carefully filled with mortar. Other large blocks having a thickness of at least 15 inches and a length of at least 5½ feet were laid on full beds of mortar across the tops of the pipes, but not resting upon them. Although it was impossible to break joints, the mortar was so worked in about the pipe that no moisture was noticeable at the down-stream face of the dam. Two gates were set on each line below the dam, separated by a piece of pipe 30 inches long, and the lower gate on each line was anchored back to the masonry, to a distance of 15 feet, by iron bars which were bent over a length of 12 inches at the ends. The capacity of these pipes is about 350,000,000 gallons per day.

In the construction of this work it was necessary to lay 2.3 miles of railroad on a graded roadbed of an old lumber road, at a cost of $7,235. A branch from the construction road to the quarry, 2 miles long, erected on a steep side hill, with about 1,500 feet of rock work, cost $4,600, exclusive of rails. Workable stone was obtained with the first shot at the quarry, and thereafter the cost of quarrying was about $1.59 per cubic yard.

The average number of men employed on the construction was 220, and the time occupied was from August 16, 1899, to December 14, 1901, leaving out about 100 days each winter. The total cost of the dam, including everything but the railroad, was $240,547.93. The masonry alone cost $5.98 per cubic yard.

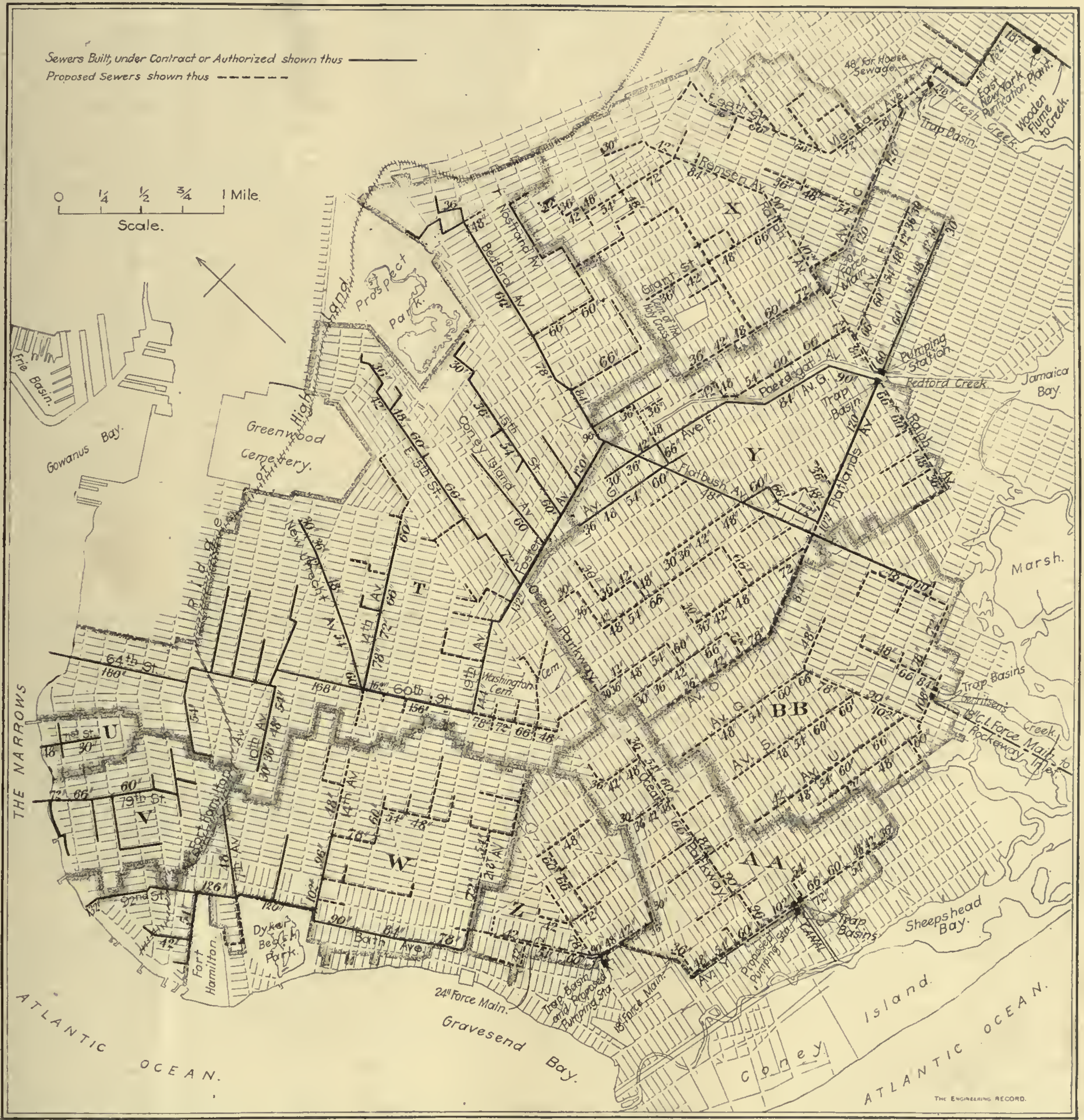


Section of Round Hill Dam at Spring Brook, Pa.

The Scheme of the Extensions of the Brooklyn Sewerage System.

The construction of several of the large new main trunk sewers for the more recently annexed and rapidly developing southerly portions of the Borough of Brooklyn has been described in a number of articles printed in this journal during the past few months and at previous times, and in the article of April 16 a little was said about some of the details of design. The general scheme underlying the design of the systems is so interesting, however, that a statement of it is here presented, based upon the report of the chief engineer.

The accompanying map will help to make clear the relation of the section under consideration to the older part of the borough and to the neighboring bodies of water, the location of the principal divide, frequently spoken of as the "Backbone of Long Island," the general trend of the land surface, the subdivision of the territory into nine sewerage districts designated as maps AA, T, etc., and the main trunk sewers in each district. Sewers already built or under contract are indicated by full lines and proposed sewers by dash lines; none smaller than 30-inch are shown, although laterals have been laid in many streets. The large territory provided for comprises the former towns of Flatbush, New Utrecht, Gravesend and Flatlands, which had been annexed to the city of Brooklyn and with it were incorporated into Greater New York in 1896, being made part of the Borough of Brooklyn. The first two towns named had sewers on the "separate" system.



Map of the Southern Portion of the Borough of Brooklyn, New York City, Showing Extensions of the Trunk Sewer System.

The conditions obtaining in this territory were somewhat peculiar in that the natural locations for the outlets of sewerage systems which might be built along the lines of the natural drainage as determined by the topography were already occupied in such a way that the discharge of sewage at these points would not only constitute a serious nuisance, but would be a menace also to properties of great value, measured by standards both of money and of sentiment. Furthermore, the growth of the borough, for the most part, had spread over the top of the ridge and down the farther side, instead of spreading inland from the shore, as more frequently happens.

The natural drainage of the territory, excepting the relatively small areas on the northerly and westerly slopes of the ridge, is toward Gravesend, Sheepshead and Jamaica bays, and, consequently, toward the attractive beaches and shore resorts of Coney Island and the adjacent portions of Long Island. The old sewerage systems laid down by the towns before their incorporation with the city discharged in these directions and were rapidly creating nuisances which threatened to injure seriously those great natural recreation and fresh-air resorts of the metropolis. To have turned all the sewage this way from the larger systems of sewers required for the southerly part of the rapidly developing borough would speedily have been fatal, it was believed, to these resorts, with the consequent great losses of property values, immediate and indirect, as well as the greater losses to the populace in health and in pleasure.

To avoid these damages, which were believed to be almost inevitable, if not quite so, if the natural courses of drainage were followed, the scheme of sewerage previously proposed for this region had contemplated several large purification plants for the treatment of the house sewage. Experience with existing plants of this kind in other parts of the borough indicated that this remedy would be inadequate and unsatisfactory as well as expensive. Hence it was determined to discover some other solution of the difficulty, if possible.

Careful study of the problem convinced Chief Engineer Asserson that a much more satisfactory solution was practicable, but before outlining this scheme, the execution of which is now progressing successfully, it will be necessary to give a few statements concerning the topography of the territory in order that the scheme may be made more easily intelligible by reference to the map, and to present a few of the other difficulties connected with the natural system of sewerage, as the scheme following the topography may be styled. The Borough of Brooklyn, as now constituted, has an area of 77.6 square miles, occupying the southerly part of the west end of Long Island. The region drained by the sewerage systems under discussion forms the southerly part of the borough, having an area of about 26.1 square miles, a considerable part of it being very flat. The land slopes rapidly for a distance of about a half-mile from the high ground, until an elevation of from 60 to 40 feet above mean high water is attained, and thence gradually toward Gravesend, Sheepshead and Jamaica bays, the natural surface drainage finding its way into numerous creeks. Jamaica Bay is bordered by marshes and is shallow and landlocked. The portion of New York Bay washing the westerly end of Long Island, known as the Narrows, is, on the contrary, deep, and has swift tidal currents; the shore here is a rather bold bluff rising from 20 to 50 feet above the water.

Several difficulties, in addition to those already suggested, would have been encountered in designing and constructing a drainage system in the direction of the natural slopes beginning with trunk sewers of small diameter on the high land and increasing their sizes as they followed the valleys of natural discharge to outlets in the creeks. Both the State and the local board of health would refuse permission to discharge crude sewage into Jamaica Bay or any of its tributaries. To use these natural outlets, therefore, at least five purification plants estimated to cost $1,250,000 for construction, and at least $200,000 per annum for maintenance would have been required. The most thickly settled areas, as indicated in a preceding paragraph, are on or near the high land, and if systems of sewers had been built to meet this peculiarity of development and to discharge into the creeks, it would have been necessary to build immediately long and large outlet mains through unopened streets and unimproved property, at great cost. Besides, the long time required for construction would have delayed the relief to be obtained from the sewers in neighborhoods where it was most needed, and it would have been necessary to levy the assessments over entire districts, bringing burdens upon many who would receive no actual benefit for a long period. Furthermore, careful computations, taking all the conditions into the account, demonstrated that the first cost of draining this territory in the direction of the natural slope entirely would be much greater than that of sewerage in accordance with the scheme adopted.

For the scheme of sewerage adopted the territory was divided into nine maps or districts, of which six have areas of 2 to 8 square miles, the remaining three being much smaller. The prominent features of this scheme are the following of the natural drainage lines as nearly as possible in each district, the driving of two tunnels westward through the ridge to carry the sewage and storm water of two large districts, and, in addition, the house sewage of two small districts into the Narrows, the separating of the house sewage from the storm water of other large districts at trap basins so as to send the sewage to a large existing purification station, the utilizing of substantially all of the pre-existing lateral sewers, and the reaching of the built-up sections of the territory quickly without long stretches of large outfall sewers through undeveloped lands. At several points on these systems of trunk sewers emergency storm-water outlets into bays or creeks can be readily constructed, whenever required in the future, if the quantity of combined sewage should for any reason become greater than predicted.

Taking up the districts individually, the salient points of the methods of sewering each may be briefly stated. Districts U and V, of respectively 164 and 589 acres area, are entirely on the west side of the ridge, bordering on New York Bay, as may be seen by reference to the map. They are, therefore, easily cared for by sewers laid on the natural lines to discharge into the bay. District U discharges through a main 48 inches in diameter at the foot of Seventy-first Street, and V through a main 72 inches in diameter at the foot of Seventy-ninth Street.

District T, of 5,100 acres, and by far the largest of all, was laid out to comprise the section of the borough immediately adjacent to the high ridge over which the growth of the city has spread from the north, as stated previously. This district is thoroughly built up and the demand for adequate sewerage was imperative. The existing small sewers for house drainage only were made a part of the new system and their capacity increased from that of a "separate" system to the capacity necessary to care for a rainfall of 2 inches per hour, by intercepting and tapping them at proper places. In this way at least 98 per cent. of the sewers of the former town of Flatbush, included within the district, have been saved and utilized. The main trunk of this district pierces the westerly ridge by a tunnel 180 inches in diameter at the foot of Sixty-fourth street, where it discharges into the Narrows. The construction of the various parts of this big sewer has been described in this journal under the designations Sixty-fourth Street tunnel, Sixtieth Street sewer, and Foster Avenue sewer.

District W, 1,904 acres in area, is drained by the Ninety-second Street sewer, recently described, which also pierces the western ridge by a tunnel discharging into the Narrows as an 11-foot main. The comparatively high level of Bath Avenue afforded the necessary covering for a large sewer, and so permitted the building of the sewer at an elevation which will make possible the entire drainage of the lands adjacent to Gravesend Bay. The pre-existing small sewers in this district have been preserved and their capacity increased in the same proportion as that mentioned above in connection with the small sewers in district T. The principal new sewers in the four districts thus far described will probably be completed by the end of the current year; much of this work has already been accomplished. In the five districts to be taken up in the succeeding paragraphs, only three of the large sewers are under construction or have been built. The system for each district, however, has been developed, as indicated on the map.

District X comprises 2,174 acres south of, and adjacent to, the "backbone of Long Island," which is to be sewered so as to drain East New York, the sewage proper being diverted to the purification plant there and the storm water turned into the creeks. The existing plant is of sufficient capacity to care for the additional area, and with the construction of the requisite number of new settling tanks, for which the property now owned by the city is of ample size, the house sewage from district Y also can be treated. In all the five districts just described only gravity sewers are contemplated.

District Y, the second largest, contains 3,226 acres and is being sewered to drain to Paerdegat Creek, as shown on the map, where the storm water will be discharged, while the house sewage will be intercepted and pumped to the main in district X, leading to the East New York purification works. The construction of one of the principal trunk sewers of this district, known as the Avenue G sewer, has been fully described, and another large main, known as the Flatlands Avenue sewer, is under construction. These two sewers will discharge at the same point, and at this place a small pumping station will be built when needed to force the house sewage through a 30-inch cast-iron force main about 4,000 feet long into district X.

The surface water from district Z, of 701 acres, will be drained directly into a creek at the head of the proposed Stillwell's Basin, but its house sewage will be intercepted and pumped through a 24-inch cast-iron force main to the main sewer of district W in Bath Avenue, eventually reaching the Narrows. Similarly the mains of district AA, of 1,245 acres, will deliver the storm water into a canal, but the whole dry-weather flow is to be pumped through an 18-inch force main to the pumping station in district Z, which is intended to handle the sewage of these two districts. Storm water from district BB, of 1,570 acres area, will be drained to Garretson's canal, but the dry-weather flow will be intercepted and pumped to a distance of about 6,000 feet, through an 18-inch cast-iron force main, into the swift, flowing tide water which discharges through the Rockaway inlet, leading directly to the ocean. After providing for the nine districts there still remains a small portion of the borough, adjacent to districts on the south, which has not yet been divided into drainage districts. Coney Island and Sheepshead Bay, constituting the greater part of this territory, already have sewers built on the "separate" system which are adequate for the present.

In designing the new system of sewers and determining the sizes of each sewer, a formula was used which is a modification of the one employed by Joseph W. Bazalgette, engineer of the London drainage works in 1857, based upon data obtained twenty years previous to that date, by Hawksley, Prony, Roe and others. This formula is $D=0.1\ (3 \log A + \log N + 6.8)$, in which D is the diameter in inches, A the area drained in acres, and N the distance per foot of fall; it was devised for a rainfall of 1 inch per hour, for which it has proved adequate.

The sewerage system of the former city of Brooklyn, devised by Chief Engineers Kirkwood and Adams, based upon the Adams formula, gave results agreeing closely with Bazalgette's experience, and at all times was sufficient for a 1-inch rainfall, which the data available at the time of design indicated to be a suitable provision. Forty years of observation has proved the smaller sizes, up to about 24 inches in diameter, to have a capacity large enough for a 2-inch rainfall under this formula, while the larger mains were inadequate for this increase. This led the engineers of Brooklyn subsequent to the year 1878, Messrs. Julius W. Adams, Robert Van Buren, Van Brunt Bergen, and Peter Milne, to adopt a modified formula for the main sewers larger than 24 inches in diameter, in order to meet the local climatic conditions.

The modified formula, $D=0.1\ (3 \log A + \log N + 8)$, allowing for a 2-inch rainfall per hour, has been used in the recent designs for sewers down to 30 inches in diameter, while a parabolic curve diagram has been adjusted for the sizes between 30 inches and 12 inches in diameter, thus providing for small sewers between the limits of Bazalgette's results and the results of the formula just stated, thus furnishing a simple and adequate formula based upon forty years of experience and careful study.

The estimated cost of the systems of sewers for the nine districts is given in tabular form herewith. The total cost for all the districts amounts to $13,614,400, which includes the cost of the construction of about 98 miles of brick sewer ranging in size from 180 inches to 30 inches in diameter, the cost of construction of 576 miles of pipe sewers from 24 inches to 12 inches in diameter, a total of 674 miles of sewers; the cost of four pumping stations, and the additional work necessary at the East New York purification works. This estimate was intended to cover the whole territory, on the assumption that the area was fully populated and each sewer absolutely needed.

Many of the structural details of the design, together with interesting features of the methods of construction, have been given in the descriptive articles previously referred to. A very large part of the work has conformed to standard practice and is chiefly noteworthy on account of its extent and the large size of many of the sewers of the various systems. The sewers have all been made large enough to safely carry off a maximum run-off of 2 inches per hour from the tributary areas. The studies and the resulting designs have been the work of Mr. Henry R. Asserson, M. Am. Soc. C. E., chief engineer of sewers for the Borough of Brooklyn. In all this work he has been assisted by Mr. Frank R. Bartlett, who has had charge of the engineering force in the office, and by the various division engineers who have been mentioned in connection with the construction work executed under their direction.

Statement of Estimated Cost.

	District T.	
12,550	lin. ft. 180-in. to 162-in. tunnel brick sewer, manholes included.	$1,130,000
141,350	lin. ft. 156-in. to 30-in. brick sewer, manholes included............	1,550,000
152.12	miles 24-in. to 12-in. pipe sewer..	925,000
8,433	manholes on pipe sewers.........	296,000
2,192	street basins....................	229,000
		$4,130,000
	Engineering and contingencies, 10 per cent.	413,000
	Total	$4,543,000
	District U.	
4,100	lin. ft. 48-in. to 30-in. brick sewer, manholes included............	$18,800
5.54	miles 24-in. to 30-in. pipe sewer..	35,000
308	manholes on pipe sewers.........	11,000
64	street basins	7,000
		$71,800
	Engineering and contingencies, 10 per cent.	7,200
	Total	$79,000
	District V.	
18,050	lin. ft. 72-in. to 30-in. brick sewer, manholes included	$140,000
23.09	miles 24-in. to 12-in. pipe sewer..	138,000
1,225	manholes on pipe sewers.........	43,000
246	street basins..................	25,000
		$346,000
	Engineering and contingencies, 10 per cent.	34,600
	Total	$380,600
	District W.	
7,250	lin. ft. 132-in. to 120-in. tunnel brick sewer, manholes included.	$653,000
51,850	lin. ft. 120-in. to 30-in. brick sewer, manholes included......	529,000
63.32	miles 24-in. to 12-in. pipe sewer..	383,000
3,320	manholes on pipe sewers........	117,000
834	street basins	84,000
		$1,766,000
	Engineering and contingencies, 10 per cent.	176,600
	Total	$1,942,600
	District X.	
70,850	lin. ft. 138-in. to 30-in. brick sewer, manholes included......	$817,000
84.31	miles 24-in. to 12-in. pipe sewer..	507,000
4,415	manholes on pipe sewers........	155,000
973	street basins	98,000
		$1,577,000
	Engineering and contingencies, 10 per cent.	157,700
	Total	$1,734,700
	District Y.	
100,100	lin. ft. 120-in. to 30-in. brick sewer, manholes included......	$1,025,000
115.99	miles 24-in. to 12-in. pipe sewer...	694,000
6,171	manholes on pipe sewers.........	216,000
1,310	street basins	132,000
	Pumping plant and house with appurtenances	90,000
		$2,157,000
	Engineering and contingencies, 10 per cent.	215,700
	Total	$2,372,700
	District Z.	
22,900	lin. ft. 90-in. to 30-in. brick sewer, manholes included	$155,000
24.49	miles 24-in. to 12-in. pipe sewer..	153,000
1,312	manholes on pipe sewers.........	46,000
324	street basins..................	33,000
	Pumping plant and house with appurtenances	80,000
		$467,000
	Engineering and contingencies, 10 per cent.	46,700
	Total	$513,700
	District AA.	
34,900	lin. ft. 102-in. to 30-in. brick sewer, manholes included........	$285,000
47.28	miles 24-in. to 12-in. pipe sewer..	295,000
2,510	manholes on pipe sewers........	88,000
440	street basins	44,000
	Pumping plant and house with appurtenances	55,000
		$767,000
	Engineering and contingencies, 10 per cent.	76,700
	Total	$843,700
	District BB.	
44,500	lin. ft. 108-in. to 30-in. brick sewer, manholes included......	$406,000
59.35	miles 24-in. to 12-in. pipe sewer..	359,000
3,133	manholes on pipe sewer.........	110,000
734	street basins..................	74,000
	Pumping plant and house with appurtenances	55,000
		$1,004,000
	Engineering and contingencies, 10 per cent.	100,400
	Total	$1,104,400
	Increasing pumping plant at East New York, with additional settling tanks for sewage from Districts X and Y........	$100,000

Architectural Competition for the Buildings of the Carnegie Technical Schools, Pittsburg.

An architectural competition of unusual importance both on account of the magnitude of the work for which designs are to be presented and because of the educational interest in the institution for which the buildings are to be erected, is that for the Carnegie Technical Schools, to be established in Pittsburg, Pa. The programme for this competition is a handsomely printed pamphlet of about fifty pages and is accompanied by a map of the site and a block plan. This programme was prepared with great care by Prof. Warren P. Laird, of the University of Pennsylvania, acting as advisor to the committee of the trustees having the matter in charge. Professor Laird will also advise in connection with the making of the awards. A copy of the programme with some additional notes has been received from him, and these furnish the basis for the following brief statement. Every effort has been made by the committee to place this competition upon the highest professional grounds.

The Carnegie Technical Schools will provide a comprehensive system of secondary technical education based on the needs of workers in the industrial field generally. There are at present numerous industrial schools throughout the country organized for work along definite and more or less restricted lines, but a new significance attaches to the organization of the Carnegie schools, for the scheme of instruction is arranged to meet an expressed demand. This was brought about by a thorough canvass of the industrial workers in Pittsburg, and the younger people of both sexes in the public schools from whom the ranks of the workers are to be recruited. These persons were individually asked by the committee to state the particular calling for which they desired to be trained, and upon the basis of some 15,000 replies thus received the courses of instruction now announced have been arranged. These are no fewer than seventy in number, covering practically the entire range of the manufacturing industries of Pittsburg, and thus, presumably, very broadly those of the country at large.

The scheme upon which the work is to be administered was outlined by a commission composed of Messrs. Arthur L. Williston, of the Pratt Institute, Brooklyn; Arthur A. Hamerschlag, of the New York Trade Schools, now the Director of the Carnegie Technical Schools, and C. B. Connelly, of Pittsburg. The problem laid before the architects is that of providing for the instruction, under this scheme, of 4,000 students, including both day and night classes. The programme states in an appendix the general character of the work to be done in designing the buildings for the various schools or departments.

The plot of ground reserved for the schools adjoins Schenley Park and the Carnegie Institute; it is 32 acres in extent, and it is probable that the actual ground area covered by the buildings will lie between 10 and 12 acres. This includes extensions of shops, etc., for which provision must be made in the preliminary design. The total floor area of rooms, exclusive of hallways and other auxiliary spaces, will possibly reach a total of one million square feet. The probable cost of buildings and equipment is not stated in the programme, it being the desire of the committee to secure an architectural scheme suitable for carrying into effect the educational plan of the schools; but it is quite certain that an expenditure of several millions of dollars will be required to construct and equip the buildings called for by the programme.

The trustees of the Carnegie Institute, of Pittsburg, have been empowered to carry the project into effect, and Mr. Carnegie has promised to erect and equip the buildings and to endow the schools. The committee on the Carnegie Technical Schools appointed by the trustees consists of Messrs. William McConway, chairman; John A. Brashear, W. Lucien Scaife, William N. Frew, James J. Booth, John G. Holmes, Charles L. Taylor, John F. Steel and Arthur A. Hamerschlag, director. This committee has been given authority to engage an architect, determine upon a general plan, and proceed with the preparation of working plans and specifications.

Five architects and architectural firms have accepted the invitation of the committee to submit designs in the competition, for which service they will be paid $1,000 each. They are Messrs. Carrere & Hastings, Cass Gilbert, Howells & Stokes, and George B. Post, all of New York, and Messrs. Frank Miles Day & Brother, of Philadelphia. The competition will be open also to all other architects whose experience and capacity in the design and execution of large work may warrant the committee in extending to them an invitation to take part. Architects desiring to enter are therefore requested to provide the committee with information as to their professional work upon blanks to be had from Director Arthur A. Hamerschlag, 313 Sixth avenue, Pittsburg. Five awards of $1,000 each are offered to competitors, other than those who are named above, and will be paid to the five architects whose designs stand highest in merit, one of these five being assured in any event to Allegheny County architects.

Low-Rental Dwellings grouped in three blocks were recently opened in Westminster, London. The buildings, six stories in height, have 793 rooms divided into 342 tenements, which will accommodate about 1,600 persons. The rents, according to the "Architect," range from 73 to 98 cents per week for one room to $2.68 to $2.92 per week for four rooms. The living rooms have an average area of 154 square feet.

The Electrolytic Purification of Oil-Laden Water according to the Davis-Perrett process, to which reference was made recently in these columns, appears to lie in the destruction of the emulsion of the oil and the formation of a flocculent precipitate which can be removed by subsequent filtration. The system is in use in the power house for the Leicester, England, electric tramways.

Tests of Different Steam Turbines.

As noted in the Current News Supplement this week, in the report of the joint meeting in Chicago of the American Society of Mechanical Engineers and the Institution of Mechanical Engineers of Great Britain, four papers were presented on steam turbines. The four were largely descriptive of the De Laval, Westinghouse-Parsons, Curtis, and Rateau turbines, respectively, and all contained more or less extended references to the performance of the respective prime movers. In every case records of tests have already appeared in these columns, but some later data were given in the papers that may be recorded in this connection.

In the paper by Messrs. Lea and Meden a chart was shown of curves drawn from tests of a De Laval two-stage high-pressure steam-turbine pump, designed to lift 250 gallons of water per minute against 700 feet. With a steam pressure of 180 pounds and a vacuum of 25 inches, the low-speed pump wheel ran at 2,050 revolutions per minute and the high-speed wheel at 20,500 revolutions. The tests were conducted by Profs. J. E. Denton and Wm. Kent. It appears that when pumping 250 gallons the head attained was nearly 760 feet, the steam consumption per water horse-power-hour was about 41 pounds and the duty per 1,000 pounds of steam 48,000,000 foot-pounds. At 700 feet head, about 280 gallons were pumped per minute, the steam consumption was 41.5 pounds per water horse-power-hour and the duty 47,500,000 foot-pounds. At 800 feet head, 200 gallons were pumped and the steam consumption was about 41.5 pounds per horse-power-hour.

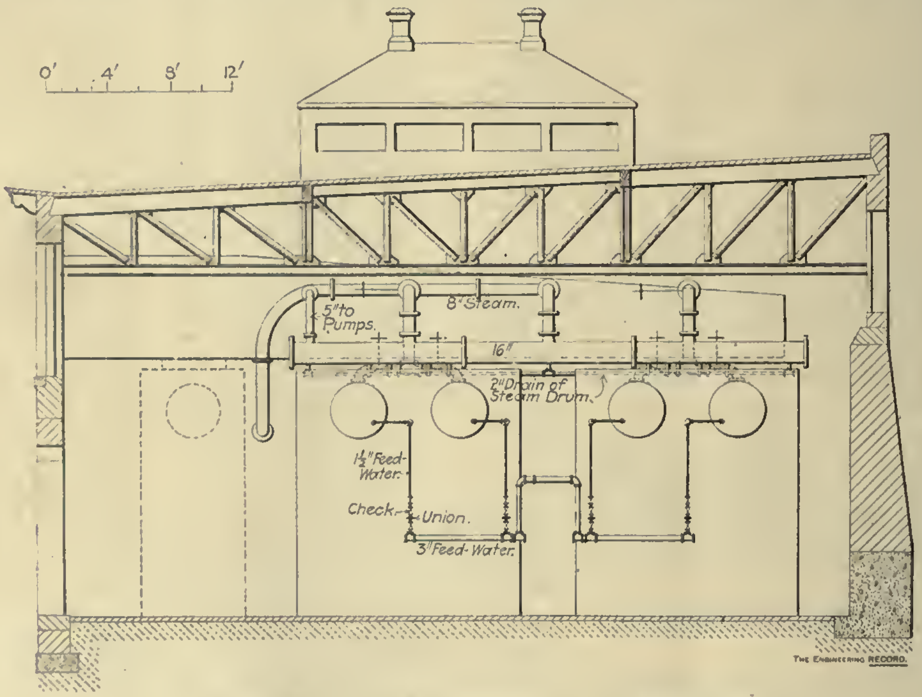
In the contribution by Mr. W. L. R. Emmet, a few figures were given relative to the operation of a 2,000-kilowatt Curtis turbine, embodying some improvements not incorporated in the machines for which records have thus far been available. This machine was temporarily installed in the General Electric Company's power station at Schenectady and operated a 6,600-volt, 25-cycle generator at 750 revolutions per minute. With it is installed a surface condenser of 6,000 square feet of cooling surface. Under a load of 637 kilowatts, a superheat of 215 degrees Fahr., and a vacuum of 28.2 inches, 20.1 pounds of steam were required per kilowatt-hour. Under a load of 1,000 kilowatts, a superheat of 242 degrees, and a vacuum of 28.9 inches, 16.3 pounds of steam were used per kilowatt-hour. Under a load of 2,000 kilowatts, a superheat of 242 degrees, and a vacuum of 28.73 inches, 15.3 pounds of steam sufficed per kilowatt-hour. Under 2,270 kilowatts, a superheat of 250 degrees, and vacuum of 28.1 inches, 16.2 pounds of steam were used per kilowatt-hour. The steam gauge pressure was for the four tests 150, 160, 155 and 100 pounds, respectively.

In the tables of Mr. Francis Hodgkinson's paper figures were given of a number of tests made by Messrs. Dean & Main, of Boston, on a 400-kilowatt Westinghouse-Parsons turbine. The full report of these tests has come to hand and the following information is taken from it. Trials were made with dry saturated steam, with steam at 100 degrees superheat, and with steam at 180 degrees superheat. They plotted curves to show, so far as the range of superheat allowed, what the influence of the degree of superheat was, the curves being for three-fourths, full, and one-and-one-fourth load conditions. The results indicated that the saving of steam is about 1 per cent. for every 10 degrees of superheat within the limits of superheat employed.

The results of the tests may be briefly stated. For the 100 degrees superheat trials with a steam pressure at the throttle of about 153 pounds and a vacuum of 28 inches in the exhaust pipe (referred to 30-inch barometer), the following steam consumption per brake horse-power-hour was obtained: 12.07, 12.41, 12.86, and 14.62 pounds for brake loads of 758.9, 594.6, 445.3, and 239.9 horse-power, respectively. The average actual superheat of the steam was 104, 109, 104 and 87 degrees Fahr., respectively. With 180 degrees superheat and about the same initial and terminal pressures as above, 11.17 pounds of steam were consumed per brake horse-power with a load of 762.6 horse-power, and 11.45 pounds of steam with a load of 592.3 horse-power. The superheats were actually 182 and 181 degrees in the two cases. Tests with dry, saturated steam and 28 inches of vacuum gave the following results: With a load of 728.4 horse-power, the water rate was 13.63; 593.2 horse-power, 13.91 pounds; 448 horse-power, 14.48 pounds; 241.3 horse-power, 16.06 pounds. With dry steam and 27 inches of vacuum the steam consumption was 14.01 pounds per brake horse-power with a load of 694.8 horse-power, and 14.35 pounds with a load of 593.1 horse-power.

Power Plant of the Whitlock Branch of the American Cigar Company, Richmond.

A power plant that is chiefly interesting from the standpoint of its design—in the proportions of its various parts—drives the factory of the Whitlock branch of the American Cigar Company in Richmond, Va. Some time ago a new building was erected for this establishment and it was decided to drive it by means of alternating-current motors, chiefly because it was felt that induction motors would give the least trouble under the conditions that would obtain. Alternators at 220 volts giving current at 60 cycles were determined on as being a character of supply that would prove satisfactory both for lighting purposes as well as power. While this pressure would serve for lighting and some power, it was decided to employ motors of a higher potential and the use of alternating current allowed for raising the voltage by means of transformers Besides heating, which is arranged for by means of a fan system, the plant had to provide elevator service and furnish refrigeration. It was located at the rear of the building in a single-story structure, and space was provided for three generating units of 150 kilowatts each.



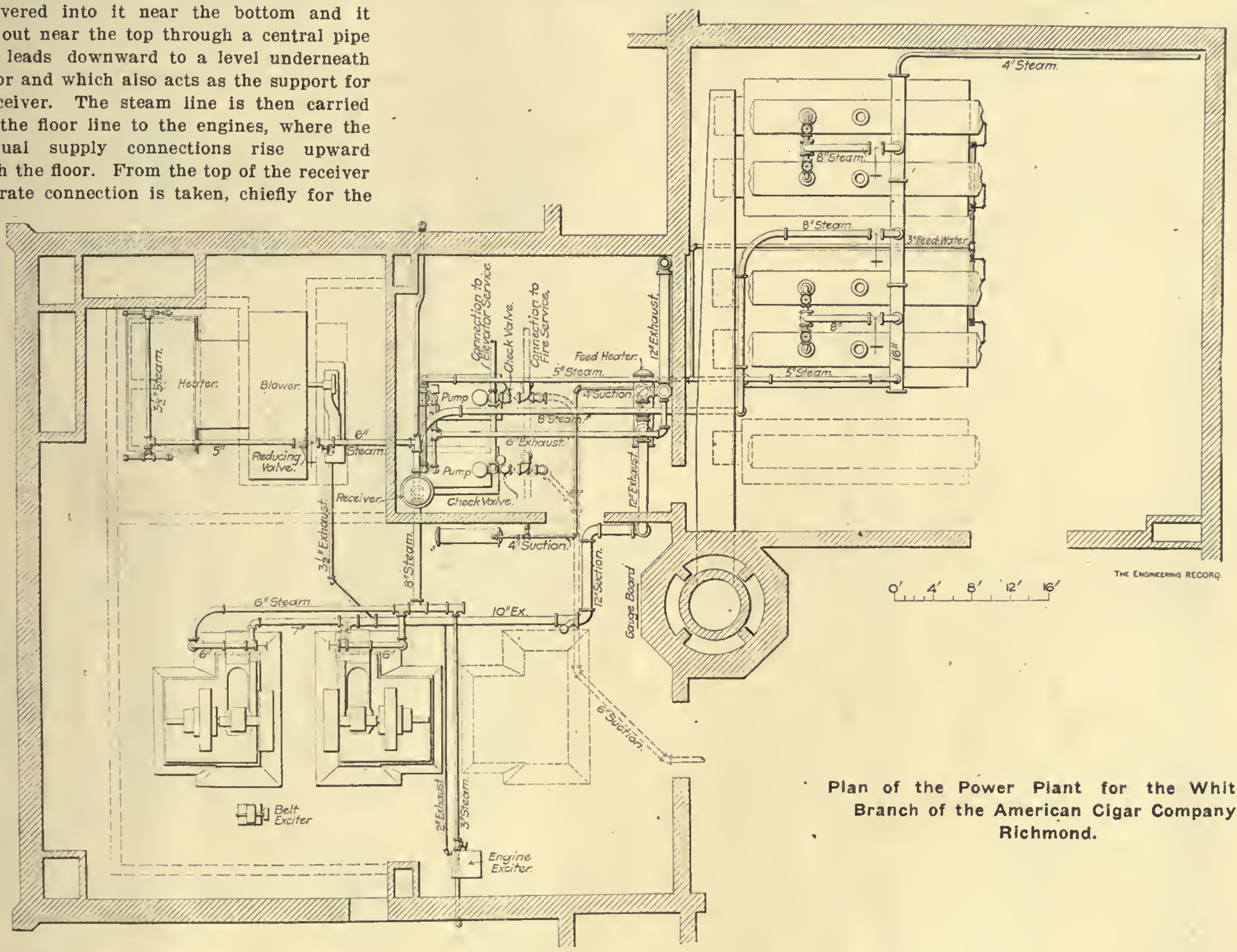
Longitudinal Sectional Elevation of Boiler Room.

The accompanying illustrations show the general characteristics of the plant. The boiler and engine rooms had to be placed diagonally with respect to each other, so that the length of steam piping is necessarily long. Immediately back of the boiler room and partitioned off from both this and the engine room, is a space into which most of the pumping equipment and feed-heating apparatus is placed. Back of this, but open with the engine room, so that it is readily accessible to the attendant in charge of the engines, is the heating unit. The rooms are all on the same level and in close communication with one another. The engine-room floor is supported above an excavation left around the machinery foundations and is constructed of expanded metal with a terrazzo finished upper surface. The walls of the engine room are of white enamel brick, the under side of the roof, which contains a large amount of glass surface, is, together with the supporting roof trusses, painted buff, and the piping in the room and the engine frames are a dark green. The windows between the engine room and the main building are wired glass in metal sash. Altogether the engine room makes a very agreeable appearance. The floor in the boiler room is of brick laid on edge, the wall and the under side of the timber roof are painted white, with buff-colored trusses. Over it there are two monitors protected with wired glass.

There are at present installed two batteries of two Babcock & Wilcox boilers, each containing 72 tubes 4 inches in diameter and 18 feet long, placed eight wide and nine high, and one steam drum, 42 inches in diameter and 23 feet 3⅝ inches long. There is space for a fifth boiler, as indicated on the plan. They are hand fired and the coal is dumped on the floor in front of them, the space between the boiler fronts and the outside wall of the boiler room being about 24 feet. They are served by a brick chimney 150 feet high from the base to the top and 5 feet 8¾ inches in inside diameter. This has an octagonal base, changing to a circular shaft for the greater of its height. A steam pressure of 120 pounds per square inch is normally carried.

The boilers are connected into the steam header in pairs. It will be noted that while the steam pipe from each pair is 8 inches in diameter, the header is made up of 16-inch pipes. This affords a reservoir for the steam and allows for draining such water as may be carried over from the boilers, by the reduction of the velocity of flow, so that the pipe leading from the header to the engine room is thereby less liable to carry away any water. The steam connections to and from the header are connected into it, in the usual way, at the top, and there are virtually two valves in the connection of each boiler, one being at the nozzle over the steam drum and the other at the header. The header itself is without any valves.

The steam supply to the engine room is 8 inches in diameter, while a separate connection is carried from the header for the pumps. The height of the boiler room is greater than that in the engine room, and the steam line is dropped a few feet in transit, and before delivering to the engines, is connected into a receiver. This receiver is supported overhead in the pump room about 10 feet above the floor line and is 3 feet in diameter and 5½ feet high. The steam is delivered into it near the bottom and it passes out near the top through a central pipe which leads downward to a level underneath the floor and which also acts as the support for the receiver. The steam line is then carried under the floor line to the engines, where the individual supply connections rise upward through the floor. From the top of the receiver a separate connection is taken, chiefly for the engine which is installed for driving the fan of the heating system. Besides the main units there is a steam-driven exciter in the engine room. Each of the main units, of which two are now in place, comprise a 17x16-inch Ball & Wood simple engine and a Westinghouse generator, giving two-phase current at 220 volts at its normal speed of 240 revolutions per minute. The steam-driven exciter consists of a 7x6-inch engine built by the W. D. Forbes Company, of Hoboken, N. J., and a 125-volt 11½-kilowatt Westinghouse direct-current dynamo. There is also a 10-kilowatt belt-driven exciter operated from one of the units. For the motors there are two transformers, each of 75 kilowatts capacity.



Plan of the Power Plant for the Whitlock Branch of the American Cigar Company, Richmond.

The run of the exhaust piping, which is also carried underneath the floor in the engine room, is indicated in the drawings. The exhaust main enters the pump room above floor level, and at the partition wall between the pump room and the boiler room is located the feed-water heater supported above the boiler feed pump. The exhaust can bypass the heater, and beyond the main is carried through the roof as an outboard exhaust. Beyond the feed-heater connections, the exhaust pipe of the pumps is connected into the main line, as the pumps are designed partly for fire service. The feed-water heater is of the Wainwright type with corrugated tubes and is rated at 600 horse-power. The boiler feed pump is of the Dean duplex pattern, with 7x4x10-inch cylinder sizes.

The other pumps comprise a duplicate set of underwriter fire pumps, to be operated interchangeably and as relays on the elevator system and for use in case of fire. There is also a 7½x1¾x6-inch Worthington pump operated in connection with a horizontal accumulator for a 1,000-pound hydraulic system required in the factory. There are four elevators, installed by Messrs. Morse, Williams & Company, operated from 8 to 1 ratio cylinders. Two of the elevators are designed for a load of 2 tons at 100 feet per minute, a third for a load of 2½ tons at 100 feet per minute, and the fourth for 3 tons at 80 feet per minute. A single tank of 60,000 gallons capacity is connected to the system.

The heating season in Richmond is, of course, a comparatively limited one, and for simplicity of connections, arrangements were made only for supplying live steam to the blast coils of the fan system. Beyond the live steam connection to the fan engine, a pressure-reducing valve is inserted in the steam pipe for delivering low-pressure steam to the pipe coils. These are arranged in double sections, so that the steam supplies are carried to both sides of the heater casing, and there are, all told, 16 sections of heating surface. The fan is a three-quarter housing centrifugal blower with a blast wheel 12 feet in diameter by 6 feet wide, and depended on to heat the building to 70 degrees Fahrenheit when the outside temperature stands at 10 degrees below zero. The engine and fan were both furnished by the B. F. Sturtevant Company, and the fan engine is 11½x16 inches in cylinder size and of the horizontal, side-crank type. The unit is arranged to run at 200 revolutions, if necessary. The water of condensation is returned to a tank in the boiler room, and is delivered to the boilers by means of a 6x4x6-inch Deane pump. Clean high-pressure drips are returned by the Holly system.

The switchboard in the engine room is one of five panels. There is one panel for each generator, each having a double-throw four-pole switch, the generator giving two-phase current, it will be remembered, two ammeters, two plug switches and two two-pole double-throw field switches with the rheostat wheel. Another panel is given over to the exciters with two ammeters and one voltmeter and two three-pole single-throw switches, so that the two may be operated together, having an equalizer connection. The two remaining panels are for the feeders, and each of them has two four-pole double-throw switches, as there are two sets of busses. So far as the power is concerned, group driving is generally in vogue. There are fifteen motors of 7½ horse-power, six of 20 horse-power, and six of 10 horse-power.

The factory itself is of mill construcion, with brick walls, cast-iron columns, main girders of I-beams, and the others of large size timber attached by angle plates to the webs of the I-beams. The walls are painted red for a distance of 6 feet above the floor, and white on the upper parts and the ceiling. Automatic sprinklers are provided, electric wires are wired on the open system to porcelain cleats, and the motors are mainly hung from the ceilings. The power equipment, it may be added, also includes a De la Vergne refrigerating plant of

10 tons capacity, for cooling the filtered water for drinking purposes. It is operated from a 10x7½x16-inch horizontal compressor for the direct expansion of ammonia.

The entire mill, including the power plant, was designed by Messrs. Lockwood, Greene & Company, of Boston. The plant is in charge of Mr. J. H. Robb, engineer for the American Cigar Company.

The New York Times Building.

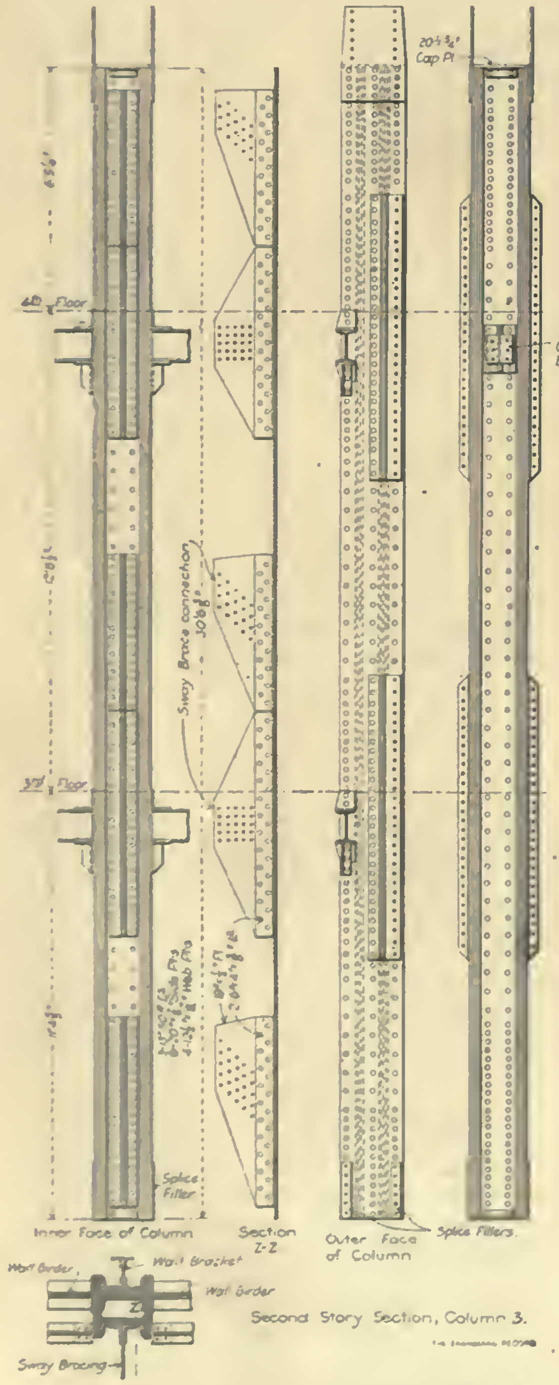
Part V.—Columns and Wind Bracing.

There are in the Times building three main groups of columns. One group contains thirteen columns reaching continuously from the press-room floor to the roof of the twenty-third story, the six upper stories forming the main part of the tower framework. The upper sections of these columns are proportioned for stresses of 4,400 to 196,600 pounds, but have a uniform cross-sectional area of 23.5 square inches, made up with two 12-inch channels and two 14x5/16-inch flange cover-plates. The heaviest section is in the lower part of column 13, and has a maximum stress of 2,746,000 pounds, which is provided for with a cross-sectional area of 218.8 square inches, made up with three 13-inch channels, five 12½x⅞-inch web reinforcement plates and six 20x1-inch flange cover-plates.

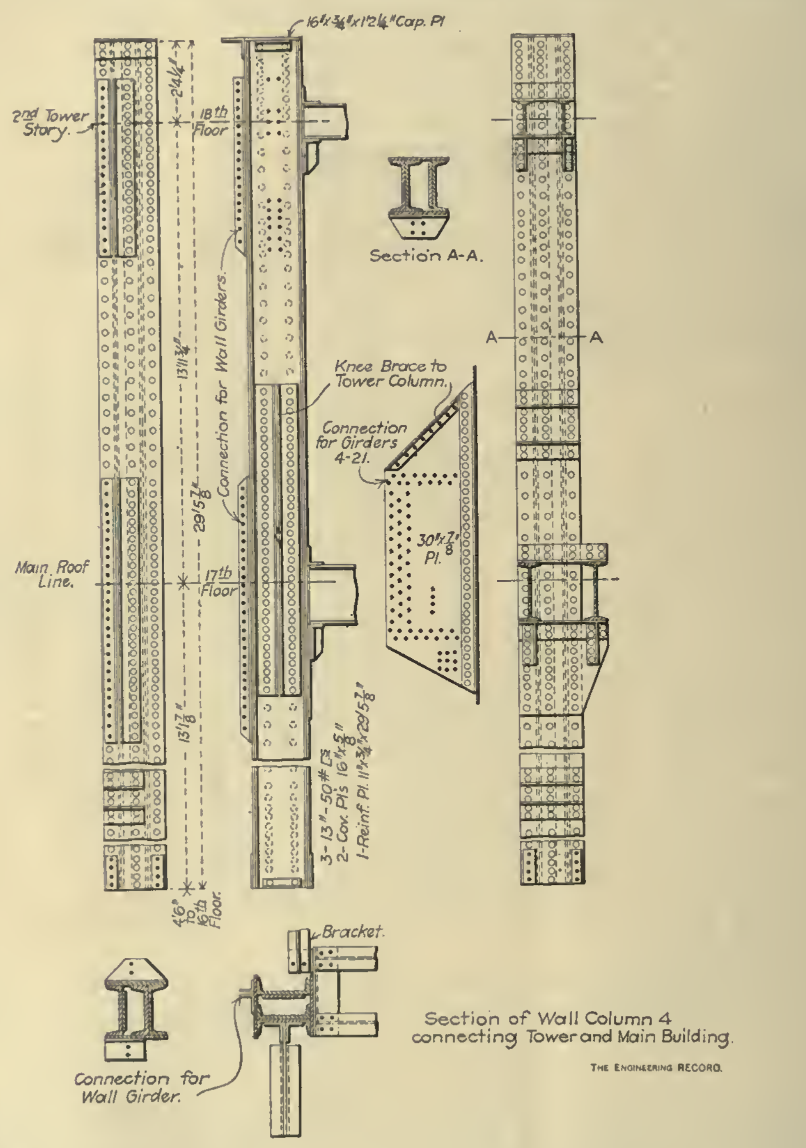
The twelve columns of the second group reach from the first floor to the seventeenth floor, except in five cases, in which they are continuous to the press-room floor. The stresses in the upper sections of these columns vary from 36,200 pounds to 134,360 pounds, and their uniform area of 25.2 square inches is made with two 12-inch channels and two 14x⅜-inch cover-plates. The heaviest section is at the foot of column 21, where the maximum stress is 1,491,400 pounds, and the area of 190 square inches is made with two 13-inch channels, four 12x1-inch web reinforcement plates, and six 20x5/16-inch cover-plates.

In the third group are the seven substructure columns reaching only from the press-room floor to the first floor to support the triple-web girders carrying the superstructure columns over the subway roof. Of this group column K, with a maximum stress of 2,140,900 pounds, has the largest cross-sectional area, namely, 258 square inches, which is made with eight 12-inch 40-pound channels, four 11x⅞-inch web reinforcement plates, and four 42x¾-inch flange cover-plates. Besides these columns, two others, 21-A and 21-B, are seated on the seventeenth-story girder and extend to the roof to carry part of the tower load. They have duplicate cross-sections with an area of 23½ square inches at the top and 51.3 square inches at the bottom, where they are made with three 13-inch 40-pound channels, and two 16x½-inch flange cover-plates.

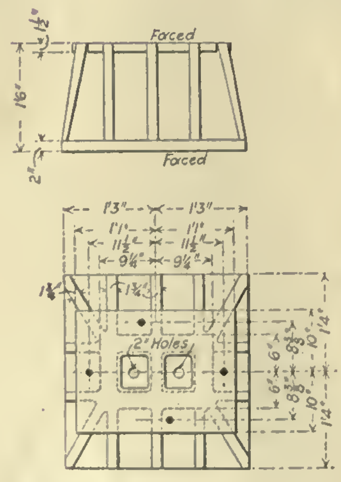
All columns, except those starting at the first floor, which have the first section only one story high, are made throughout in two-story



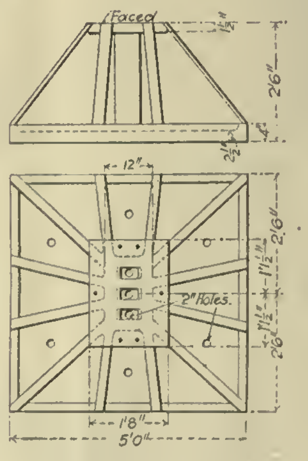
Second Story Section, Column 3.



Section of Wall Column 4 connecting Tower and Main Building.



Cast Steel Pedestal for Column 9.

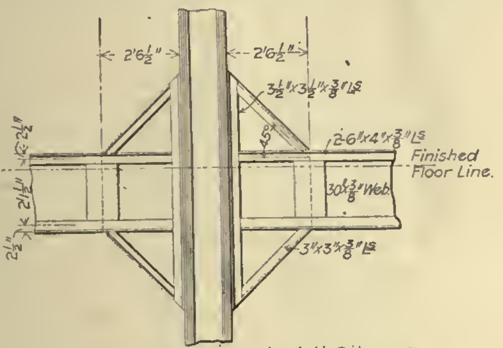


Cast-Steel Column Base.

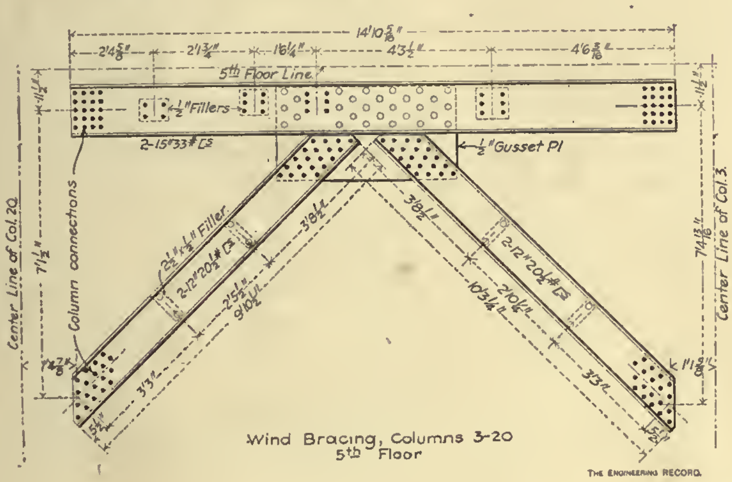
THE TIMES BUILDING, NEW YORK: DETAILS OF COLUMNS AND PEDESTALS.

sections, with their splices uniformly located 6 feet 5¼ inches above the floor lines in the basement, second, fourth, sixth and successive alternate stories. In all except the substructure group, and in one or two special lines, the upper section of each row of columns is made with 12-inch channels and 14-inch plates, which generally give a sectional area in excess of that required by the calculations, but which was adopted for uniformity of construction. In all but the exceptional cases, the next lower section of the column has its dimensions slightly increased by using 13-inch channels and 16-inch cover-plates. These sizes are in all cases maintained throughout the whole of the lower part of the column, so that their external dimensions do not vary, the difference in section being secured by increasing the weights of the channels and the thicknesses or numbers of the web and flange plates. The cross-sections vary in outline only with the different combinations of two or three channels, and the addition of the web and cover-plates, which are arranged either as simple ordinary rectangles or are combined as shown in the views of columns 3 and 4, or as in the substructure columns, which were illustrated on page 683.

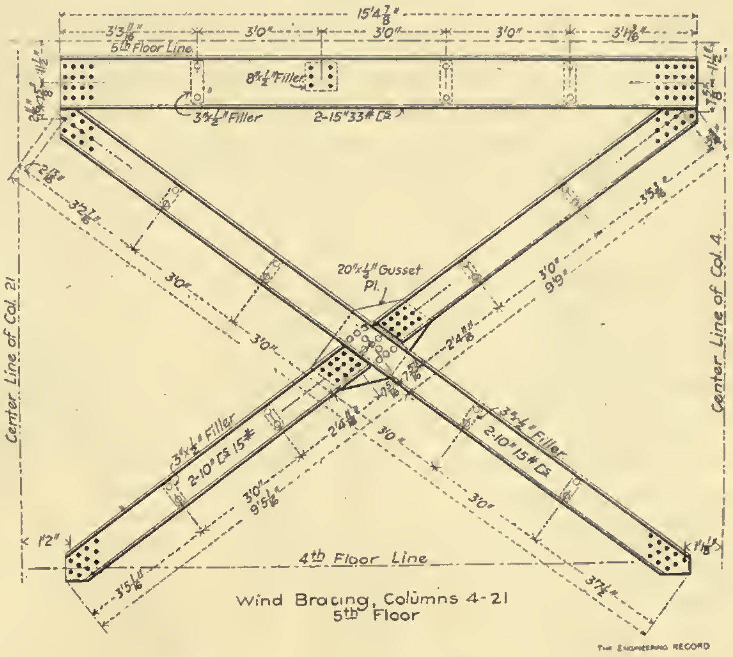
All column splices are made with flange cover-plates shop-riveted to the upper ends of the lower sections to form jaws which are field-riveted to the lower ends of the upper sections. The number of field-rivets and the number of shop rivets in each splice are equal, but in some cases there are shop rivets through the flanges of a center channel and field rivets only through the flanges of the side channel, so that the rows of field rivets are longer than those of the shop rivets, and the splice plates are unsymmetrical



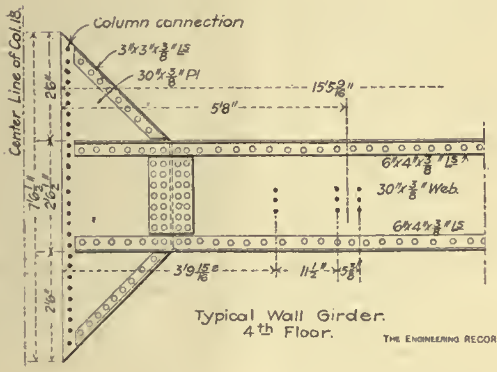
Girder connections at Wall Columns.



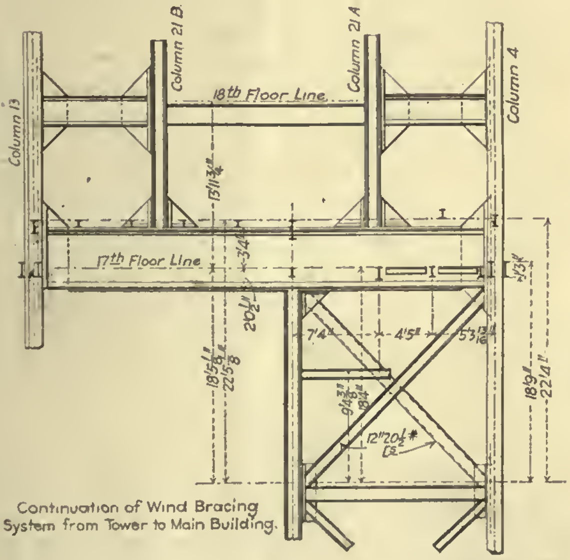
Wind Bracing, Columns 3-20
5th Floor



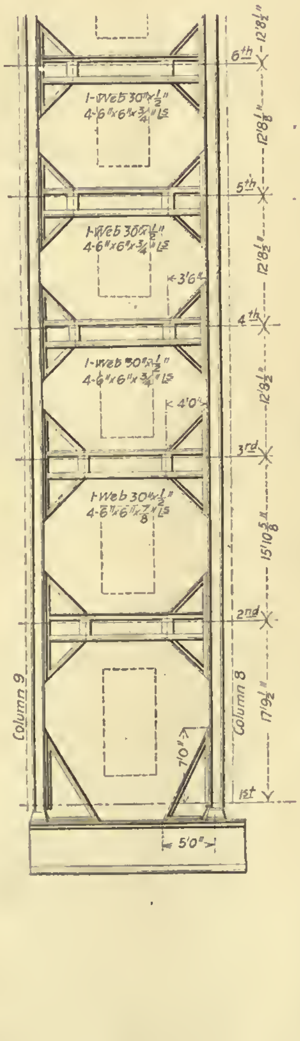
Wind Bracing, Columns 4-21
5th Floor

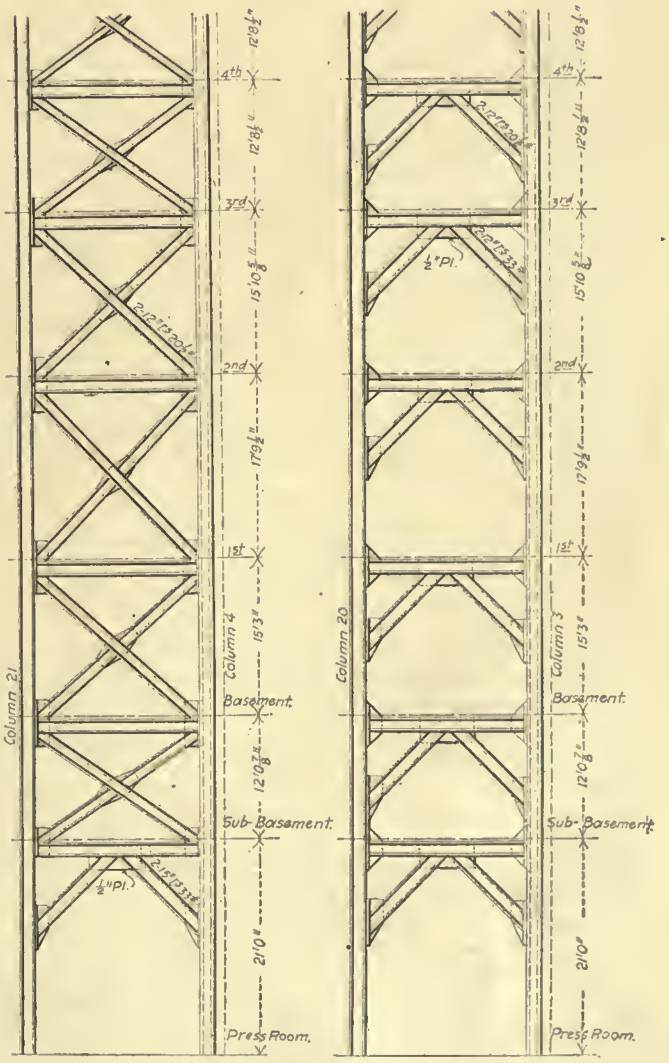


Typical Wall Girder.
4th Floor.



Continuation of Wind Bracing System from Tower to Main Building.





THE TIMES BUILDING, NEW YORK: SCHEME AND DETAILS OF WIND BRACING.

both sides of the joint. All joints are made with a horizontal diaphragm plate between the adjacent milled ends of the column, field-riveted to horizontal flanges on each column section.

The wind stresses in this building are resisted by its inertia, by an indeterminate amount of stiffness in the floors, partitions and walls, by the depths of the girders and the rigidity of their connections to the columns and by three special systems of transverse sway-bracing proportioned to take definite calculated amounts of the bending moment and transmit it as vertical trusses or stiffened beams from the roof to the foundations. The principal system extends about half-way through the building near the center, and is in the plane of the north wall of the tower. It consists of a series of X-braces, which form complete diagonals in every panel made by the intersections of columns 4 and 21 with the floorbeams. The lower portion of this system is shown in the general diagram of the wind bracing, and the upper part corresponds to it except in the size of the channels, which are reduced to 10 inches in the ninth story and to 9 inches in the fifteenth story.

In each panel one diagonal is made with a pair of continuous channels riveted together with ¼-inch filler plates between the backs of their webs, and has a connection plate shop-riveted at the center, projecting beyond both flanges, to receive the field-riveted connections with the channels of the intersecting strut, which are cut to clear it. The horizontal struts serve as floorbeams also, and are field-riveted to the same web-connection plates that are shop-riveted to the columns and receive the ends of the diagonals. The two columns in this panel of bracing have their upper ends connected by solid-web kneebraces to the lower flange of the seventeenth-story transverse plate-girder which supports the north side of the tower wall. Above this girder the transverse bracing is carried through the framework in the tower wall by means of kneebraces between the columns and the plate-girders in the end panels of the framework, as shown in the general diagram. These kneebraces are continuous with the girder-webs and correspond in detail to those for the wall girders of the lower stories.

Between columns 3 and 20 there is a different system of transverse bracing, as shown in the general diagram, which consists of pairs of inclined struts reaching from the center of each floorbeam to points on the columns as near as convenient to the floor below, thus allowing doors between the braces in the portions which conceal them. This system commences with 15-inch channels in the lower stories, where each brace has twenty-four ¾-inch rivets at each end. In the ninth story the braces are made with pairs of 12-inch channels having twenty rivets in each end, and in the sixteenth story the channels are reduced to 10 inches.

The third complete system is between columns 8 and 9, and is also shown for the lower stories in the general diagram. It is designed in such a manner as not to obstruct the windows in the end wall of the building, and consists of plate-girders with kneebraced ends like those in the long sides of the building. At the fourteenth and fifteenth floors, the 30-inch plate-girders are replaced by 20-inch I-beams with web and flange connections to the columns, but without kneebraces. At the sixteenth floor the 30-inch plate-girder has kneebraces on the lower flange only. At the roof line there are two I-beams without kneebraces.

The wall girders which carry the brickwork in all fronts of the building correspond in general with the fourth-floor girder 4T5 here shown, except for variations in the dimensions, and rivet spacing in the connections for brackets and columns. The flange angles are continuous from column to column, but the web is cut short at both ends and is shop-spliced to the end sections, which project beyond both flanges and are field-riveted to the columns to make kneebraces. The inclined edges of the web are stiffened with pairs of 3x3-inch flange angles, and the vertical edges are field-riveted to two connection angles, one of which is shop-riveted and the other is field-riveted to the column, as shown in the accompanying column details. This arrangement allows one of the long column angles to be shipped loose and promotes the facility of field connection.

All columns are seated on rectangular cast-steel bases corresponding to that here shown for column 4, which weighs 7,290 pounds, and distribute the loads on the granite piers, which in turn reduce the loads to a maximum pressure of 20 tons per square foot on the rock foundation. The pedestals were very carefully adjusted with transit and leveling instruments and set on grout poured in under slight pressure. They contain no metal less than 1½ inches in thickness, and all angles are carefully filleted. The large holes in the base plates are cored to receive 1¾-inch anchor bolts, and the small open holes in the cap-plates are drilled to match the column bases to which they are field-riveted. Very great care was taken in assembling all columns and girders and sway-bracing so as to prevent any deviation from verticality in the tall column lines, most especially in the lower stories. The first two columns which were erected in each tier were very carefully plumbed with a transit and were immediately braced by diagonal timbers in longitudinal and transverse planes firmly clamped to the upper tier of floorbeams. Afterward the successive column sections of the same tier were braced to these by their floorbeams and girders, and the permanent steel sway-bracing was connected as rapidly as possible, additional temporary braces being inserted and adjustment being made with wedges or tackles, if necessary, to correct the alignment and maintain it perfectly until the permanent sway-bracing was completely riveted.

Messrs. Cyrus L. W. Eidlitz and Andrew C. McKenzie are the architects; Mr. W. B. Bamford and Mr. Paul Gemelin, of their staff, are respectively the general superintendent in charge of the building and the chief draftsman. The foundations and structural steel were designed and detailed in the New York office of Purdy & Henderson, Mr. Charles F. Berger, manager. The general contract was awarded to the George A. Fuller Company, Mr. L. R. Barras and Mr. George Meyer being successively superintendents of construction. The structural steel work was furnished by the Carnegie Steel Company.

Open Courts around Theaters must be provided hereafter in New York City in the case of new structures of this class. An amendment to the building code has been adopted that requires that such a building shall have at least one front on the street, this having suitable means of entrance and exit at least 25 feet in width, and in addition shall have an open court or space in the rear and on the side not bordering on the street, where the building is located on a corner lot, or in the rear and on both sides where there is but the one frontage. The width of the courts must be 7 feet where the seating capacity is not over 1,000 people, 12 feet where the seating capacity is between 1,000 and 1,800, and 14 feet where the seating accommodation is over 1,800.

Types and Details of Bridge Construction; Plate Girders—III.

By Frank W. Skinner, C. E.

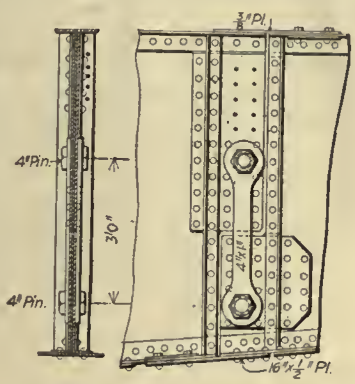
Suspended and Rocker Bearings.—A double-track through plate-girder bridge on the line of the Chicago, Milwaukee & St. Paul Railway is about 202 feet long between the end bearings on the abutments, which are square with the bridge axis. It is divided into three approximately equal spans by two river piers skewed at an angle of nearly 45 degrees with the bridge axis. The ends of the girders all have pin bearings, and all are movable longitudinally except at one abutment. On both piers the adjacent spans are supported on the same pedestals, thus affording a continuity of the lower flanges, which permits expansion without the distortion that would otherwise occur with the skew piers.

Riveted shoes are bolted to the bottom flanges of the girders and are much wider transversely than the bottom flanges are. They take bearing on sole plates extended beyond the flange angles and reinforced by vertical transverse gusset plates riveted to the web-stiffener angles. They have three double longitudinal web plates spaced far enough apart to provide lateral stability for the support. The pedestal is like the shoe reversed, but is somewhat longer and wider. It has double web plates in the same planes as those of the shoe, and these pairs of plates are far enough apart to receive between them solid vertical links, bored to engage top and bottom pins, which connect them and lock the different members of the bearing together.

These links serve as rockers and permit longitudinal movement without lateral displacement. They are considered advantageous because they afford perfect distribution of the bridge weight on the pedestals and cannot be clogged with dirt or rust as rollers sometimes are. At the abutment ends of the girders of one span each shoe has three links and each link has two pins. At the opposite or fixed-end abutment the shoe and pedestal webs overlap and are locked together longitudinally by a single pin. At both the piers all the bearings are similar to those of the expansion abutment, except that each shoe and pedestal receives the ends of the two adjacent girders in the succeeding spans and has two sets of pins and links, one under the bearing of each girder, thus securing continuity between the lower flanges of the girders in both spans. This detail was illustrated in The Engineering Record of November 21, 1891.

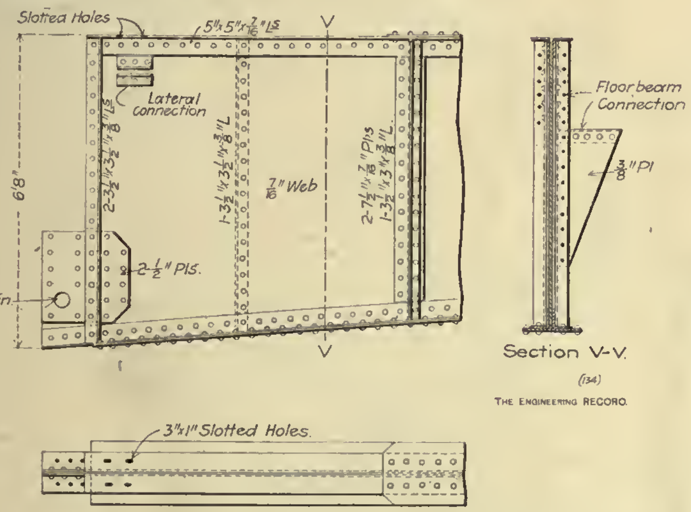
In the 1896 standards for plate girders on the Northern Pacific Railroad the expansion ends of plate girders 70 feet and more in length were seated on rocker bearings made with a riveted shoe and pedestal connected with curious double-cylindrical pins. The shoes had triple webs, with their ends covered by bent transverse plates, to exclude dirt, and were bored to give about 220 degrees bearing on the pins. The pedestals were like the shoes reversed and made with wider base plates, so as to allow for the outside anchor bolts. They were seated on lead bearing plates, and the web cover plate on the outside end was bolted on instead of being riveted, in order to allow its removal to facilitate inspection and cleaning. There was a clearance of 1 inch between the shoe and pedestal which provided amply for longitudinal displacement.

The pins were the most interesting part of the connection, and consisted of solid steel bars finished to a cross-section resembling two tangent 4-inch circles with their circumferences connected by straight lines about 3 inches apart, parallel to the line through the centers of the circles. The ends of the pins were turned cylindrical and projected several inches beyond the nuts to form shoulders long enough to afford bearings by which the girder could be raised if necessary. Oval washers between the nuts and the shoe and pedestal webs protected the ends of the pins and locked the shoe and pedestal together without requiring nuts of very large diameter.



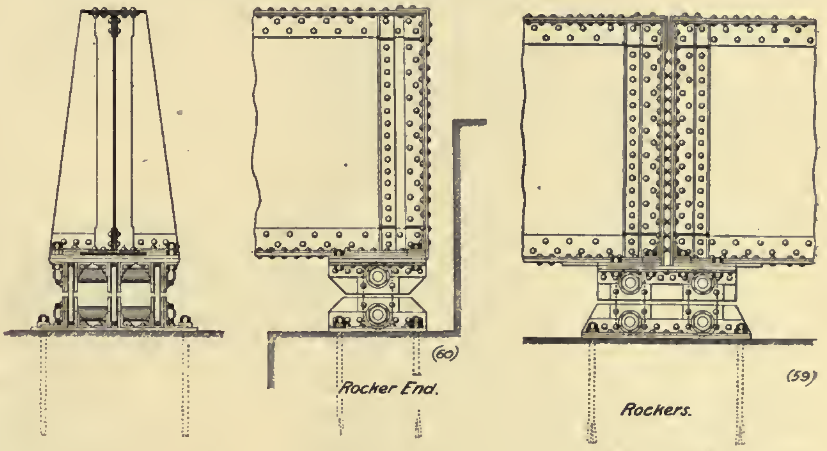
Detail at S.

SUSPENDED GIRDER CONNECTION, HARVARD BRIDGE.

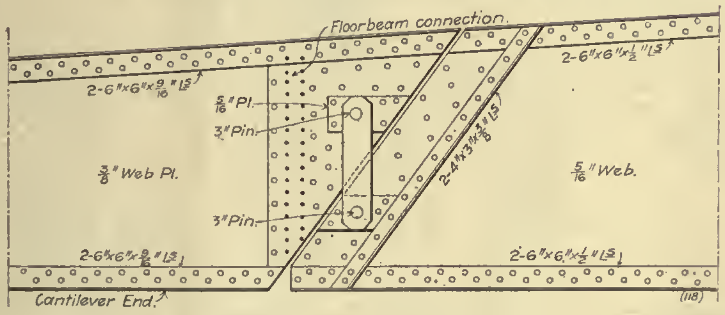


End of Suspended Span.

END OF GIRDER IN CENTER OF SPAN, HARVARD BRIDGE.

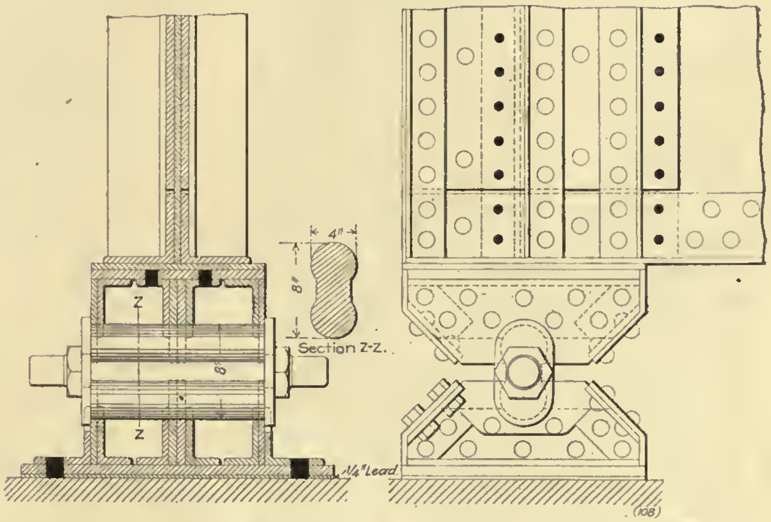


SINGLE AND DOUBLE ROCKER BEARINGS, CHICAGO, MILWAUKEE & ST. PAUL RAILROAD.



Support of Suspended Span.

CONSOLIDATED TRACTION COMPANY'S BRIDGE BETWEEN NEWARK AND JERSEY CITY.



Expansion End.

ROCKER BEARING FOR 70-FOOT DECK SPAN, NORTHERN PACIFIC RAILWAY, 1896.

Examples of Suspended and Rocker Bearings for Expansion Ends of Plate Girders.

The electric street cars of the Consolidated Traction Company cross the tracks of the Delaware, Lackawanna & Western Railroad between Jersey City and Newark, N. J., on two single-track skew plate-girder viaducts. The 94-foot spans have a curious arrangement of girders in which one of them, 78 feet long, is supported at one end on a vertical column, and at the other end is suspended from the extremity of a girder which cantilevers nearly 15 feet beyond the supporting column. The adjacent ends of these girders are cut at an angle of about 45 degrees with the vertical, and their tapered webs are reinforced at the ends, that of the suspended girder having inclined stiffener angles about a foot from the edge and parallel with it. The girder is suspended by a pair of vertical sheared plate links about 9 inches wide, with a 3-inch pin through each end. No jaws are provided on the ends of the girders to secure transverse stability, and the joint is a flexible one. The bridge was described in The Engineering Record of June 5, 1897.

The long spans of the Harvard Bridge, Boston, alternate with the short spans, and the girders of the former spans project 15 feet ½ inch beyond the pier centers to form, on both sides of the long spans, cantilever arms, from which are suspended the 75-foot 2½-inch connecting girders. The adjacent ends of the webs of the cantilever and suspended girders are notched about 12 inches on their upper and lower sides respectively, so that they will just fit together, with an offset joint having about 1 inch vertical and horizontal clearance. The web-stiffener angles are set back to the inner edges of the notches and the projecting ends of the web are reinforced and bored for 4-inch pins, which engage the pair of vertical eye-bar suspension links. Lateral rigidity is secured and longitudinal expansion and contraction is permitted by top and bottom flange cover plates, which are riveted to the end of one girder and bolted through slotted holes to the other, and vice versa.

The viaduct which has been designed to carry Atlantic Avenue, Boston, over the tracks of the Boston Terminal Company, is composed in part of plate-girder spans. The substructure has been built, but the superstructure has not yet been built, although the design has been detailed as here described. In one span the three lines of longitudinal girders, about 75 feet long and 8½ feet deep over all, are supported at one end by a field-riveted connection through the end web-stiffener angles, and at the other end are suspended by vertical eye-bars from the tops of vertical columns. Each column is made with a trough-shaped cross-section composed of two built channels and a cover plate, and has near the top a cast-steel flanged bearing riveted to each web, to receive a 5-inch horizontal pin.

The horizontal bases of these castings are seated on the milled upper ends of vertical bearing angles riveted to the column, and distributing the loads through a sufficient rivet bearing area.

The pin engages two 6x1½-inch eye-bars 4 feet long on centers, which at their lower ends take a similar but shorter pin through the lower edge of the girder web. The end of the girder is thus free to swing back and forth inside the column to allow for expansion and contraction, but fits so closely between the bearings that there is little room for transverse motion.

The end of the web of the girder is reinforced with side plates, and has a steel bearing casting on each side seated on vertical stiffener angles like those of the column. An 8x10-inch slotted hole on the center of the upper pin gives clearance for the latter to pass through the girder without bearing. This bearing is sensitive to slight movements, cannot transmit any longitudinal stresses from column to girder, and is not in danger of being impaired by the accumulation of dirt or rust. The design is not shown in the drawings.

Effect of Meters, New Storage Reservoir and Yield of Watershed, Newark Water Works.

In connection with the article on the probable effect of metering at Pittsburg, printed May 14, and in view of the current interest in the subject of water waste restriction, some statements and a diagram in the forthcoming report for 1903 of Mr. M. R. Sherrerd, engineer and superintendent of the department of water of Newark, N. J., deserve attention. The diagram is so plain that it needs no explanation. It shows the influence of the compulsory introduction of about 4,000 meters on wasteful consumers during 1899 and 1900. The average daily consumption per tap was reduced from 840 gallons in the year 1898, to 700 gallons for 1900. The result has practically extended for five years the period for which the present watershed development will be adequate.

The effect on reducing the revenue of the department by these meters was slightly felt for two years, but the average yearly increase in water rent income became normal after that time. The voluntary introduction of meters by consumers to obtain the advantage of the absence of a minimum rate has been more apparent in the effect on the revenue than the meters introduced by the department. The average daily consumption of water during the year 1903 was 26,611,000 gallons, the average rate per tap per day being 716 gallons. At the close of the year there were about 37,180 taps connected with the distribution system.

The necessity for a large storage reservoir located near the city and independently connected with the distribution system was repeatedly recommended by Mr. Sherrerd. Such a reservoir is now nearing completion; it is known as the Cedar Grove reservoir, and was fully described in an illustrated article published December 5 and 12, 1903. The following paragraphs from the report will supplement that description, bringing out several points of interest:

Water is brought to Newark from the Pequannock watershed through two lines of steel pipe, each 21 miles long. It is delivered into small reservoirs which serve merely to regulate the pressure, there being within or near the city storage capacity only sufficient for a day's supply of water under normal draft.

Under these conditions, and until the new storage reservoir shall be completed, the security of Newark's water supply depends upon the constant integrity of these two lines of steel pipe 21 miles long, and as the two pipes are only 12 feet apart, an accident that injured one would be very liable to put the other also out of service. The possibility of such accidents were very vividly shown in the flood of last October, when in two places both pipes were undermined by greatly swollen streams, and for a number of days the city's water supply was in grave danger of being altogether cut off. If a break had occurred repairs could not have been made immediately, due to the general interruption of transportation caused by the flood. A description of this accident, illustrated by photographs kindly furnished by Mr. Sherrerd was printed in the issue of January 23, 1904.

The Cedar Grove site has many advantages for the location of such a reservoir. The contour of the ground forms largely a natural basin, and with the construction of three dams or dykes, a storage capacity of about 700,000,000 gallons can be obtained. The elevation is such that the water surface of the reservoir will lie on the hydraulic grade line of the watershed conduits, thus insuring no loss of head in delivering water to the city nor diminution in carrying capacity of the conduits. Also, the location is only one mile from these conduits, and in such a relation between them and Newark, that a direct connection from the reservoir to the city will materially shorten the distance over the present Belleville route and thus increase the available head, and possible maximum draft. This location gives an opportunity of supplying a large territory of high land adjoining Newark which is likely before long to look to the city for water.

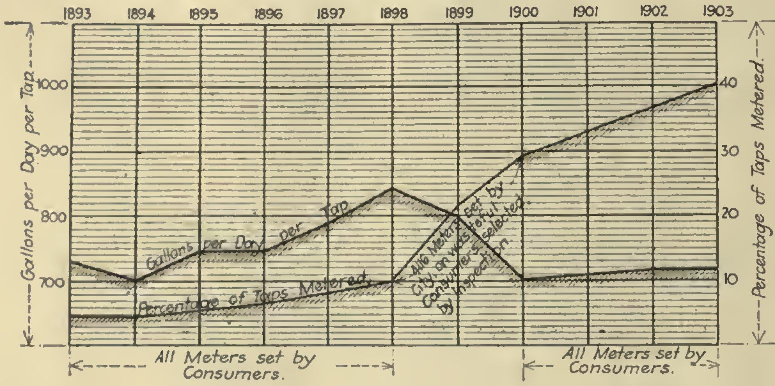
The complete undertaking included the Cedar Grove storage reservoir; a supply pipe leading from the watershed conduits to the reservoir; an outlet tunnel from the reservoir under First Mountain; and a distribution pipe from the end of the tunnel to the city, about 7 miles long. The total cost of these works will be very nearly $1,650,000, including cost of land.

In service, under normal conditions, all of the water used by Newark will be delivered into Cedar Grove reservoir from the watershed, and thence sent out through the tunnel and distribution lines to the city. Besides serving as a storage place for a large amount of reserve water in case of an emergency, and incidentally increasing the efficiency of the watershed, the reservoir will answer another useful purpose in improving the quality of the water by allowing sedimentation and bleaching to take place. To secure this latter object proper circulation must be provided, and the structures and pipes within the basin are in a large measure arranged to attain this end. The circulating conduits are of concrete steel; their construction was shown, and described in detail in the articles referred to. Another important advantage will be gained from the use of the new storage reservoir in avoiding the present necessity of sending roily water during periods of heavy rainfall, into the pipe lines at the Macopin Intake and thus into the distribution system.

The report contains valuable information relating to rainfall and the yield of the watershed. Gaugings have now been made at the Pequannock watershed for twelve years; and while it is probable that in the future a period of more severe drought will occur than has been experienced since these records have been kept, yet they have been continued long enough to be of substantial value.

Areas of Watersheds and Reservoirs and Capacities of Reservoirs.

	Gross Area of Land and Water, Square Miles.	Area of Full Storage Reservoir.		Area of Natural Ponds and Storage Reservoir When Full.		Area of Swamps per Topographic Maps of Geological Survey.	Storage Capacity of Reservoirs, Million Gallons.
		Square Miles.	Per Cent. of Area.	Square Miles.	Per Cent. of Area.		
Above Canistear Dam	5.6	0.547	9.3	.547	9.3	0.45	2,407
Below Canistear and above Oak Ridge Dam	21.7	0.597	2.9	.652	3.0	1.19	2,555
Total above Oak Ridge Dam	27.3	1.144	..	1.199	4.39	1.64	4,962
Total above Clinton Dam	9.4	0.662	7.2	0.914	9.7	...	3,518
Total above Echo Lake Dam	4.6	0.468	10.0	0.468	10.0	0.76	612
Below Oak Ridge, Clinton and Echo Lake Dams and above Macopin Intake	21.2	0.02	0.1	0.04	0.2	0.67	...
Total above Macopin Intake	62.5	2.294	3.67	2.621	4.2	3.07	9,092



Data Concerning Pequannock Watershed.

Year.	Yield or actual natural run-off of entire watershed above Macopin intake dam in mil. gals.	Unavoidable waste under draft of 50 mil. gals. per day**	Amount utilized for water supply if 50 mil. gals. per day had been drawn since June 1, 1891**	Average rainfall in inches.	Run-off in inches depth on drainage area (62.5 sq. m.)	Ratio of run-off to rainfall.	Volume in storage if 50 mil. gals. per day had been drawn since June 1, 1891.** Max.	Min.
1891	10,486	836	9,650	*....	9.66	...	5,262	2,060
1892	22,802	7,308	15,494	45.41	21.00	0.46	6,073	1,835
1893	35,607	13,500	22,107	49.73	32.79	0.66	6,073	2,617
1894	30,830	12,827	18,003	44.62	28.39	0.64	6,073	2,871
1895	20,601	8,437	12,164	36.67	18.97	0.51	6,073	172†
1896	33,389	8,890	24,499	51.89	30.75	0.59	5,760	167
1897	31,893	13,409	18,484	57.97	29.37	0.51	6,073	4,220
1898	31,465	14,310	17,155	51.39	28.98	0.56	6,073	2,146
1899	29,187	14,196	14,991	47.94	26.88	0.56	6,073	1,332
1900	23,348	8,718	14,630	42.00	21.50	0.51	6,073	1,262
1901	34,676	9,788	24,888	64.69	31.94	0.49	9,092	887†
1902	38,795	20,594	18,201	60.44	35.73	0.59	9,092	8,277
1903	50,011	31,811	18,200	64.79	46.06	0.71	9,092	7,319

Data for 1891 include 7 months only—June to December.

*No record in watershed.

†Shows deficiency.

**NOTE—Storage capacity prior to Sept. 30, 1900:

Clinton	3,518
Oak Ridge	2,555
	6,073 Mil. Gals.

Storage capacity subsequent to Sept. 30, 1900.

Clinton	3,518
Oak Ridge	2,555
Canistear	2,407
Echo Lake	612
	9,092 Mil. Gals.

In the use of these records the development of the watershed and some of its physical characteristics should be taken into account. In outline the watershed is shown on the map. It will be noticed that Clinton reservoir receives the entire drainage from one of the upper branches of the Pequannock; that Canistear reservoir supplements Oak Ridge reservoir in storing drainage from the entire upper portion of the main river; and that the lower portion of the watershed, about a third of the entire drainage area, has no storage development whatever. Echo Lake is a natural body of water from which a comparatively small amount may be drawn. A tabulated statement concerning the areas of the sub-divisions of the watershed and reservoir capacities is given here as explanatory of the map. At least 75 per cent. of the watershed is of a rugged and mountainous nature and the territory is sparsely settled.

The run-off records are accompanied by statements of unavoidable waste, amount utilized for water supply, and the amounts in storage. These statements are taken from a calculation made to determine whether sufficient reservoir storage had been provided to enable 50,000,000 gallons per day to be drawn from the Pequannock watershed. They are based upon the supposition that each day since June 1, 1891, 50,000,000 gallons had been drawn through the conduits from the watershed, but all data used is from actual gaugings. Up to the end of 1895, the gaugings of the East Jersey Water Company were taken; since that time those of the Newark Water Department have been used. In this calculation after September, 1900, when the entire supply was turned over to the city, Canistear reservoir and Echo Lake were also included with Clinton and Oak Ridge reservoirs, which were previously the only ones considered.

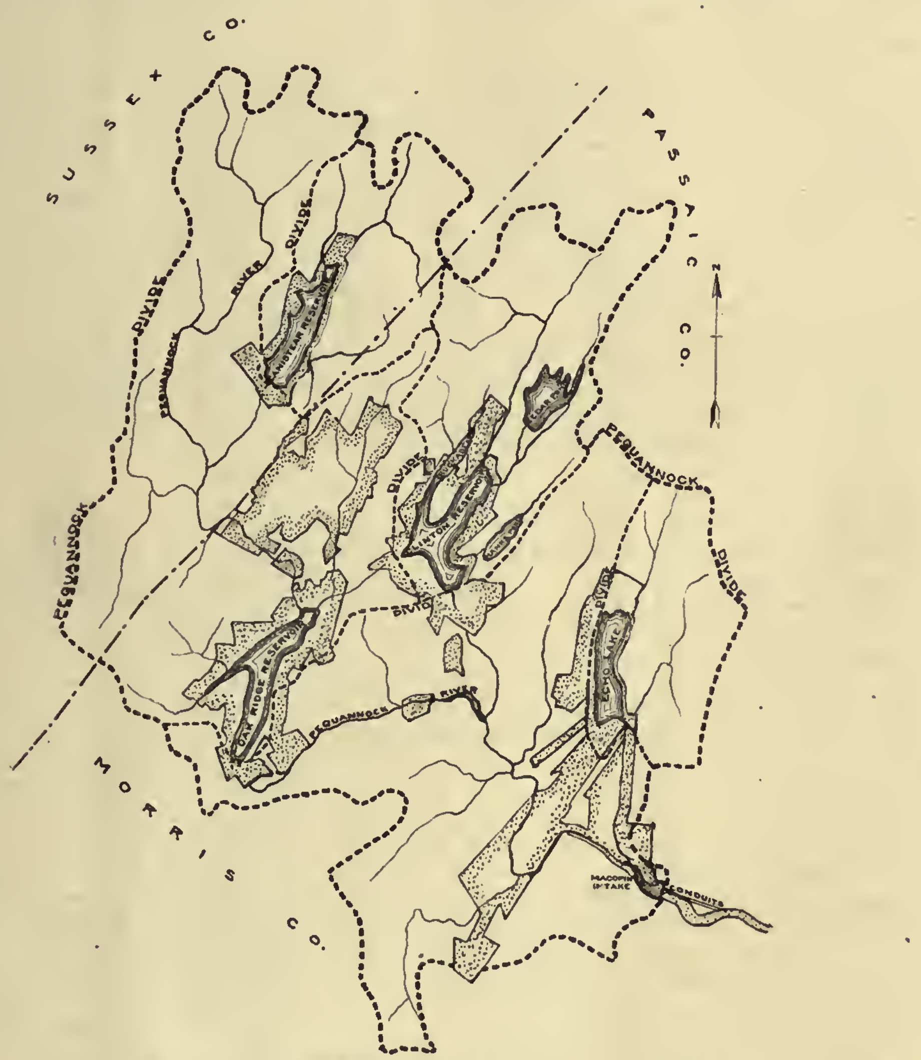
The gauges read to obtain the average rainfall for the various years were located as follows: For 1892, at Macopin; 1893 to 1896, inclusive, Oak Ridge and Charlottesburg; 1897 to 1903, inclusive, Oak Ridge, Charlottesburg and Newfoundland, as shown by the accompanying table.

The column, "Unavoidable Waste," gives the total amount of water wasted over Macopin Intake dam under a draft of 50,000,000 gallons per day, and shows in a large measure what might be saved for use with an increased storage capacity. The tables show that in 1901 there would have been a deficiency in the supply of 887,000,000 gallons under a daily draft of 50,000,000 gallons. To have a continued uninterrupted supply of this latter quantity, the storage capacity should have been increased by at least the amount of the deficiency. Cedar Grove reservoir, when completed, will add about 700,000,000 gallons to the storage. The amount which could have been furnished daily during the period above mentioned under the present watershed development, would have been 47,000,000 gallons. Cedar Grove reservoir storage added would have made the daily available supply approximately 50,000,000 gallons.

The minimum run-off in inches depth on the drainage area was 18.97 inches in the year 1895. A yield of 50,000,000 gallons per day from 62.5 square miles is equivalent to an annual depth of water over the entire watershed of 16.8 inches.

The column, "Amount Utilized for Water Supply" gives the quantity delivered into the conduits and added to storage.

The Board has adopted as a settled policy that land lying along all main streams in the watershed, which may be offered at a reasonable price, should be acquired by the city; the amount of land purchased in any one year being limited only by the funds available, and the reasonable offers made.



Map of Pequannock Watershed of the Newark Water Works.

THE TELEPHONE STATISTICS of the United States for the year 1902 show a total of 9,136 systems and lines, 4,900,451 miles of single wire, and 2,371,044 telephones.

RAINFALL ON THE PEQUANNOCK WATERSHED OF NEWARK WATER SUPPLY.

Month.	1893.			1894.			1895.			1896.		
	Oak Ridge.	Charlottes-burg.	Average.	Oak Ridge.	Charlottes-burg.	Average.	Oak Ridge.	Charlottes-burg.	Average.	Oak Ridge.	Charlottes-burg.	Average.
Jan.	3.49	....	3.49	2.07	2.28	2.18	3.60	4.01	3.80	1.67	1.89	1.78
Feb.	5.76	....	5.76	2.77	2.74	2.75	0.14	4.31	0.23	8.45	10.06	9.26
Mar.	3.51	....	3.51	1.68	1.64	1.66	2.11	2.06	2.08	5.50	6.04	5.77
Apr.	3.27	3.50	3.38	2.48	2.46	2.47	5.22	5.76	5.49	0.81	0.69	0.75
May	5.66	5.76	5.71	7.17	6.03	6.60	3.35	2.85	3.10	3.17	3.83	3.50
Jun.	3.32	3.22	3.27	2.24	2.32	2.28	2.85	2.34	2.59	4.22	5.02	4.62
Jul.	2.88	2.44	2.66	0.80	1.09	0.95	4.88	5.80	5.34	5.94	5.77	5.85
Aug.	6.00	7.14	6.87	2.60	2.65	2.62	2.13	2.38	2.26	2.83	2.47	2.65
Sep.	2.81	2.44	2.63	7.45	11.40	9.43	1.00	1.03	1.01	9.52	8.74	9.13
Oct.	4.79	5.37	5.08	5.88	6.15	6.01	3.43	2.90	3.17	2.10	2.24	2.17
Nov.	4.05	4.12	4.08	3.35	3.46	3.41	3.11	4.86	3.98	5.32	5.68	5.50
Dec.	3.55	3.02	3.29	4.30	4.23	4.26	3.35	3.89	3.62	0.97	0.85	0.91
Total ...	40.69	....	49.73	42.79	46.45	44.62	35.17	38.18	36.67	50.60	53.28	51.89

Month.	1897.				1898.				1899.			
	Oak Ridge.	New-foundland.	Charlottes-burg.	Average.	Oak Ridge.	New-foundland.	Charlottes-burg.	Average.	Oak Ridge.	New-foundland.	Charlottes-burg.	Average.
Jan.	2.21	2.53	2.85	2.53	4.54	5.15	4.79	4.83	3.92	4.01	3.38	3.77
Feb.	3.46	4.91	4.29	4.22	1.76	3.99	3.99	3.25	5.42	6.23	3.75	5.13
Mar.	2.55	2.87	3.45	2.96	2.84	3.18	3.46	3.16	6.47	7.71	7.13	7.10
Apr.	3.66	3.55	3.54	3.58	3.23	4.43	4.10	3.92	2.73	2.88	3.25	2.95
May	5.94	6.85	8.23	7.01	7.15	7.46	7.63	7.41	1.25	2.11	2.26	1.87
Jun.	3.03	3.58	3.71	3.44	2.16	2.04	2.12	2.11	2.61	2.70	3.15	2.82
Jul.	14.78	14.35	13.34	14.16	2.03	3.50	4.50	3.34	7.37	6.16	5.98	6.50
Aug.	4.44	6.75	7.97	6.39	5.71	6.30	5.91	5.97	3.14	3.56	3.60	3.43
Sep.	2.86	2.83	2.90	2.86	1.19	1.45	1.78	1.47	5.77	5.53	5.73	6.68
Oct.	1.68	1.63	1.95	1.75	6.77	5.26	7.37	6.47	1.21	1.45	2.76	1.81
Nov.	4.96	4.89	5.20	5.02	6.75	6.24	6.41	6.13	3.28	3.36	2.48	3.04
Dec.	4.67	4.91	2.57	4.05	3.09	2.62	4.27	3.33	3.28	3.94	4.30	3.84
Total ...	54.23	59.65	60.00	57.97	47.22	51.62	56.33	51.39	46.45	49.64	47.77	47.94

Month.	1900.				1901.				1902.				1903.			
	Oak Ridge.	New-foundland.	Charlottes-burg.	Average.	Oak Ridge.	New-foundland.	Charlottes-burg.	Average.	Oak Ridge.	New-foundland.	Charlottes-burg.	Average.	Oak Ridge.	New-foundland.	Charlottes-burg.	Average.
Jan.	3.94	3.90	4.29	4.04	1.69	2.42	1.96	2.02	3.68	4.47	4.35	4.17	3.68	4.18	4.77	4.21
Feb.	7.04	6.96	7.54	7.18	0.92	0.93	0.80	0.88	6.18	7.75	7.89	7.27	4.37	5.29	5.47	5.04
Mar.	4.32	4.80	4.15	4.42	6.45	7.35	8.07	7.29	4.03	5.04	4.78	4.62	5.04	5.73	5.92	5.57
Apr.	2.11	2.20	2.39	2.23	6.68	9.07	10.22	8.66	4.85	5.44	5.36	5.22	4.04	4.50	4.42	4.32
May	1.86	4.32	4.46	3.55	5.66	7.39	6.57	6.54	2.43	2.24	2.31	2.33	0.39	0.26	0.24	0.30
Jun.	3.14	3.38	3.87	3.46	2.60	2.83	2.89	2.57	7.01	6.27	6.61	6.63	11.29	11.22	10.45	10.99
Jul.	4.28	4.45	4.78	4.50	7.51	7.35	7.32	7.39	4.19	5.57	4.47	4.74	3.63	4.11	3.79	3.84
Aug.	2.40	1.98	1.64	2.01	11.81	12.49	12.11	12.14	3.55	3.94	4.09	3.86	7.27	7.66	7.78	7.57
Sep.	2.11	1.68	2.16	1.98	5.27	4.90	3.94	4.70	6.58	7.84	7.86	7.43	3.42	3.60	3.29	3.44
Oct.	1.83	2.65	2.76	2.41	1.91	1.82	1.66	1.80	6.50	6.11	6.06	6.89	12.90	14.10	14.06	13.69
Nov.	3.16	3.86	3.85	3.62	2.21	2.01	1.03	1.75	1.20	1.16	1.30	1.22	1.58	1.55	1.47	1.53
Dec.	2.13	2.60	3.06	2.60	7.92	9.48	9.45	8.95	6.62	7.71	6.85	7.06	3.73	4.50	4.63	4.29
Total ...	38.32	42.78	44.95	42.00	60.03	68.04	66.02	64.69	55.82	63.54	61.93	60.44	61.34	66.70	66.30	64.79

Elevation of Rain Gauges—Oak Ridge, 825; Newfoundland, 800; Charlottesburg, 720.

Refuse Destruction by Burning.

At the joint meeting last week of the Institution of Mechanical Engineers and American Society of Mechanical Engineers, two papers were presented on the subject of the burning of town refuse. One of these was contributed by Mr. C. Newton Russell, electrical engineer of the Metropolitan Borough of Shoreditch, London. The Shoreditch destructor plant has already been described in The Engineering Record, so that the review of this paper need only cover operating data. The second paper was read by Mr. George Watson, of Leeds, England, and paid special reference to destructors at Brussels, West Hartlepool, Moss Side and Westminster.

The amount of refuse destroyed at Shoreditch is between 25,000 and 26,000 long tons per annum. The residue or clinker amounts to 33 to 35 per cent. of the weight. The average amount of refuse received per day is 85 tons, and this is delivered between 9 A. M. and 5 P. M., but the amount varies considerably, being as low as 60 tons in summer and as high as 140 tons in winter. The cost of handling and burning the refuse, including men employed in the yard, averages 60.6 cents per ton; the unit cost for charges to clerks and establishment expenses is placed at 9 cents per ton, and for repairs and maintenance and supplies is added 20 cents, making the total cost per ton about 90 cents. The amount of electric power consumed in the burning and handling is as follows: Electric fans, for the forced draft fans, is 4 kilowatt-hours per ton; for the elevators and trucks for handling material and delivering it to the cells, 0.5 kilowatt-hour; and for lighting, 0.48 kilowatt-hour, making the total 4.98 kilowatt hours. The residue from the refuse is made up of about 30 per cent. common clinker, 3 per cent. fine ash, ½ per cent. flue dust, and ½ per cent. old tins and irons.

Tests as to its steam-raising capacity have shown results of 0.95 pound of water evaporated at a steam pressure averaging 130 pounds for one pound of refuse burned. A considerable reduction must, however, be made in these figures when taken over, say, twelve months. The conditions may easily bring down the average results, in the opinion of the author, to 0.5 pound of water for one pound of refuse burned. Experience at Shoreditch shows that in burning coal in conjunction with refuse, the full efficiency of the coal is not obtained as in an independent boiler, for the reason that during the process of clinkering a considerable amount of cold air unavoidably finds its way to the boiler tubes.

The disposal of clinker when produced at works situated in the center of large cities is a difficult and expensive matter, as it is usually found impracticable to use more than a small portion for concrete purposes. The greater portion has to be carted to the outskirts of the city. The author believes that it is unnecessary for the destructor to adjoin an electric-generating station; in fact, it should be located so that the dust from the works and clinker yards cannot reach the engine room. The flue dust is suitable for use as a base for disinfectant powder, and large quantities are utilized in this way.

The author is a believer in the efficacy of the forced-air blast. His equipment comprises three Sturtevant fans, each designed to give 8,000 cubic feet of air per minute. The full number is only put to work during the time of heaviest load. The fans draw the hot air from the top platform of the destructor. The air pressure in the ashpits is slightly less than 1 inch, and with this figure the author states that the temperature obtained in the furnaces often exceeds 2,000 degrees Fahrenheit. By increasing the air pressure in the ashpit to 2½ inches, he has found it possible to burn 25 per cent. more refuse than with a pressure of 1 inch, and a harder and better class of clinker is also produced.

The second paper, by Mr. Watson, was prefaced with a detailed account of the considerations applying to the burning of refuse. It is, he says, a fairly safe generalization to analyze town refuse in Great Britain as consisting of one-third by weight of water, one-third combustible matter, and one-third incombustible. He asserts that in many places it is safe to guarantee one pound of steam per pound of refuse in summer and 1¼ pounds in winter. With regard to the lining of the destructor furnaces, he says the fireplays should consist of 60 to 70 per cent. silica and 30 to 40 per cent. alumina. Brick too rich in silica expand and contract far too much, and clays which answer well for metallurgical purposes are often found too brittle for destructor work.

As to the steam jet for draft, he had the following to say: For working at the rate of 10 tons per twenty-four hours on a grate area of 30 square feet, or at a rate of say, 30 pounds of refuse per square foot of grate per hour, a volume of about 700 cubic feet of air per minute at atmospheric pressure and temperature for each cell is required, or, say, 23 cubic feet of air per minute for every square foot of grate area in use. To deliver this quantity of air about 100 pounds of steam per hour for each cell of the given grate area is required, whereas with a good centrifugal fan only about one-fifth this amount, or, say, 20 pounds of steam per hour, is needed. To compensate for the larger consumption of the steam jets, it may be stated that provided the refuse is rich enough in carbon to give the necessary temperature for the dissociation of the steam, water gas is formed and improves the combustion.

He described a steam jet devised in conjunction with Mr. C. W. James. The nozzle is flat instead of round, yielding a ribbon of steam instead of a plug of steam. A thickness of 1/40 inch is found best. It is important that the steam should be superheated, so as to prevent obstruction in the nozzle itself, and a pressure of 30 to 40 pounds to the square inch for the steam blast gives, he says, the most economical results. Steam jet trumpets are used in the West Hartlepool installation, combined with cast-iron sides of the furnaces, both above and below the grate bars, the side boxes serving the double purpose of heating the blast to a temperature of 400 degrees, and protecting the brickwork at the sides of the furnace from the undermining action of the hot clinker.

The paper was concluded with the results of two tests. One of these covered the West Hartlepool destructor, where there are six cells aggregating 180 square feet of grate surface. The steam jet draft was used. The refuse consisted of ashpit, nightsoil and market refuse. The boiler, of the Babcock & Wilcox type, has 2,393 square feet of heating surface. Some 31.5 pounds of refuse were burned per square foot of grate per hour. The labor cost 17.8 cents per ton. About 3.03 pounds of water were evaporated per square foot of heating surface per hour, and 1.56 pounds per pound of refuse from and at 212 degrees Fahr. The steam pressure was 155 pounds and the feed temperature 43 degrees. The other was of the Westminster plant. With a total grate surface of 252 square feet, steam-jet draft, house, trade and market refuse, 27.2 pounds were burned per square foot of grate per hour, and 24.9 per cent. of clinker and ash remained. The conditions at this destructor did not allow for the full tests cited for the West Hartlepool plant.

A Small Concrete-Steel Sewage Pumping Station, at Newton, Mass.

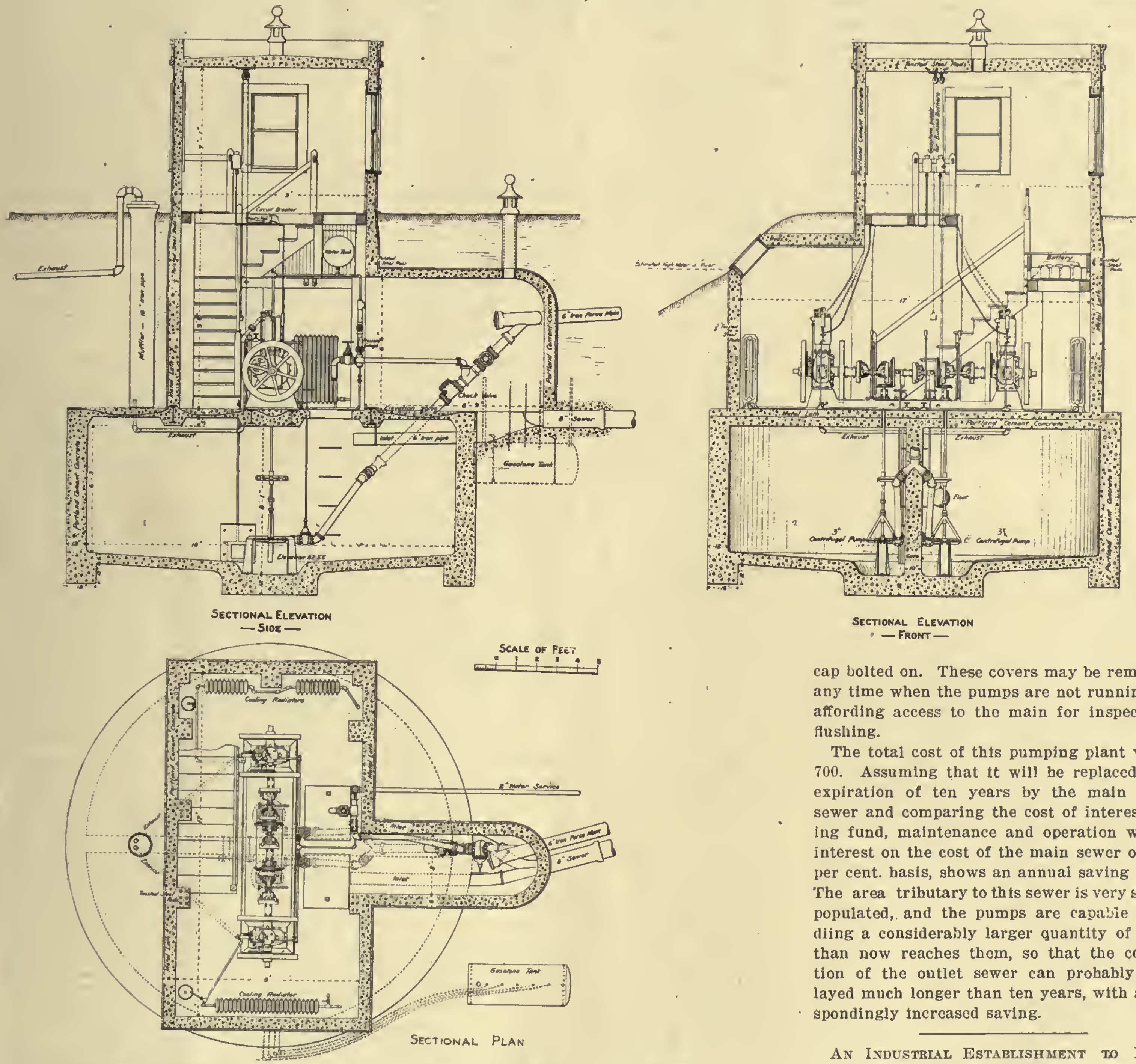
Newton is a residential city of about 35,000 inhabitants, a suburb of Boston. During the past year or two some interesting work has been done in connection with the sewerage system of this place, in small ways, as, for example, the construction of a sewer crossing beneath the old Cochituate aqueduct of the Boston Metropolitan Waterworks, described in this journal November 14, 1903, by means of telescopic steel tubes pushed through the earth beneath the aqueduct from one side to the other.

In the section of the city known as Newton Upper Falls there is a comparatively small built-up area situated between the New England branch of the New York, New Haven & Hartford Railroad and Needham Street, which was for some time in urgent need of sewers and for which relief was provided during the past year. To have discharged the sewage from this locality through a gravity outlet would have required the construction of 3,600 feet of trunk sewer along low land adjacent to the Charles River, at an estimated cost of $45,000, an expense which would have been too great a burden upon the property benefited. The difficulty was surmounted by the construction of a small pumping station with an inexpensive force main. The following description of this plant and the accompanying illustrations have been taken from the recent annual report of City Engineer Irving T. Farnham, under whose general supervision the work was done. This station may be superseded in the future whenever the development of the district to be benefited may make it expedient to construct the gravity outlet sewer.

Lateral sewers have been laid in the streets in immediate need so as to conduct the sewage through an 8-inch sewer to a tank built in property, near the river, already owned by the city, over which a small pumping outfit was installed that, with a total lift of 30.7 feet, sends the sewage through a 6-inch cast-iron force main 1,400 feet long into an existing gravity trunk sewer. The tank and the pump house are wholly of Portland cement concrete reinforced with twisted square steel rods and metal lath. The drawings show the arrangement and most of the details of the plant.

The tank is 18 feet in diameter and about 7 feet deep inside, having a capacity of approximately 13,000 gallons. Its walls are 12 inches thick with footings 18 inches wide. The bottom is 6 inches thick and slopes to a sump at the center, about a foot deep. A partition wall 10 inches thick, built on a diametral plane, divides the tank and sump into two equal parts. This wall is pierced at the bottom by an 8x8-inch opening controlled by a sluice gate, thus permitting the cleaning of one chamber or the repairing of the pump in it while the sewage is discharging into the other. The roof of the tank is 5 inches thick and its top is about 10 feet below the surface of the ground. To support the longer walls of the pump house two 10-inch steel I-beams were laid across the tank and supported by its walls, and similarly two 8-inch I-beams were set as shown to carry the pumping machinery. The roof is reinforced with metal lath and the slab between the 8-inch beams is 10 inches thick.

The pump house is 9x17 feet and 9 feet 8 inches high underground, while the superstructure is 9x11 feet, and only 7 feet 1 inch high inside. The basement walls are only 8 inches thick, reinforced with metal lath and twisted steel rods, but have several inside buttresses, as shown. From the middle of one of the long sides of the basement there is an extension 3 feet wide and 8 feet long inside which serves as a valve and pipe chamber. Through it the sewage enters, and in it the discharge pipes from the pumps connect with the end of the force main, the latter being conveniently fitted with a clean-out. This chamber can be entered only from the basement, but is ventilated directly to the open air, as shown. Besides the indirect illumination from the upper story the basement receives light through two bulkhead windows set in the sloping tank. The superstructure walls are 6 inches thick and pierced by liberal windows. The roof is 5 inches thick at the side walls and 7 inches at the ridge, the only pitch in the outer surface of the roof being the 2 inches due to the increase in thickness.



SECTIONAL ELEVATION
— SIDE —

SECTIONAL ELEVATION
— FRONT —

SECTIONAL PLAN

Concrete-Steel Sewage Pumping Station with Gasoline Engine, Newton, Mass.

The pumping apparatus consists of two 3½-inch horizontal centrifugal pumps operated by two 6-horse-power Fairbanks-Morse gasoline engines. The machinery is in duplicate, and the connections are such that either engine can be used to drive either pump, or both engines to operate one or both pumps, running together. A special feature of the plant is the cooling, by means of a system of radiators, of the water which is circulated through the engine cylinders. This saves considerable space in the engine room which would otherwise be occupied by large tanks. A check valve placed in the discharge pipe between the pumps and the force main closes and prevents the backflow of sewage from the main after the pumps have stopped. The engines, pumps, radiators and all the piping inside the station were furnished and set up under contract by the Charles J. Jager Company, of Boston, the company agreeing to make all necessary repairs and keep the plant in working order for a period of five years, and leave it in good condition at the end of that time. The contract for the installation required a delivery of 150 gallons per minute from each pump when running at full speed. Tests made after the pumps had been in operation a short time showed a discharge of 200 gallons each per minute.

The introduction of such a pumping plant into the Newton sewerage system, which is otherwise entirely a gravity system, is made possible, considered from an economic point of view, by the low cost of attendance and small amount of attention required for the running of the gasoline engines. As the station is now operated, an attendant employed at the water-works station about 300 feet distant visits the sewage pump twice each day and starts the engine. When the well is discharged, an automatic float device cuts out the electric ignitor and stops the engine. The cost of fuel consumed has been $0.012 per thousand gallons of sewage pumped.

The gasoline tank is buried in the ground near the pump house, and the pipes connected with it are reached through a manhole. The 6-inch force main was laid alongside the trench for the sewer leading to the station, about 5 feet below the surface. The main passes through the sewer manholes and at each manhole is provided with an opening covered by a cast-iron cap bolted on. These covers may be removed at any time when the pumps are not running, thus affording access to the main for inspection or flushing.

The total cost of this pumping plant was $6,700. Assuming that it will be replaced at the expiration of ten years by the main gravity sewer and comparing the cost of interest, sinking fund, maintenance and operation with the interest on the cost of the main sewer on a 3½ per cent. basis, shows an annual saving of $500. The area tributary to this sewer is very sparsely populated, and the pumps are capable of handling a considerably larger quantity of sewage than now reaches them, so that the construction of the outlet sewer can probably be delayed much longer than ten years, with a correspondingly increased saving.

AN INDUSTRIAL ESTABLISHMENT TO EMPLOY GAS ENGINES solely for power purposes is the Union Switch & Signal Company, Swissvale, Pa. For four years 500 brake-horse-power of Westinghouse three-cylinder vertical gas engines of the direct-connected type have been in use, and now a 300-horse-power Westinghouse horizontal gas engine of the double-acting type is to be added to the equipment. This engine is to have two cylinders, 16½x24 inches in size, arranged in tandem. As regards the performance of the older plant, a test of one of the engines gave the following results: 148 brake horse-power, 10.2 cubic feet per brake horse-power-hour; 123.5 horse-power (full load), 10.5 cubic feet, or 9,920 thermal units, per horse-power-hour.

Papers on Meters, Growths in Pipes and Private Fire Systems before the American Water Works Association.

Of the papers read before twenty-fourth annual convention of the American Water Works Association at St. Louis from Monday to Thursday of this week three relate to water meters, one narrates an experience with growths in water mains and meters, and one discusses private fire systems, while a paper by Mr. Alfred M. Quick, water engineer of Baltimore, tells of the points of interest to water-works officials connected with the great fire in his city last February, and a paper by Mr. W. R. Hill, formerly chief engineer of the Aqueduct Commissioners, New York, tells the reasons for important changes in the construction of the New Croton dam. Mr. Quick's paper, which, among other lessons, emphasizes the value of effective private fire systems, is printed in abridged form elsewhere in this issue, while the other papers are presented here collectively much condensed.

In a paper entitled "Meter Rates," Mr. John B. Heim, superintendent of the city water works of Madison, Wis., points out forcibly the dangers and unfairness of comparisons of rates and costs of water in different communities when based on incomplete information. During 1903 some citizens contended for uniform rates for water by meter measurement and no minimum fixed charge, incidentally drawing comparisons between Madison with its minimum charge of $4.50 per annum and sliding scale of from 5 to 20 cents per 100 cubic feet and Milwaukee with a uniform rate of 4½ cents, neglecting to take into account many important conditions. Milwaukee has a population of 308,000, pumps its water from Lake Michigan, using soft coal at $2.90 per ton, charging $1 each per annum for reading meters and its water department receiving $127,755 for the year from various sources, in addition to the 4½ cents per 100 cubic feet for water sold by meter. Madison, of 20,000 inhabitants, obtains its water from driven wells, pumping it twice for storage with coal that costs $6.98 per ton, and its water department receives no income excepting that from water rents. The total average income per consumer in Milwaukee is $14.72, in Madison, $9.34, with average operating expenses $4.42 and $4.36. Taking all these elements into the account Milwaukee received a trifle over 10¾ cents and Madison a trifle less than 8 cents per 100 cubic feet for all water supplied during the year. In studying the question a special committee of the Madison water commissioners sent inquiries for information to 200 water departments. Statistics contained in the 135 replies have been tabulated by Mr. Heim and will be valuable for reference; his chart will be published in the "Proceedings" of the association. The conclusions drawn are that a properly adjusted minimum charge is just and necessary and that a sliding scale is the only fair and practicable way of charging for metered water, at least in the great majority of communities.

"Meters—Their Use and Benefits" was presented by Mr. Park Woodward, general manager of the Atlanta, Ga., water works, from which the following extracts are given:

Prior to 1885 there were no meters in Atlanta. The consumption of water became so great that it resulted in the necessity of adding to our pumping machinery and mains. It was known that a large per cent. of the water pumped was allowed to run to waste; and to effectually stop this waste it would be necessary to make the consumer pay for it. So we adopted then the universal meter system.

Much complaint was made at the time, it being argued that it was unjust to require water consumers to pay for meters to measure the water they paid for. But the Board contended it was the only equitable way, for it was manifestly unfair to take the money from the general tax fund to put meters on consumers in about one-third the territory of the city where water mains were laid, and therefore require those who lived out of the reach of the water supply or fire protection to pay for meters used by those more fortunate in having the comfort and convenience of water supply and fire protection and decreased rate of insurance.

The introduction of meters saved money for the general taxpayers of this city, for without their use the rate of taxation would have been increased in order to raise a sufficient amount of money to pay for an additional main, more pumping machinery and larger reservoir and other necessary additions to the plant, estimated at that time to cost approximately $150,000 or more.

As an illustration of the result of the introduction of the meter system here, the pumpage for the month of November, 1884, when we had no meters, was 132,679,900 gallons, and the coal consumed was 575,000 pounds, being an average pumpage of 4,442,663 gallons per day and the consumption of 19,166 pounds of coal per day.

For the month of November, 1885, with the meters in service, the pumpage was 48,130,000 gallons, showing a decrease in pumpage of 84,549,900 gallons for the month. The coal consumed was 256,000 pounds, showing a reduction in the consumption of coal of 319,000 pounds for the month. The reduction in pumpage was 2,818,330 gallons per day, and in coal of 10,633 pounds per day. If meters had not been introduced our daily pumpage now would be about 25,000,000 gallons per day instead of 8,000,000 as it is, and the outlay necessary to put the plant in condition to meet the demands would have been over a million dollars more than has been spent on it.

One argument against the use of meters is that it reduces the income. This, of course, depends on what is charged. A minimum rate can be fixed and a maximum amount allowed for that rate. We charge here 80 cents per month for 6,000 gallons or less, and allow a discount of 25 per cent. on all bills paid on or before the tenth of the month following the month of consumption. And we charge 10 cents per 1,000 gallons net for all used over the 6,000 gallons.

The average domestic consumption here is 3,500 gallons per month. It must be borne in mind, however, that our accounts close each month, so that the minimum rate and maximum allowance commences with the first of each month. The revenue here under the meter system has grown from $32,000 in 1886, to $178,000 in 1903, and it will be over $200,000 in 1904. And in addition to this the city service, that is, fire, sewer, public buildings and grounds, etc., used in 1903 $160,000 worth of water, the same being charged for at the rate it would have been charged had the plant been owned by a private company. Of course, no money was paid for this service, but the water department took credit for it, as they were entitled to, so as to show the actual earnings of the plant.

Manufacturers are charged a scaling rate of 10 cents per 1,000 gallons net for 75,000 gallons, and scaled each 75,000 gallons ½ cent per 1,000 gallons until it reaches 6 cents per 1,000 gallons. The estimated cost to deliver the water, counting operating expenses and interest on the bonded debt, last year was 5.7 cents per 1,000 gallons; so manufacturers get water practically at cost above 90,000 cubic feet.

Many interesting facts relating to "The Meter System in Cleveland" were stated by Mr. Edward W. Bemis, superintendent of the water works. Descriptions of the methods and results of this work have been printed in this journal, especially in the issues of September 26 and October 17, 1903. No city has ever set so many meters in so short a time as has Cleveland during the past two years.

Until last November few objections were heard to the rapid increase of meters in Cleveland. Three causes have since somewhat changed this condition: 1. Some political conditions not at all connected with meters, but which have led to an opposition in the Council to administration measures. 2. An epidemic of typhoid fever, due in very large part to the lake water, visited the city in the early part of this winter. As this was unfortunately coincident with the discussion of the meter question the amusing idea arose, and was for a short time widely held, that the meters were the cause of the typhoid. Fortunately the introduction in March of a new water supply through a tunnel running four miles out into the lake has already almost entirely stopped the typhoid and the scare connected therewith, but those desirous of prejudicing the people against the meters have introduced the matter of health in a new form by claiming that the screen embedded in our meter, the Trident, collects organic sediment and especially small fish and allows them to putrify and injure the water. Investigation has shown that no animal matter is to be found on these screens, except that on less than one meter out of a hundred a small fish may lodge in the course of a year. Usually, however, this lessens the flow of water, and the water department is notified and removes the fish. To avoid this difficulty in the future, screens are being placed at the outlets of the tunnel and the reservoirs with a ⅛-inch mesh, which will probably prevent all such trouble hereafter.

A third cause of objection to meters this year has been the freezing of many meters and metered services. This condition has not been peculiar to Cleveland. From water works superintendents all over the North have come reports of similar conditions. The Weather Bureau records show this to have been the coldest winter since the establishment of the Signal Service. The effect of this on the water department was greatly aggravated by the almost entire absence of snow since the thaw in January, which left the ground exposed to the cold. During the last few years our tappers have been instructed to refuse to tap the street mains for new services until the trench from the main to the curb was 5½ feet deep, but a large portion of the old services of the city were originally laid only 4 feet deep, or have become only that deep on account of the grading down of the street along the line of the service pipes. No special trouble, however, had occurred from freezing prior to the past winter, when the frost on some streets went down from 5 to 7 feet.

The knowledge of a meter being in place led many families to refrain from letting the water run night and day to prevent frezing, as had been customary. Our water rates are so low, being only one cent for 200 gallons, that I announced through the papers that one could permit one quart a minute to run constantly at an expense of only two cents a day, or $1 for the fifty days when the most of the freezing occurred, during January and February. Many misunderstood this, and allowed a large stream to run, and are now claiming that they should not be charged for it, as they did it by what they thought was the authority of the department. Many others, however, did not let their water run constantly, and their service pipes were so poor that they froze in the unusual winter weather.

The meters themselves, in many cases, were not set properly in the sewer pipe setting. The meter hitherto, when placed outside and not in brick vaults, was enclosed in 4 feet of sewer pipe 15 inches in diameter on the inside. Risers came up from the service pipe to the meter, the top of which was only 18 inches from the iron cover. Resting on the top of the meter was a loose wooden cover. Within the entire 4 feet of sewer pipe there is no earth, but merely an air chamber.

With 979 settings in such sewer pipe in the winter of 1902-3 not one froze, but during the past winter 1,226 out of 10,423 set in sewer pipe, or 11.7 per cent. froze, as compared with 136 out of 4,483, or 3 per cent. set in brick vaults and 165 out of 9,727, or 1.7 per cent. set in basements. To be sure, this is not a fair comparison, at least as between sewer pipe and basement settings, since meters were only set in basements where the latter were in good condition and gave promise of being free from frost. In the older sections of the city where the service pipes were near the surface, the sewer pipe settings were almost universal.

Unmetered services also froze in large numbers in the same sections of the city in which the metered services froze in largest numbers. Still, after all allowances are made, we believe that there were two defects in the sewer pipe setting which are now being remedied as fast as possible. First, the wooden meter cover did not fit tightly enough; indeed, it often became tilted as it rested loosely upon the meter. We are now substituting a wooden rim tightly caulked by oakum against the sewer pipe. Attached to the rim, which is about one inch thick, is a hinge, which is also attached to an inner wooden cover that comes down to the opening of the wooden rim on a bevel, and fits so tightly as to give promise of being almost air tight. This wood is being subjected to a chemical treatment. This wooden cover is only one foot below the iron cover, and cannot be left up against the sewer pipe or the iron cover, so that the meter reader will be obliged to put the wooden cover in proper position before leaving. In some sections of the city where there is most danger of freezing an extra foot of sewer pipe is to be placed underneath the 4 feet that we now have, and a cross brace of wood is to be used part way down the riser to keep everything in place.

Of our meters and metered services, 60 per cent. more froze on the south side than on the north side of the streets running east and west, as was to be expected, but about the same number on each side of the streets running north and south. Of 2,904 services that froze—although in about one-half of the cases the meters did not freeze—40 per cent. were on the south side of the streets, 25 per cent. on the north side, 18 per cent. on the east side, and 17 per cent. on the west side.

The thawing of services was done mostly by four electrical machines. Three of them obtained their current from the street railways, at a cost of 6 cents per kilowatt. This current was of 300 amperes and 5 volts, or a total of 1.5 kilowatts per hour. In cases where the wires, nearly 1,000 feet long, could not reach from the trolley to the meter we used a steam machine to furnish power to the dynamos. This machine of 12 horse-power had just been purchased for other uses of the water department and was easily transported on wheels. The total cost to the department of repairing meters and thawing out the services has been $11,520, or about 46 cents per meter, if distributed equally over the 25,000 meters in place. Of this sum about $3,500 has been required for inspection, taking out frozen meters, or those where only the service was frozen, repairing the meters either in place or at the shop, and resetting them. The machines thawed out 1,164 metered services and 349 unmetered, or a total of 1,513, at a cost of about $7,700, or about $5 per service. Private plumbers thawed out a few metered services, and many more unmetered ones.

The average costs of setting meters have been as follows, for a ⅝-inch meter, exclusive of the meter: in basement, materials $0.72, labor $3.23, total $3.95; in brick vault, materials $6.54, labor $2.92, total $9.46; in sewer pipe, 1903, materials $3.61, labor $4.01, total $7.62; in sewer pipe, 1904, improved setting, estimated, materials $4.32, labor $4.51, total $8.83.

It is too early in the history of the domestic meters in Cleveland to determine the results to the consumer. At the semi-annual collection last October only 8 per cent. of the entire number of houses metered paid more than under the assessment rate. Two-thirds of 1 per cent. paid the same, and the other 92 per cent. paid less. Twenty-four streets were selected with a good class of houses where nearly every home had been metered for over a year. On these streets having an average annual assessment of $11.83, the 825 families were paying under our system of minimum charges $7.36, or 62 per cent. of their old assessment rate, and they were using only $3.95 worth of water per year, or 33 per cent. of their old rate; that is, they were using on the average only 9,875 feet per family per year, or 202 gallons per day. In a class of houses considerably poorer on eight streets were 172 residences, the average assessment rate being $7.64 per year, and the payments under the present minimums are $5.38, or 70 per cent. of this, and they are using on the average only $2.61 worth of water, or 6,525 feet per year. This is equivalent to only 134 gallons per day per family.

Finally the 648 metered places on 23 still poorer streets have been investigated for the year ending April 1. Their annual assessment averaged only $6.14. They are now paying $4.66, or 76 per cent. of the above, and are using an average of only $2.32 per year, or 5,800 feet. This is equivalent to only 120 gallons per day per family, or probably only 25 to 30 gallons per capita. The better class of houses would only pay 33 per cent. of the assessment rates if there were no minimum, the next poorer class of houses would pay 34 per cent., and the still poorer would pay 38 per cent.

"Experience with Growths in Water Mains," by Owen T. Smith, secretary and superintendent Water Company, Freeport, Ill., tells of persistent troubles with growths in water pipes and driven wells which apparently affected even a few meters, and how the difficulty was overcome. In the fall of 1895 the water supply of Freeport, Ill., suddenly acquired a bad taste and odor, which could not be accounted for in the ordinary way, the supply being from wells in the drift along the river bottom. The mains were flushed and the suction pipe cleaned by a large flue brush, made to order.

We could not locate the seat of the trouble for some time, until finally we gathered a sample of water, with a yellowish brown matter floating in it, and sent it to the State University, at Champaign, for analysis. The chemist reported the water not bad, but that the floating matter was known as crenothrix kuhniana, or well thread, which had given trouble in some parts of the United States and a good many places on the continent of Europe. We found that the growth depended upon the iron in solution in the water. We also found that it required about .30 part per million of the iron, in order to feed the growth.

We flushed the mains and the system thoroughly very often during the season and kept the growth down as much as we could in that way, but the service pipes and small mains began to fill up and, in some cases, shut off the flow of water entirely. Finally we arranged with the New York Continental Jewell Filtration Comapny to erect a small experimental plant at the works, to ascertain just what could be done by filtration.

In the various analyses of the raw water which were made during these experiments, the amount of iron varied greatly, being as much as nineteen parts per million in the outskirts of the system, while at the pumping station and in the city, upon some of the large mains, the amount was much lower, the minimum being .4 part per million. The largest quantities were in water from dead ends. Free carbonic acid averaged 21.4 parts per million in the raw water. In the effluent from the filters the iron content averaged .045 part per million, and there was no carbonic acid. The quantity of iron remaining in the filtered water being well within the limit below which several chemists believed the crenothrix could not live, a contract for a permanent filter plant was eventually made with the same company. This plant was built in the spring and summer of 1903. Lime water is used as the coagulant, in the proportion of two to four grains per gallon. The iron is reduced to an average of .04 part per million, all carbonic acid gas is removed and the water softened 13 to 15 per cent. The growth has been absolutely stopped.

The old growth has given us considerable trouble by sloughing off and making the water roily and bad, yet by heavy flushing, this trouble has been very largely removed and we find now where we have cut the mains that, while there is a little of the old growth still remaining, yet a large percentage has been removed by the flushing.

We have some photographs of a meter which had been on a service where the supply was almost altogether stopped, which shows the condition of a large number of our services, before the filter plant was installed. These pictures show an accumulation of the crenothrix on the working parts and the inside of the meter case.

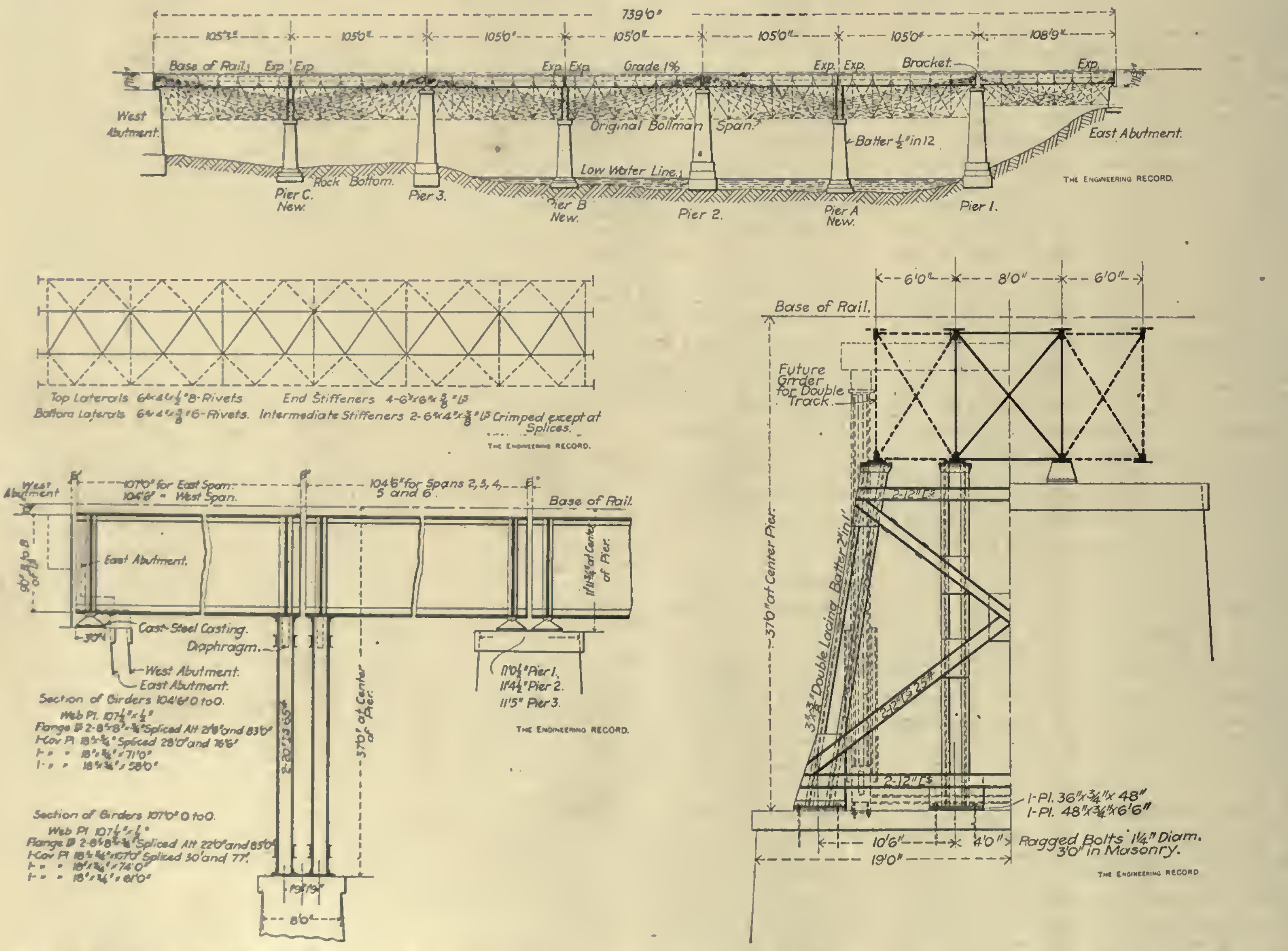
"Private Fire Systems" were discussed by L. N. Case, manager Water and Light Department, Duluth, Minn. The following paragraphs from this paper describe the method of regulating and the system of charging for this class of services which have been in satisfactory use in Duluth for two years.

At the head of the lakes are a large number of saw mills, lumber yards, elevators, ore docks and railroad properties, besides large buildings, all of which are equipped, or being equipped, with different kinds of systems for the suppression of fires. Most of these are of what is known as the "wet" or "dry" sprinkler system, with storage tanks of various capacities; some are equipped with simply a pipe line with hydrants, and some with independent lines with hose connections on the different floors.

It is required that a written application be made for each of these services, and, if such application does not state clearly that the system is entirely independent from the ordinary supply, that the service be metered. This application also contains an agreement by the applicant to pay the rate established for the privilege accorded and for expense of inspection, running from $5 to $50 per annum, and to pay also for all consumption of water used or wasted from the system, other than for the actual suppression of fires, at the regular schedule of rates. When the application is received and the permit granted, all openings and valves controlling the system, if found necessary, are sealed with the ordinary copper wire and lead disc attachment, which are inspected monthly or oftener if we have any reason for thinking they are being tampered with.

In addition to this, in order to discover if, and to what extent, water is running away through any cause we require a by-pass on the valve controlling the system, and on the by-pass is installed a ⅝-inch meter. Once each month, or oftener, if necessary, the large valve is closed and a record made of the registration of the meter, if there is any. If the meter indicates a consumption of water, one hour's registration is recorded, and a notice is served on the firm of the above conditions. Every five or ten days thereafter a registration is taken and at the end of the month a bill is rendered of a continuous consumption indicated by readings above referred to.

Now, as to the regular charge made: If the system consists of mains ramifying through grounds and buildings, the charge is invariably $50 per annum. If it is a building only, a charge is made upon the basis of the capacity of the system, including tank and pipe lines. With onr schedule of rates, four times this quantity for an annual consumption is sufficient to reimburse the department for all expenses. It is to be remembered in this connection that the city pays the department a hydrant rental from the tax levy.

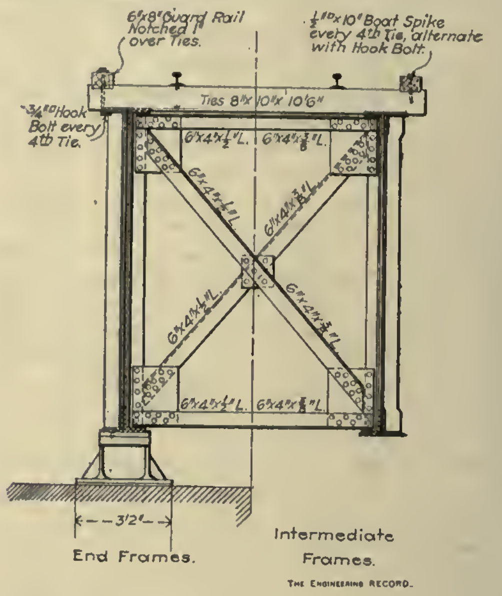


The Monocacy River Bridge, Baltimore & Ohio Railroad: Diagram Showing Old Trusses and New Girders; Details of Girder Supports.

The Monocacy River Bridge.

The Baltimore division of the Baltimore and Ohio Railroad crosses the big Monocacy River on bridge 38 A of the Metropolitan branch. This structure is 739 feet long and carries a single-track on a 1 per cent. grade. It originally consisted of four Bollman truss deck spans with three masonry piers between the abutments. In the recent renewal the superstructure was replaced by deck plate-girder spans supported on the old piers and abutments and on three new intermediate piers at the center points of the old spans. The new structure was built and the old one removed without diverting the trains or interrupting the traffic. In order to do this the new piers were built only as high as the lower sides of the old trusses, and carry the ends of the plate girders on vertical steel trestle bents which were designed to clear the old trusses and be erected without interfering with them. The new spans have sliding expansion seats at these points and at the other ends are pin-connected to fixed pedestals on new seats prepared on the old piers.

The trestle bents are composed of independent vertical and battered posts braced by horizontal and diagonal pairs of channels field-riveted across their faces. The girders are 105 and 108 feet 9 inches long and have a uniform depth of 9 feet over all. They were made with web plates ½ inch thick and flanges each composed of two 8x8x¾-inch angles spliced in two places and reinforced with three 18x¾-inch cover plates 58 feet, 71 feet and 104½ feet long, respectively. All girders corresponded except in the lengths of the materials. They were designed for a live load of two 177½-ton locomotives followed by a train load of 5,000 pounds per linear foot. They were built of open-hearth steel and were proportioned according to the standard specifications of the Baltimore and Ohio railroad, based on a unit stress of 16,000 pounds per square inch in tension. The structural details conform to the railroad company's standards.

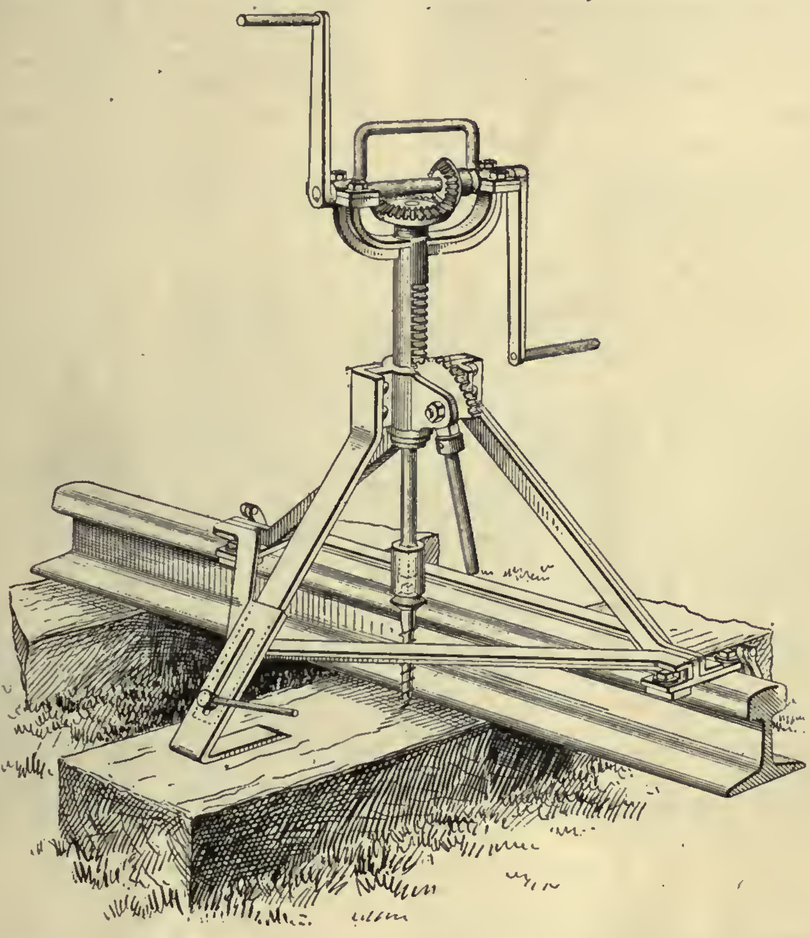


The bridge was designed to be, at present, a single-track structure, but is built so that it may hereafter be transformed into a double-track bridge by the addition of two more lines of girders outside the present ones. The girders are braced together by ordinary vertical trans- zigzag lateral angles. The total weight of the verse frames and by 6x4-inch top and bottom structure is about 1,200,000 pounds. It was designed and constructed under the direction of Mr. J. E. Greiner, engineer of bridges and buildings, and was built and erected by the Pennsylvania Steel Company.

Machine for Driving Screw-Spikes in Railroad Ties.

The efforts of the Bureau of Forestry of the United States Department of Agriculture to conserve the timber resources of the country have been directed along many of the lines on which this class of materials is used in large quantities. Among the subjects of investigation much study has been given to methods of increasing the life of railroad ties, including improved devices for fastening the rails to the ties. It is stated that the screw-spike is now used on practically all railway systems on the continent of Europe, in one form or another, either exclusively or in combination with bolts or ordinary spikes. In The Engineering Record of October 24, 1903, brief mention was made of machines for driving screw-spikes rapidly, two of which had then recently been made for the Pennsylvania and the New York Central railroads. The detailed design for these machines was drawn by Prof. A. L. Smith, of the Worcester Polytechnic Institute, and the machines are being built by the Washburn Shops, connected with the Institute. A full description of this device, together with much kindred information, is contained in the recently-issued Bulletin No. 50 of the Bureau of Forestry, Mr. Gifford Pinchot, forester, entitled, "Cross-Tie Forms and Rail Fastenings, with Special Reference to Treated Timbers," written by Dr. Hermann von Schrenk.

Reference to the accompanying drawings, together with the following description, taken from the Bulletin, will make the design and the method of operating the machine quite clear. The principal parts of the machine are a small steel tripod, a vertical spindle rotating in a sleeve sliding in the head of the tripod and the cranks actuating the spindle through a pair of bevel gears. Two feet of the tripod rest on the rail-head and are each clamped to it by means of a hook and set-screw, while the third foot rests on the tie into which the spike is being driven and is adjustable to allow for variations in the level of the upper surface of the tie and for different heights of rails, so that the spindle may always be vertical during operations. The other two feet are adjustable so as to accommodate railheads of various widths in order to locate the axis of the spindle in correct position relatively to the flange of the rail and prevent lateral movement of the machine while driving the spike. The legs of the tripod are strongly braced. By simply loosening the hook clamps the machine may be slid along the rail from one position to another, for when it is canted on the rail by lifting the foot which rested on the tie, the clamp hooks by action of gravity swing free from the railhead. On the other hand, when the machine is restored to the vertical position, the hooks swing back into place ready for clamping.



Perspective View of Machine for Driving Screw-Spikes into Railroad Ties.

The vertical sleeve slides through a collar in the top or head of the tripod, and has cut on one side of it a rack which meshes with a segmental gear rotating on a pin in an arm projecting from the collar, as shown. A lever is attached to this gear, and the combination forms the feed for raising and lowering the sleeve, and with it the spindle. A yoke fastened to the top of the sleeve supports the cranks and the bevel gear, also a handle which the workman can grasp with one hand to steady himself and the machine as he turns the crank with the other hand. The sleeve can slide vertically in the head of the tripod, but is prevented from rotating by a key; the spindle can rotate in the sleeve, but cannot slide up nor down in it. This machine is not limited to hand operation, but can be arranged for power driving.

The machine having been properly set up on the rail at any given tie, the feed lever is depressed so as to raise the sleeve and spindle. Then the screw-spike is put in place and the spindle lowered by means of the lever until the socket at the bottom of the spindle engages the head of the spike. As the spindle is rotated by the cranks it is fed downward by the weight of the parts, assisted by an upward pull on the lever. Instead of the screw-spike the shank of a drill may be inserted in the socket for boring holes in the ties for the spikes, or for any other purpose desired.

A test recently made on the Pennsylvania lines with one of these machines showed that it could put in two screw-spikes while three ordinary spikes were being driven. Although this operation required a little more time than the driving of the ordinary spikes, it is claimed that the saving secured by avoiding the tearing of the ties much more than offsets the loss of time.

According to the bulletin, the chief objection which can be urged against the screw-spike at the present time is the matter of boring holes. In Europe this is done almost without exception at the treating plants, by the machine which adzes the tie. In this country, with the numerous different rail sections used on almost every railroad, it will not always be practicable to bore the holes in advance, and some method will on that account have to be devised for boring holes out on the track by machinery.

The Bureau of Forestry recently made a number of tests of the pulling strength of spikes at its timber-testing station at Purdue University, the details of which are given in the bulletin. The tests with ties of several different kinds of wood showed that the resistance of the screw-spikes to pulling was 1.87 times that of well-driven common railroad spikes in white oak and 4.63 in longleaf pine, the ratios for other kinds of wood falling between. The maximum resistance of the screw-spike to pulling is given as about 13,000 pounds in white oak.

Tests were also made to determine the relative effects of a side blow upon rails held by the two kinds of spikes. The results are said to have shown that a common spike is pulled out from 1/4 to 1/2 inch, while the screw-spike is not perceptibly started, the blow for purpose of test being that of a 500-pound weight dropped 3 inches against the side of the railhead. On the Eastern Railway of France the screw-spike is dipped in tar oil or tar oil is poured into the hole just before the spike is driven. The screw-spike used has a tapering enlargement in the upper part of its shank, and holes of corresponding shape are bored in the ties, so that when the screw is dropped into the larger part at the top of the opening it will stand practically vertical. Great care is taken in making the final turn of the screw not to turn it too far, which would destroy the thread made in the wood.

After the newly-driven spikes on newly-laid track have been in position for a few weeks they have to be tightened. This is not because the screws have loosened, but because the ties, tie-plates and rails have been forced more closely together under the action of the trains. After the screws have been tightened they remain so for long periods. On the railway mentioned the section crew once a year goes over the track with great care, testing and tightening each screw.

The Disposal of Strawboard Waste.

A particularly troublesome source of contention among various interests in Indiana, Ohio, and Illinois is the effect of waste from strawboard, or, as they are more commonly called, pasteboard mills, on surface waters. Desirous of determining whether or not this strawboard refuse is a source of damage to interstate streams, the United States Geological Survey recently made, through its division of hydro-economics, a careful study of the process used in the manufacture of strawboard, the character of the refuse, the nature of the pollution produced, the consequent damage to the stream, and the possible means of preventing such pollution. The results of this investigation are embodied in a report made by Prof. Robert Lemuel Sackett, of Earlham College, Richmond, Ind., which will be published by the Survey in the near future. Briefly the results show that strawboard wastes have damaging effects, but the problem of purification offers no great difficulties.

The principal factories in the United States are confined to a comparatively small area. Indiana, Ohio, and Illinois make 83 per cent. of the board produced in the United States, and Indiana alone produces nearly 50 per cent. of the total. After these three leaders, New York, Maryland, and Michigan rank next in order of production. The census record of 1900 shows that there are 59 strawboard factories in the country, which used 157,534 tons of raw material to make a finished product valued at $3,187,342.

Strawboard waste is an extremely stable substance, which does not degenerate when kept in clean containers, but when mixed with substances of a putrescible nature, such as sewage and other organic matter in streams, it becomes extremely foul and objectionable. The waste liquors from the mills are ordinarily discharged into neighboring streams. The result depends upon the character and volume of the water in the stream. As many Indiana rivers flow over limestone beds, their water is hard, carrying 15 to 20 grains of lime to the gallon. The waste liquor from a strawboard mill where wash water is not plentiful sometimes contains 200 or more grains of lime to the gallon. In order to reduce the quantity to 40 grains a gallon, the minimum stream flow would need to be about ten times the volume of water employed in the manufacturing process. This limits the number of streams upon which such mills can be operated in the present manner, without nuisance, to a few rivers in each State.

Artificial drainage, the destruction of forests, and the eccentricities of rainfall have made the flow of rivers of the Ohio basin extremely low in the late summer and fall. Some streams, indeed, cease to be more than isolated ponds. Under these circumstances the discharge of sludge produces serious pollution.

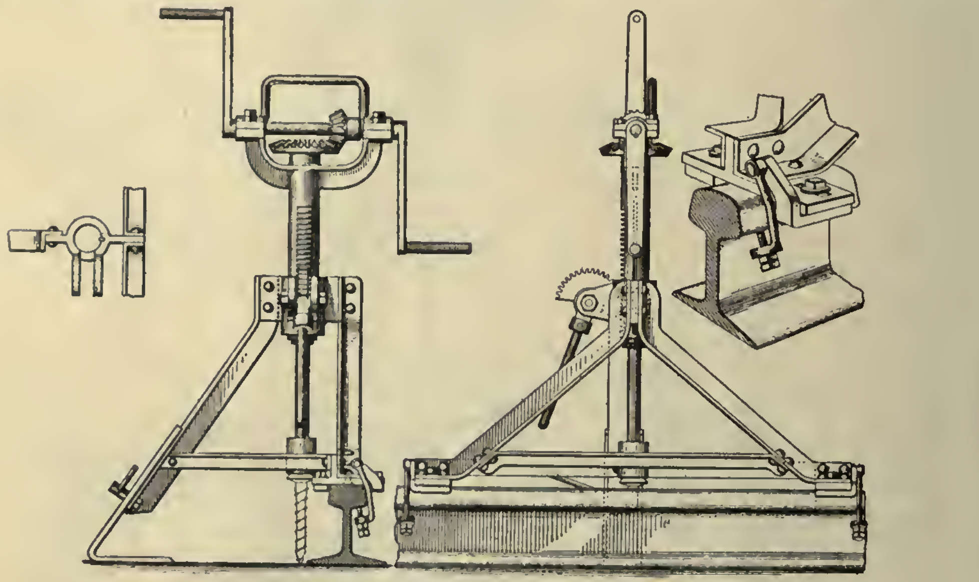
The interests of the States are concerned in this pollution of streams by strawboard mills, for the strawboard refuse is destructive of fish, water supply and ice crop, and lowers the value of real estate that lies near the polluted stream.

Some manufacturers have run the waste into a series of beds scooped out of a gravel bottom land. Here the straw and lime slowly settle while the water filters through the subsoil and eventually finds its way to the neighboring creek. But the great quantity of straw wasted soon clogs such natural filters and dependence is placed upon high water to wash the refuse out of the beds. It is then deposited on other lands below, so that this method is only a makeshift. What a carefully constructed settling and filtering plant may accomplish has not yet been absolutely determined, although the American Strawboard Company made experiments in that line during the summer of 1903.

The experiments of the Geological Survey have demonstrated that there are two possible methods of purifying the waste—filtration and chemical precipitation. Simple sedimentation is not effective. Neither is simple filtration, but this, when combined with chemical precipitation, is an aid to the process. Chemical precipitation appears to be entirely effective and is satisfactory in every respect except that of cost.

The most effective chemical precipitants for purifying strawboard waste are the sulphates of iron and alumina, but they must be used in such large quantities that they make the cost of the process prohibitive. Neither lime nor carbon dioxide is of value as a precipitant, but a combination of carbon dioxide and milk of lime is effective when properly applied. The process can be economically maintained if conditions are favorable, and it will secure the removal of 75 per cent. of the suspended material. Higher efficiencies can be obtained by slower rates of operation and by the use of sand filtration, which would be necessary, however, only in extreme cases.

The objection raised by the officials of the United Box Board & Paper Company to the processes suggested by the Survey is based on cost. They maintain that the different kinds of box board now on the market are so evenly balanced in cost of production and competitive selling price that the additional expense incurred in manufacture as the result of adopting this process would drive strawboard from the market.


Side and Front Elevations of Machine for Driving Screw-Spikes.

It is hoped that the experiments made may stimulate interest in the question and may lead to further investigations tending toward a practical solution of the problem that may be satisfactory to all the interests involved.

An Artesian-Well Water-Supply that is remarkable from the fact that it can be used without treatment for feeding steam boilers is obtained from a 700-foot stratum under New Orleans. It is regularly delivered to the boilers of one of the stations of the New Orleans Railways Company. Its analysis is as follows, the figures being grains in one gallon: Chloride of sodium, 6.16; carbonate of soda, 14.36; carbonate of potash, 0.14; silica, 1.57; organic matter, 1.75; total solid, 25.31; free carbonic acid, 1.36. The station in question has a boiler plant of 4,400 horse-power in water-tube boilers, part burning oil and the rest mechanically-fired coal.

An Architect's Picturesque Office.

A quaint wooden building, intended both as a bachelor den and a private business office, has recently been built on the lawn of Mr. E. C. Webster's residence at Orono, Me. Particular effort was made to secure a unique design, and it was at first proposed to build it like an old-fashioned log camp for lumbermen. Afterwards, it was suggested that the conditions afforded an excellent opportunity to copy the old style of Swiss chalet, and considerable pains were taken to study the details of such buildings and to make this structure conform to them, even in minute particulars. It consists of a single room, 20x25 feet inside, with the walls built of 8x8-inch sawed pine timber in single lengths of about 24 and 29 feet, notched at the corners to lock together and build solid courses. The faces of the timber were adzed by old-time adzmen, so as to correspond exactly with the timber used in such structures two or three centuries ago. Each course was fastened to the next lower one by intermediate vertical wooden pins. The roof is of grooved and splined planks laid on rafters which rest directly on the upper timbers in the walls, project about 6 feet beyond them, to shelter the piazzas on each side, and are covered with cedar shingles. At the gables the side timbers have cantilever ends projecting farther and farther beyond the walls in the top courses, so as to form brackets carrying two rafters outside the walls to support a clear area of roof projection. The interior is a single room, open from floor to roof. The upper part is crossed and the tops of the side walls are tied together by heavy beams, which are kneebraced to the inner ends of bracket timbers which project from the faces of the side walls. These kneebraces and the ends of the bracket timbers have curved surfaces carefully chiseled by hand to imitate the ornamental scroll work formerly used in Switzerland.

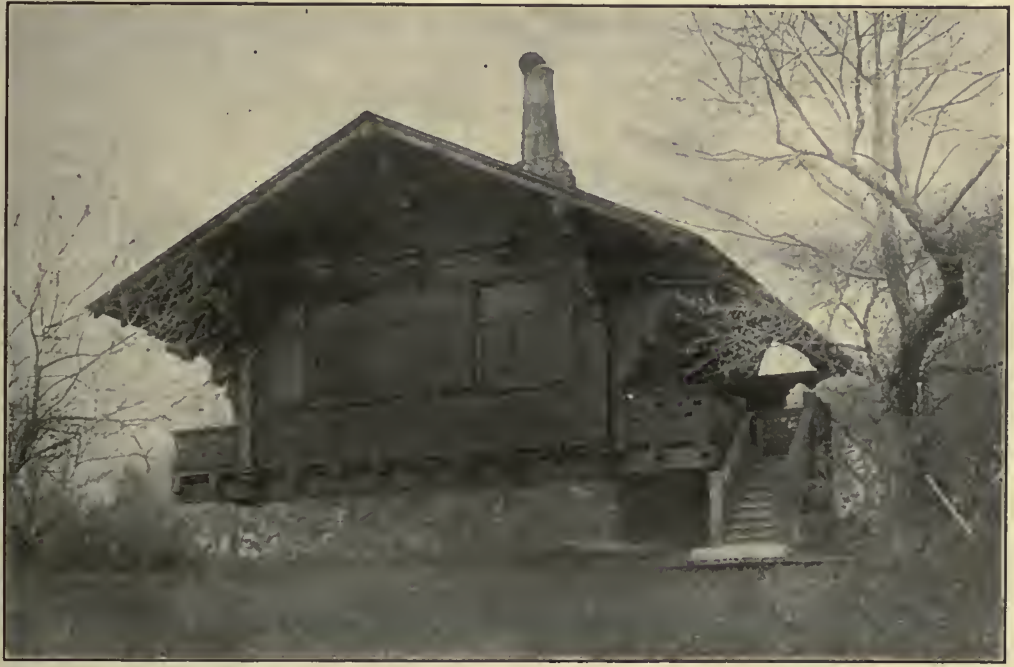
Very few nails were used in the construction, which was chiefly fastened with ash pins, from ¾-inch to 1 inch in diameter. The timber sills are supported on foundations of rough stones. These were taken from old walls, and care was exercised to avoid disturbing the moss on them. The cracks between the wall timbers were calked with oakum. The exterior was stained slightly to give it a weather-beaten appearance, and the interior was left natural without ceiling, plastering or other finish. The windows are glazed with the smallest size panes of glass, and their sashes and the doors and frames were made by hand by Swiss mechanics. The massive locks and latches for the doors and other hardware were of artistic design.

The veranda, at the entrance on the side, is several feet above the ground and its heavy floorbeams are chiseled and carved on the ends and are supported by carved kneebraces. The railing is of a very old design and is essentially a solid parapet wall, made with thick vertical planks pierced with ornamental openings. A fireplace near the center of the building is built of rubble masonry and has a stone hearth supported on the heavy floor girders. It will accommodate large logs and it is located and the furniture around it so arranged as to practically form a partition enclosing a portion of the room for the owner's private office.

A log cabin, built on the wooded shores of Phillips Lake, Town of Dedham, Me., is of simple and economical construction, in which considerable pains have been taken to secure artistic effect and provide a comfortable hunting and fishing lodge for summer and winter use. It is 25x20 feet inside and is one story in height, the front portion being a single room, open from floor to roof. The walls are made of spruce logs, from 14 inches in diameter at the bottom to 10 inches at the top. These were cut in the winter and retained life enough so that in the spring the sap started and loosened the bark and enabled it to be easily peeled. The logs are crossed at the corners and locked together, the under sides only being notched to fit the convex upper surfaces of the lower courses, thus avoiding any possibility of the leakage or collection of water, which often causes decay at these points. All horizontal joints between the logs were calked with oakum, outside of which triangular battens were driven to secure it.

Round transverse beams were built into the side walls at a height of about 7 feet above the floor and supported the board floor of the loft in the rear. The roof was built with three slopes on each side, giving it almost a segmental cross-section and affording increased height in the loft. It has round longitudinal purlin logs at each angle supported by intermediate vertical posts from the floorbeams and covered with matched board, shingled. The end walls are carried up only to the height of the eaves, and above them the gable ends are built with round vertical studs sheathed with horizontal boards, covered with tar paper, outside of which vertical split poles or slabs are nailed to give it the required rustic appearance.

The roof projects 6 feet beyond the front gable and 4 feet beyond the rear gable, where the upper courses of side wall timbers are corbeled out to carry the overhanging rafters. The fireplace and chimney are built of rough stones, laid in lime mortar, the former having a brick lining for the stone arch. The masonry is carried through the floor to footings in the earth and stones projecting from it form brackets, on which the floors are supported so as to prevent unequal settlement. The main floor is divided into different rooms by wooden partitions and burlap curtains, and a loft is built over the rear portion of it only, sub-divided in the same manner into sleeping rooms. Access to the loft is obtained by a Jacob's ladder of unique design. This consists of a single pine log about 16 inches in diameter, which is inclined about 20 degrees from the vertical. The flat steps are notched into it by cutting away about three-quarters of the cross-section on alternate sides, thus making comfortable supports for one foot and leaving a continuous quarter section of the timber to carry the load. At the main entrance is a Dutch door, fastened by a heavy hardwood latch operated from without by the old-time latch-string, the door handles being made from crooked hardwood pieces of natural growth. In the front portion is a large wrought-iron chandelier of unique design, having brackets for candles, and supported from the roof purlins by chains. Both buildings were designed by Mr. W. E. Mansur, architect, Bangor, Me., the latter being for his own use.



A Picturesque Office for an Architect.

A Cable Road nearly 4,000 feet long forms part of the electric traction system of Palermo, Sicily, to assist the cars over a grade averaging 12 per cent., with 13.17 as a maximum for about 650 feet. The cable passes around a wheel fixed at the top of the grade, and each end is attached to an electric locomotive weighing 8.7 tons. In operation a car is coupled to the locomotive at the top of the incline and another car to the second locomotive at the bottom, and the two pass at a turn-out at the center. At the bottom the locomotive descends into a pit between the running rails for the cars, the rails for the locomotives lying between the others. The car to be hauled upward passes over the locomotive, so that it can be on the upward side of the locomotive on reaching the upper limit of travel. One car descends as the other ascends.

Letters to the Editor.

The Newport Steam Turbine Tests.

Sir:—I was very much interested in the report of Mr. Barrus' tests, presented in your issue of May 14, on the steam turbine plant at Newport, R. I. The results given in this report are certainly excellent and should furnish added impetus to the turbine industry in this country.

In closely examining the results, however, I find that in no case is mention made of the vacuum which was carried during the various runs at full and fractional loads and under varying conditions. It is hardly probable that these tests were made under non-condensing conditions, and I therefore assume that the vacuum was omitted either intentionally or through an oversight.

These data are particularly necessary in properly interpreting the results, as it is generally understood among engineers that the economy of the steam turbine is very considerably affected by the vacuum or exhaust pressure. The results of the tests might, therefore, very readily be better or worse than they appear, were the true vacuum known under each specific condition.

Yours truly, William S. Johnson.

Boston, May 26.

[A statement on this head by Mr. W. L. R. Emmet reads as follows: "During tests the steam pressure was about 145 pounds and the vacuum about 95 per cent."]

Health Conditions on the Isthmus of Panama.

Sir:—The article on health conditions on the Isthmus of Panama, by Dr. Gorgas, which you have been so fortunate as to secure for your paper, is most timely and interesting. Because of the source from which it emanates, it is authoritative, and will certainly be indorsed by all who have lived in tropical countries, as being quite in accordance with general principles.

I believe Dr. Gorgas to be perfectly correct in relegating yellow fever to a secondary place among the dangers to health to be encountered on the Isthmus, and putting malaria, with its attendant anæmia, in the front rank. Yellow fever is avoidable and curable. Malaria can scarcely be said to be either. Before the war, in Havana, yellow fever was endemic, and many deaths occurred every year, notably among the soldiers of the garrison. It was then a saying that no captain-general nor archbishop had ever died of yellow fever, which was only another way of saying that the disease was chiefly confined to those living in poor, badly ventilated habitations, uncared for and improperly or insufficiently nourished. When about to pass my first sickly season in Havana, while building the new waterworks for that city, I asked Dr. Burgess, the U. S. Health Officer, and a practitioner of long exerience, what risk, if any, I was running, and he replied, "None whatever." It was considered improbable, at that time, that any one living in thoroughly perflated apartments, well and properly nourished, and of regular habits, should contract the disease, while a cure was regarded as certain if medical attendance was promptly called in and good nursing obtained. I think any old resident of Havana will bear me out in these assertions. Every credit is due to the American authorities for the intelligent and energetic measures which have resulted in practically banishing the *fiebra amarilla* from Havana, but their work was half done when the Spanish troops were withdrawn. I have always considered that there was less danger in Havana from yellow fever in the sickly season than in New York, in winter, from pneumonia.

The great danger in a long residence in the tropics is the gradual lowering of the tone of the system and a reduced vitality, leading to anæmic symptoms. In inquiring after the health of friends in those days one would be informed that they were suffering from an attack of anæmia, the condition being referred to as if it were an ordinary indisposition. Malaria is, of course, the predisposing agent in bringing about this undesirable state, but climatic conditions will always make it the characteristic danger of the tropics.

Yours truly, E. Sherman Gould.
Yonkers, N. Y., June 6.

The Technical School and Engineering Practice.

Sir:—The consideration which The Engineering Record has lately given to educational problems has been a great satisfaction to the writer, as it must have been to others interested in the welfare of technical schools. At this season of the year, when so many newly-made graduates are taking their first plunge into the current of practical affairs, it seems particularly profitable to consider ways of spanning the gap which still exists between the college and the outside world. It surely is an "old graduate's" privilege to deliver himself at such a time of some convictions which several years' experience has settled upon him. None the less does the writer appreciate the space granted him, in view of former discussions.

A very limited acquaintance with professors of engineering convinces one that their lot is not a sinecure. While the foundation principles which underlie every branch of applied science remain fixed, it is a difficult task to keep thoroughly posted upon the details of apparatus and method which are all important in the domain of practice, so constant are the changes in design and application. As an illustration, let us call to mind the development of telephone central office equipment, from the early days of magneto signaling down to the present lamp signal, central energy multiple boards, which are in turn being threatened in supremacy by "automatic" exchanges. It is pretty safe to say that the average professor of electrical engineering would find himself completely "floored" if one of his students should ask a detailed explanation of either the circuits or the operating sequence of events which accompany a single conversation between two subscribers in a modern city exchange. We can scarcely blame the professor, for his days and nights are taken up as it is by work which leaves little time to follow the advancing progress of specialized branches like telephony. The student joins a telephone company and spends several years in unraveling circuits before he can promptly locate a fault in an underground cable or a central office switchboard.

In his own technical course the writer would never have seen the inside of a car controller or had the remotest conception of its circuits if he had not worked out its connections in a holiday period on his own account. The laboratories were tolerably well equipped, but rheostats and motor starting boxes were the nearest approach to anything like the controller. If the writer had not possessed this knowledge in the four years which he spent in electric railway practice, it would have been impossible for him to perform either the theoretical or practical work in rapid transit motor and equipment problems which fell upon his desk.

A common fault of present-day scientific education is found in the segregation of departments which fails to take account of their interrelation. Enthusiasm in the teaching specialist is an absolute necessity if success is to be attained in preparing students for engineering work, but it is a grave mistake to overlook the connection of the subjects which make up the curriculum. Thus, scores of mathematical problems are presented which have no more bearing upon engineering questions than the depth of the Pacific Ocean at the Hawaiian Islands has upon the annual rainfall in New York. Innumerable problems in the mathematical courses are of necessity apart from the conditions of practice, but the writer believes that just as much mental training can be obtained in the solution of a stress diagram for a roof truss as can be secured by wasting time and energy over the distance an imaginary fox will run in a hyperbolic path when pursued by a pack of hounds, also imaginary. Certainly the tractive power of locomotives is as worthy a foundation for mathematical problems as considerations of the probability of drawing an ace four times in succession from a theoretical pack of cards.

Mechanics is a hard subject to teach, and yet it lies at the bottom of practically every engineering problem. The lack of a good course in this important study is felt by the graduate for many years after he takes his diploma and goes out to conquer the world with that potent weapon—the slide rule. It is a notable fact that mechanics as we encounter it in practice is one of the most fascinating subjects in the world, and yet it is one of the dullest studies in the curriculum, in many technical schools. There seems to be no life about its problems. Surely the great railway systems offer questions unending in rolling stock design and operation available to the mechanics course; the power transmission, lighting and electric railway companies afford countless opportunities for practical electrical engineering problems to be solved; and bridges, permanent way, waterworks and railway tracks from the marshes of New England to the Continental Divide offer the embryo civil engineer innumerable occasions for both field work and calculation.

One of the best ways of opening the college windows to the stimulating air of the outside business world is the arrangement of lectures to be given before the entire student body by distinguished practising specialists in the various departments of engineering. Long ago the medical and legal professions were thus drawn upon by the schools, but the engineering schools have required extended time to realize the importance of the messages which the leaders in scientific and commercial activity can bring to their platforms. It is no small privilege and inspiration to the earnest student—and there are few who are not earnest in the technical school—to be brought face to face with the personalities of men who stand for achieved results in the competitive arena of professional life. Such men realize, as few teachers can, the trend of practice, the cost of great enterprises and general economic questions of design and operation, and in so far as they are willing to place their experience before the college student, do they span the gap between academic education and business experience. It is a sign of the times that college authorities are growing more and more to appreciate these facts.

The solution of commercial problems by the college laboratory is also coming to the front as an undertaking mutually beneficial to the engineer, the student and the teacher. The calibration of instruments and testing of materials are but two illustrations of what is and may be done in the way of bringing the world and the school into closer touch. Still another benefit is secured when the professors enter consulting practice to a reasonable degree, and perhaps one of the most productive methods of all to bring the student into better harmony with practical work is the inspection trip to neighboring or distant installations, which are in actual operation. Such trips must be planned and carried out according to fixed schedules, talked over afterward, and not be allowed to degenerate into junketing expeditions, if the highest return upon the investment of time and money is to be secured. Lastly, the technical journal and the professional club, properly used, are two efficient aids toward a better understanding of what comes after graduation. The professor may do his best, but the educational problems of to-day are so exacting that additional help must be pressed into service.

Yours truly, Technical Graduate.
Denver, Col., June 2.

High-Speed Steam Locomotive Trials were run in Germany during the early spring on the Marienfelde-Zossen track made famous by the record-breaking achievements with electric locomotives. Four different locomotives were tested, each with two trains, one of six and the other of three vestibule cars, weighing about thirty tons apiece. The track is straight, nearly level and 14.5 miles long. The locomotives were built by four different German firms, two of them being of the same general model as the "Atlantic" type used in this country. Records of 79.53 miles per hour with six cars and 85.12 miles with three cars were made by a machine of original type, designed by Chief Engineer Wittfeld, of the Prussian railway administration, which has been sent to the St. Louis exhibition. These were the best records made, but were only slightly better than those made by an eight-wheeled compound engine equipped with Schmidt's device for superheating steam and having drivers 78 inches in diameter. According to the report of the United States consul at Berlin, the most striking peculiarities of the Wittfeld locomotive are that it is so built that the engineer stands in front within a glazed cab, like the motorman of an electric car, and both engine and tender are covered with a sheathing of sheet iron with glazed windows and so arranged as to provide a covered passage from front to rear. The engine is carried on twelve wheels, viz., a four-wheel bogie in front and rear and between them the two pairs of drivers, coupled in the usual manner. This arrangement is for the purpose of securing a smooth steadiness of motion despite curves or irregularities of track surface. The engine is of the compound type, the high-pressure cylinder being located midway between the side frames, where its piston connects with an inside crank on the forward driving shaft. The low-pressure cylinders, of which there are two of equal diameter, are external and drive two outside cranks set parallel to each other and on the same side of the axle 90° from the inside crank that connects with the high-pressure cylinder. This secures an even balance between the reciprocating parts, from which important results have been expected. The boiler is, from the European standpoint, enormous, having 2,766 square feet of heating surface, and it is calculated that, with a coal consumption of 2.5 pounds per horsepower hour, it will develop about 1,775 horsepower. It weighs 76.8 tons and cost $23,800. The tender weighs 47 tons and carries 7 tons of coal and 4,400 gallons of water, which it is equipped to take up at speed, as is done on some lines in the United States.

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Reinforced Concrete for Bridge Trusses.

The use of reinforced concrete has been pushed to an extraordinary extent in France, as is illustrated by the description of the test of reinforced concrete bridge trusses in the issue of The Engineering Record of June 4. The compression members of the trusses tested were reinforced not only by longitudinal steel bars, but also by steel hooping, in the manner already made familiar to the readers of this journal in the printed accounts of the empirical and other investigations by M. Considère. This method of double steel reinforcement of members in compression possesses the important advantage of holding the concrete in place, so as to enable it to carry a far higher compressive load than the unaided concrete could possibly sustain, or, rather, that is the effect of the steel hooping. Under high intensities of compression the concrete, if unsupported laterally, would obviously separate by oblique shearing or in some other manner peculiar to failure by compression. If these modes of failure can in any way be avoided the concrete will be held up to its work and experience a substantial increase in its ultimate resistance. This end is effectively attained by the use of the steel hooping. It has been found that this effect may be considered equivalent to a mass of steel longitudinal reinforcement which, in the test of trusses to which reference is made, was tentatively considered equal to about two and four-tenth times that of the steel hooping. Under this interpretation or view of the capacity of resistance to compression the ultimate resistance of a reinforced concrete strut would consist of three parts; as stated in the description of the test, the compressive resistance of concrete without reinforcement, the resistance to compression of the longitudinal steel rods and the added resistance given to the concrete by the steel hooping.

It is to be observed that the compressive resistance of the longitudinal steel rods is assumed to be essentially that of short blocks, *i. e.*, their concrete environment is assumed to give them complete lateral support in every direction and at all points, so that they cannot deflect laterally. This seems reasonable, inasmuch as they are entirely buried in the concrete; at the same time this view seems to make no allowance for the inevitable lack of straightness of the rods. It is absolutely certain that those rods will not take their places exactly parallel to each other and to the axis of the member. Indeed, we know from actual experience in connection with the construction of concrete-steel members that that parallelism is very far from being secured in such cases. Again, accuracy in the placing of the hooping is practically unattainable, although it is stated in the description of the French test that that accuracy is not essential. This latter observation is doubtless well founded, for it is obvious that there might be considerable initial displacement of the hooping without much disturbance of its reinforcing effect on the compressive resistance of the concrete embraced by it.

When the actual constitution of such compressive concrete-steel members is carefully considered, one cannot help being impressed with the necessity for an accurate and careful construction to secure their full resistance. Not only must there be assumed a good admixture of the elements of the concrete, but, what is probably more difficult to secure, a combined continuity of that concrete and accurate placing of all the steel members. Where the concrete must be placed in comparatively thin masses among and around a considerable number of small steel rods, as well as outside of the hooping, most careful work must be performed throughout every portion of the structure to secure reasonably satisfactory results.

Admittedly such perfection of results was not attained in the model bridge tested. It is stated that the origin of these defects was carelessness or indifference easily avoided in the actual construction of such work. This may or may not be so. As a rule, it is well known that a higher degree of excellence will be attained in the fabrication of a structure for experimental purposes than in ordinary field construction. It is a matter of very grave doubt whether M. Considère himself would secure even as good work in an ordinary reinforced concrete truss, as in the model truss built for test; indeed, it is practically certain that he would not, and hence that it never would be safe to assume any greater unit resistances than were found in the model truss; it would be safer to use less

In this account apparently much importance is attached to the fact that failure occurred at one place in a compression member, while all other compression members exhibited no sign of weakness, even by the cracking of the exterior shell of concrete outside the steel hooping. This is illusory, for that is the way in which any structure composed of a number of members would fail, and it is precisely the kind of failure which must be expected to occur in any structure if by any chance it should ever reach the stage of failure.

It was computed that the concrete in the members of the model truss tested must have sustained compression ranging from about 6,500 to over 11,000 pounds per square inch. Such ultimate compressive resistances are far in excess of any ever disclosed by non-reinforced concrete and they show in a marked manner the great gain in compressive resistance due to the steel hooping. M. Considère concludes from the tests made up to the present time that when engineers become more accustomed to the use of hooped-reinforced concrete the same factor of safety will be employed as for steel structures and that for the present a working compressive stress as high as 2,130 pounds per square inch may be used when six per cent. of the section is used for the spiral hooping and two and one-half per cent. for the longitudinal reinforcing rods. When the hooping is reduced to 2.5 per cent. and the longitudinal reinforcement to 1.5 per cent. he would reduce the working stress to 1,300 pounds per square inch.

Engineers familiar with the use of even the best quality of concrete masonry and of concrete-steel masonry will probably hesitate to use such high working intensities. The well considered types of reinforced concrete are certainly most promising structural materials, but it is a serious question whether their most ardent advocates are not straining the merits of an excellent material. The fact that concrete-steel is admirably adapted to structural purposes when properly used does not justify excessive working intensities. Concrete of bad quality coupled with high working intensities has already produced failures in this class of material, and if working pressures are placed too high more failures will follow. The quality of the material as a whole in a reinforced hooped compression member is far from being under such control as the metal in a steel compression member, and it is worse than idle, because dangerous, to consider seriously the use of the same safety factor for both. It is probably conservative to state that the safety factor in a reinforced concrete-steel strut should be at least fifty per cent. greater than in a steel strut. The advocates of reinforced hooped concrete should be satisfied with the reasonable recognition of its merits, for they are many and great, but they should not make its excellence the cause of even its occasional condemnation.

The American Water-Works Association.

It will be gratifying to all who have felt that the American Water-Works Association was not advancing in influence and in numbers so rapidly as it should, to know that the St. Louis Convention last week was probably the most important in its history. Not only were more new members elected at the Convention than ever before, but the papers were of a higher order and of more practical importance than usual. Unquestionably one reason for this is to be found in the very energetic work of the Secretary during the past year. Those who are familiar with the work of such societies know that its success depends very largely on the thorough work done by this officer. In fact, the best of local committees and the most careful scrutiny of papers to be presented before a convention will fail to produce the desired results unless the secretary makes every member of the society feel that the convention is being held for him personally. The convention was also marked by the improvement in the character of the papers, which was due to a conscientious publication committee. In the past the time of the meetings has often been taken up by papers of the most ridiculous character, bringing discredit on the Association when published and mortification to many who have endeavored to make the organization one creditable to the great interests it represents. The St. Louis convention shows that the period of stagnation has passed and the development of the Association into a great national organization, thoroughly representing every feature of water-works construction and management, may be confidently expected.

The water-works, public and private, in the United States and Canada, are altogether too important to the citizens who depend upon them for one of the necessities of life to be without a strong representative national organization. The American Water-Works Association has only about 450 members of all grades, whereas it should have at least 2,000. Its comprehensive scope should make it a body of strong influence in many ways. It is neither an engineering society nor a commercial organization, but an association of every one interested in the supply of water for municipal purposes. The problems it discusses are of importance to commissioners, to supply men and to engineers, just as much as to superintendents. All these classes must be well represented in its various grades of membership if it is to assume the position it should. These classes will not join until it is definitely assured that it is to their interest to do so. In the past the organization has suffered in some ways which have prevented its growth. It has been claimed, probably without any foundation, that at one time it was simply an organization supported by supply men. Not so many years ago its proceedings were marked frequently by ridiculous or useless papers. Nothing of the sort can be said of the proceedings at St. Louis. The papers were all of them of fair quality and many were very good. The subjects discussed were of direct importance to water-works interests and the convention as a whole was better than any held before. It goes without saying that if this record can be kept up, and there is no reason why it should not be, the Association will develop into an organization comparable in strength and numbers with the National Electric Light Association, to which it is in many ways similar. If it is to grow, however, those members who have been holding back the last few years and doing nothing to enhance the usefulness of the society must take part in its work. They no longer have any ground for refusing to bear their share of the work of the body, for it is in the hands of officers of high standing in their respective fields of activity and the recent convention indicates that the silly proceedings which marked some earlier meetings are now happily a thing of the past. The importance of the work that the Association can do is so great that The Engineering Record has no hesitation in suggesting that every one interested in water-works affairs should resolve to take part in some way or another in the proceedings of the next convention. A little work during the next twelve months on the part of each individual will accomplish wonders at the meetings next year.

The Wabash in Pittsburg.

On April 13 a construction train on the Pittsburg, Carnegie & Western Railroad crossed the city line of Pittsburg and the Wabash thereby ran its first train into that city. While much remained to be done in the way of cleaning up and completion, this rough work train carrying rails and ties into the Smoky City marked a really important event in transportation. Among railway men, the Wabash stands for great work with comparatively limited resources. For years the road was the butt of jokes, but to-day it receives, to use a diplomatic phrase, "the assurance of the distinguished consideration" of every line in its vicinity. Its good train service and model roadbed indicate the loyalty and intelligence of its staff, while the way in which it fought its way into Pittsburg and is winning a route to the seaboard must bring to the managers of lines in the territory invaded the feeling that always attends the incursion of a very energetic and resourceful rival. The entrance of the road into Pittsburg is particularly interesting, because it has been largely an engineers' struggle, in which all Mr. Gould's financial abilities would have very likely come to naught without the detailed personal knowledge of the engineering problems which was possessed by Mr. Joseph Ramsey, Jr., president of the Wabash Railroad Company.

Twenty-two years ago, when Mr. Ramsey was chief engineer of the Pittsburg, Chartiers & Youghiogheny Railroad, he made a personal survey of a route from Pittsburg to the Ohio River and acquired information which has only now been utilized. The land in that part of the country is mostly on edge, and the few places where a railway can run seemed to be so well filled with old lines that a new one was not considered a practical proposition. Events have shown, however, that a good, although expensive line exists. Just before the close of the last session of the Fifty-sixth Congress a bill was introduced authorizing the construction by the Pittsburg & Mansfield Railroad Company of a bridge across the Monongahela River within the city limits of Pittsburg. It was assumed to be for an electric railway, and was passed. About the time the people discovered that the bill was for the Wabash Railroad, it was also learned that the company had obtained control of the Wheeling & Lake Erie Railroad, and thus had a through line from the West to Jewett, Ohio. The first positive information on the subject was furnished by an application to the City Councils of Pittsburg for permission to cross certain streets, and by the incorporation of the Pittsburg, Carnegie & Western Railroad Company, the Cross Creek Railroad Company, and the Pittsburg, Toledo & Western Railroad Company to build the Pennsylvania, West Virginia and Ohio sections, respectively.

By this time it was recognized that the well-established lines running into the city had trouble in their midst, so to speak. The ordinances introduced into the city councils slumbered in a committee pigeonhole, but this fact seemed to cause no worry to the men behind the invasion. They bought land for a fine station and freight terminals and built piers for the great Monongahela bridge which has been the subject of a number of articles in this journal. In other ways, also, the construction was pushed ahead with the energetic assurance of speedy success that characterizes all Wabash campaigns. Finally, the director of public works sued for an injunction to have the work in the city stopped. While it was being fought from court to court, the construction was pushed ahead rapidly, but at last, on January 1, 1903, the Supreme Court of the State issued the desired injunction. Work was immediately stopped, and the whole energy of the corporation was directed toward the people of Pittsburg. It is a characteristic of Wabash methods to waste very little time with legislative and administrative organizations when held up, and at Pittsburg its tactics were a repetition of those employed in other places on a smaller scale. The following letter was sent at once to the leading merchants and manufacturing companies of the city: "As you are aware, the P., C. & W. R. R. Co., popularly known as the Wabash, has been for the last eighteen months seeking an entrance into Pittsburg, and there has been an ordinance pending in councils to grant the consent of the city of Pittsburg to such an entrance. By a series of mishaps and misunderstandings the ordinance has been so amended as to make it practically useless to the railroad company for purpose of transportation of freight within the city limits, although it does provide for the construction of a terminal passenger station and the conduct of a passenger business. The ordinance could be amended upon the lines indicated on the return part of this postal card, so as to permit the railroad to enter the city of Pittsburg and give its manufacturing and mercantile interests the benefit of transportation facilities over railroad systems operating 16,000 miles of railroad. If you desire to give your aid and sanction to procure for the city of Pittsburg these additional transportation facilities, please sign and return immediately the other half of this card."

It is violating no secret to state that the Pennsylvania Railroad is not particularly popular in Pittsburg. Consequently there was little friendship to hinder the signing of these cards, while there was considerable business attraction about a new railroad in town, able to run its own cars over its own lines into Chicago, Buffalo, Toledo, St. Louis and Kansas City.

Consequently the signatures were readily obtained, one report being that over nine-tenths of the large mercantile and shipping interests signed the appeal. Be that as it may, the popular feeling on the subject rose so rapidly and in such strength that on February 4, after an agitation of about a month, councils gave the desired franchise. The War Department refused permission for a bridge at a practicable elevation for a direct connection with Allegheny, but this entrance will be obtained in another manner, so that the legal aspects of the work may be considered as settled.

The engineering features of this work have been no less notable than the executive. After leaving the Pittsburg terminal station the road runs on a viaduct to the great cantilever bridge already mentioned and then enters a 3,333-foot tunnel, almost at the end of the anchor arm. Viaducts, tunnels and heavy cuts and fills mark the construction from Pittsburg to Jewett, the main connection with the Wheeling & Lake Erie tracks, for the controlling grade is but 0.7 per cent., and such a profile in that country can only be secured at a great expense. Moreover, there is not a single grade crossing with highways or railways. The Monongahela and Mingo Junction cantilever bridges, the Greentree and Mt. Washington tunnels, are but the largest examples of many smaller interesting works of their respective classes which this line affords. The temporary structures have been almost equally noteworthy. Some of the timber trestles are remarkable, while in earthwork there is a fill of great height 3,500 feet long, to mention but one example. Concrete is extensively employed for arches and tunnel linings. In short, the whole road construction has been executed on thoroughly permanent plans, with the evident purpose of having a line which will require no relocation or reconstruction. It is said that the total cost of the sixty miles of road and the buildings will be about $20,000,000. This is a very large amount for such a short line, but after an examination of the country traversed by it, the engineer will be surprised only at the ability of the men who could find in those hills a location not already occupied by which, at any expense whatever, the entrance to the city could be secured. It is to be hoped that a comprehensive account of this great engineering feat of Messrs. Ramsey and Patterson will be communicated to the American Society of Civil Engineers.

The Louisiana Purchase Exposition.

For some unknown reason a ridiculous report has gone abroad in the daily newspapers that the bankruptcy of the Louisiana Purchase Exposition is imminent. This report has doubtless arisen from the wording of a communication sent to President Francis of the Exposition Company by Secretary Shaw. The rumor is unwarranted. As it may influence some of the readers of The Engineering Record unless it is contradicted positively, it is desirable to state as emphatically as possible that the exposition is one of the most interesting from an engineering point of view that was ever held. It will unquestionably draw great throngs of people just as soon as they learn that the exhibits are now practically complete. It is true that some companies have not yet completed their display, and that a very few of the most important exhibits in the steam engineering line, as well as in other technical branches, are not yet on the grounds. The number of these incomplete exhibits is extremely small, however, and any one who has an opportunity to visit the Fair now and does not do so, will regret his neglect. The attendance at the Fair during the first months was naturally small. It was recognized that both the grounds and the exhibits were incomplete and people did not care to visit the exposition under such conditions. The latter part of last week, however, the grounds were thronged, and there can be no question that hereafter the attendance will be up to the numbers expected.

From an engineering point of view the exposition is one of much importance. The number of objects of interest is so vast that it is difficult to enumerate them even in the abridged form adopted by the official guide-books to the different buildings. A large proportion of the exhibits are standard appliances, and there are grounds for believing that the novelties displayed would be more conspicuous were less standard apparatus shown. It must be remembered, in this connection, that the exposition was intended to show processes as well as products, and for this reason operating exhibits of standard apparatus have a greater justification for their display than usual. Any young student of engineering will find the Fair particularly interesting for this very reason, and he will see in well-arranged groups a large amount of machinery and supplies with which he can become familiar in no other way so quickly and thoroughly. The more experienced engineers naturally criticise somewhat the display of apparatus with which they are thoroughly familiar, but they forget that a large part of the value of these exhibits to those making them lies in the fact that many of the visitors to the Fair have never had an opportunity of personally examining them, and their character is therefore unknown to many future purchasers. It may well be questioned if an exposition of such scope will be undertaken again for many years, because the cost of very large displays runs up to a high figure. It is the general opinion among both exhibitors and visitors that future enterprises of this character will confine themselves for financial reasons more strictly to novelties and special apparatus. This view in no way detracts from the value of the Louisiana Purchase Exposition as a great museum of a practical nature, which no engineer should fail to visit if he has an opportunity to do so.

It should also be stated that the tales of the highway robbery of all visitors to the Exposition are imaginative. Any one who is willing to put up with some inconvenience can visit the Fair at a low cost. While there are hotels in the city which charge very high rates, there are many where fair accommodations and good food are to be had at reasonable prices. There are also hotels and restaurants near and in the Fair grounds where rates are moderate, and there are many excellent boarding houses, where people will be comfortable during a prolonged stay at the Exposition. This statement is made as a matter of simple justice to the people of St. Louis and the authorities of the Fair. No one need be deterred from visiting the Exposition by the stories of extortion which are current. Of course, if the visitor wishes to stop in the best hotels and makes no objection to being fleeced, he may confidently count on paying a great deal of money without receiving any visible return for it, but if he is willing to spend a little time in securing satisfactory accommodations, he may count on having every reasonable want satisfied without much expense.

It has been stated above that the exposition is not quite complete. This does not mean that the visiting engineer at the present time should feel any disappointment in what he sees. As a matter of fact, only a few of the large engine exhibits and the concrete-steel house of the Association of Portland Cement Manufacturers are in a very backward condition. The civil engineering exhibits, particularly those from foreign countries, are all in place, and some of them are of exceptional interest. The Transportation Building, where the exhibits are of unusual historical interest, is practically complete. The display in the Liberal Arts Building is finished, and the same is true of the Manufacturers' Building. There are a few exhibits not quite completed in the Mines and Metallurgy Building and in the Electricity Building. The Machinery Building is more backward than the others. A fortnight should see everything practically completed with the exception of the building of the Association of Portland Cement Manufacturers and the exhibits of two engine manufacturers. Any one who visits the Exposition to-day and fails to find enough to interest him for two full weeks of energetic sightseeing must be a walking encyclopedia, and the lack of completion of a few of the exhibits should deter no one from visiting the Fair who can do so only during the present month.

Notes and Comments.

PER CAPITA CONSUMPTION OF WATER in the Boston Metropolitan water district was 119 gallons per day, on the average, for the year 1903, being a reduction of 4 gallons from the corresponding quantity for 1902. In the annual report of the Board, just published, this decrease is attributed in part to the lack of any considerable long spells of very hot weather and to less extreme cold weather, but it is believed that a large portion of the decrease was due to the curtailment of waste effected through the special investigations conducted during the year by the engineers under the direction of Mr. Dexter Brackett, engineer of the Distribution Department. This work was described in a report abstracted in The Engineering Record, March 19. Mr. Frederic P. Stearns is chief engineer of the Metropolitan Water and Sewerage Board.

THE UNIVERSITY OF MAINE is now equipping its new building for the mechanical and electrical engineering departments. It consists of a main structure 82x56 feet and a 42x125-foot wing, the latter housing the shops. The hydraulic laboratory will be in the basement of the main building and the mechanical and electrical laboratories will occupy the north and south halves of the ground floor. The second floor will be given up to offices, recitation and drafting rooms, while the third floor is not to be utilized at present. The ground floor of the wing will contain machine, forge and foundry rooms; the second floor over the machine shop will be used for woodworking tools, and above will be a large storage room and paint shop. The forge is to be equipped with down-draft Sturtevant apparatus and all machinery will be motor-driven on the group system. The line shafting in the machine shop will be carried on Hyatt roller-bearings. The entire shop plant is being laid out to facilitate tests for power losses in transmission and the power required for driving machine tools.

THE INVESTIGATION OF ROAD MATERIALS and of all materials relating to agricultural construction, which has been a feature of the work of the United States Department of Agriculture for some time, will hereafter be in charge of a Division in the Bureau of Chemistry of that Department. The good work which is being done along this line is too well known to most readers of this journal to need comment, and the fact that it has been dignified by Secretary Wilson as a special division, to be called the Division of Tests, will be gratifying. The investigations may be confidently expected to supplement and unify the work done in a few states by their local highway departments of geological surveys. A federal division for such work, in charge of men of high standing who are now directing its affairs, brings within the reach of everybody in the country the advantages of a road-material laboratory. Not the least satisfactory feature of the Government's work along this line is the extreme conservatism of those in charge of it, which does not result in the newspaper notoriety of some other divisions of the Department work.

THE RENSSELAER POLYTECHNIC INSTITUTE suffered a serious loss on June 9, when its main building was practically destroyed. The loss has been estimated by the Treasurer of the Institution at $100,000, $48,000 of which was covered by insurance. Fortunately the work of the year had practically closed by the time of the fire, and what remained to be finished was completed in the other buildings of the Institute and the public High School of Troy. The collection of astronomical instruments stored in the building were saved, but the surveying instruments and a very valuable collection of models and specimens in the Department of Mechanics were lost. The origin of the fire is supposed to have been incendiary; there were no laboratories in the building. The trustees are taking steps to provide temporary quarters for the coming year and have appointed a committee to outline a plan for the construction of adequate buildings on a suitable site. Temporary quarters will be prepared for the classes by the fall. Unsolicited subscriptions toward the rebuilding of the Institute have already begun to come in, and a concerted effort will be made to secure the necessary funds.

Repairs and Reconstruction on the Old Croton Aqueduct.

The portion of the old Croton aqueduct between the old and the new Croton dams was built approximately from the hydraulic gradient and closely follows the contours of the hill on the south side of the Croton valley. In this part of the line the aqueduct is mostly in trench, but in some places it is carried across the valleys of intersecting brooks and in others it crosses with an embankment above the original level of the ground. The invert slopes from elevation 154.6 at the old dam to elevation 152.8 at the new dam, being, therefore, a little more than 50 feet below the level of the flow line for the new reservoir, which is elevation 206. Wherever the aqueduct is built on the hillside with slopes flatter than 2½ to 1, it is considered that it will not be endangered by the future submersion, excepting where it is near the edge of steep slopes; at these places it will be protected by riprap. At a few crossings the aqueduct is carried above the natural surface of the ground on dry masonry foundation walls which have earth footings and are enclosed in embankments extending over the top of the arch. It is believed that at these places the water might seriously soften the banks and the foundations of the dry stone walls.

When the new reservoir is filled the old aqueduct may at times have to resist an external pressure of twenty pounds per square inch. Under new conditions, which will be radically different from those contemplated in the design, it was thought possible that serious settlement might take place and breaks occur. To prevent such damage it was decided to reinforce the aqueduct, and wherever any portions of it were built on embankment to replace them by detours located on firm ground, so that the filling of the reservoir would not affect the foundations. There are five of these so-called detours, with the following lengths and locations: Orser's Brook, 294 feet; Bailey's Brook, 621 feet; Purdy's Brook, 137 feet; Spring Brook, 304 feet, and McCord's fill, 251 feet. At Clamant's Brook the dry rubble foundation wall was reinforced by grouting, and the old structure was retained.

Each detour consists virtually of a concrete conduit parallel to the old aqueduct and 50 feet away from it, between the center lines, having long-radius reversed curves tangent to and forming connections with, the old work. These detours require the construction of about 1,600 linear feet of new conduit. There remains between the two dams 13,800 feet of the old aqueduct, which will not be reconstructed, but which will be reinforced and repaired.

Surveys for the old aqueduct were made in 1835 and 1836 by Major D. B. Douglass, chief engineer. He was succeeded by Chief Engineer J. B. Jervis, who commenced construction in May, 1837, and completed the aqueduct sufficiently for the delivery of water to the Murray Hill reservoir in 1842. The aqueduct between the old and new dams is a masonry conduit, with the interior dimensions indicated by the accompanying cross-section. The interior cross-sectional area was 53.34 square feet. Its construction is described in the following paragraphs from "The Water Supply of the City of New York," by Mr. Edward Wegmann:

"The conduit was founded on a course of concrete, 3 to 12 inches thick, according to circumstances. The side-walls were built of rubble masonry. After these walls and the concrete foundation had been plastered with a coat of hydraulic mortar, about ⅜ of an inch thick, they were lined with 4 inches of brickwork, in order to make the water-channel as smooth as possible. The top arch was made of brickwork, 8 inches thick, except in a few cases in which it was made of stone masonry. The top of the arch and of the spandrel rubblework, which was built up solid from the side walls, was plastered with a coat of hydraulic mortar. Wherever the conduit was above the surface it was covered with a bank of earth to a height of 3 to 4 feet above the crown of the arch. A similar covering of earth was placed over the aqueduct in open cuts.

"Where the aqueduct crossed valleys, walls of dry rubble having a top width of 11 to 15 feet were constructed as a foundation for the masonry conduit. On both sides of this wall embankments of earth, formed in layers and carefully rolled, were brought up simultaneously with the dry rubble wall. The aqueduct was built with extra precautions on these foundation walls, which were always allowed to stand for a few months before the masonry of the conduit was commenced. The bed of concrete was made 12 inches thick, the width of the side walls was increased, more lime was used in the mortar, and the whole interior of the conduit was plastered with hydraulic mortar. A settling of the aqueduct causing cracks in the masonry has occurred on most of these embankments.

Aqueduct Detour; Finished Arch in Foreground, Side-Wall Forms in Background.

"The earth embankments were carried up to a height of 3 to 4 feet above the crown of the arch, the slopes being generally covered by dry stone walls. Along side-hills, where the aqueduct had to be constructed partly in cuts and partly in embankments, the lower side of the latter were protected by strong retaining walls. The hydraulic lime used for the mortar was all obtained from Ulster County, N. Y. Each lot was carefully tested before being accepted. For the concrete and rubble masonry the mortar was composed of three parts of sand to one of lime, but for the brickwork and the plastering the proportion was 2: 1. On embankments the mortar for the rubble and concrete was mixed 2½:1."

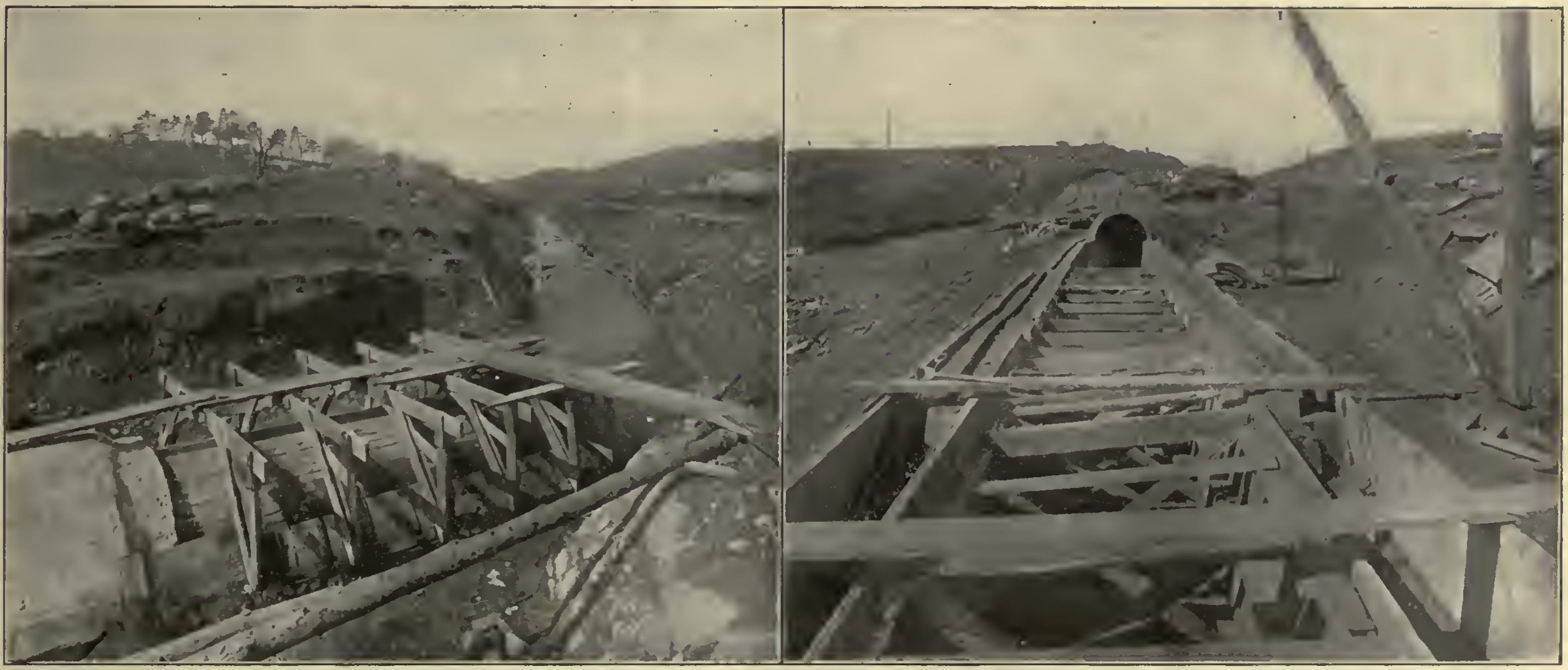
The aqueduct was designed for a maximum flow with the water level kept below the springing line of the arch, and was calculated to have a capacity of 72,000,000 gallons in 24 hours. In 1850 the aqueduct was delivering this full amount of water, and as the demand increased the delivery was also increased by increasing the depth of the water until it rose very nearly to the top of the arch and afforded an estimated discharge of from 90,000,000 to 120,000,000 gallons. This produced internal pressure which had not been intended on the arch in the lower sections of the aqueduct, where it was built on embankment and had settled from 3 to 13 inches. Many leaks were developed, most of which were stopped by dumping sawdust, fine sand, loam and cement into the aqueduct above the leak, but in some cases it was necessary to shut off the water and repair them in the dry. In order to strengthen the aqueduct and enable it to deliver an increased amount of water, the arch was uncovered and was reinforced by an additional ring of brick, increasing the thickness to 12 inches and in some places to 16 or 20 inches. The spandrel walls were carried up nearly to the top of the arch and the 5-foot earth covering was reduced to 2 feet. When the arch was exposed, many small cracks in it were discovered and repaired. After the work was completed, the depth of the water in the conduit was increased 5 inches to a total of 7 feet 10 inches.

The repairs now being made to the old aqueduct consist of the replacement of certain portions of the brick key in the arch and of the laying of a continuous reinforcement of concrete on the invert and over the arch. A total length of about 1,500 feet of conduit between the old and new dams was exposed at various places, by excavating down to the springing line, thus making trenches which in earth had side slopes of about 1:1 and a width of 30 feet on top. A single standard-gauge service track was laid alongside the old aqueduct from the old to the new dam, and at detours it was laid on top of the abandoned section of the old aqueduct. This occupied all of the available space in many places and made it necessary to devise some special methods of working from it without interfering with the use of the track for handling materials for the reinforcement as well as for the construction of the six new sections.

The first work done was the reinforcing of the invert, which was accomplished principally during the unusually cold weather last winter. Holes about 3 feet square were cut through the arch at points 360 feet apart, and from each one the invert reinforcement was built in both directions. It consisted of an 8-inch layer of

1:2:4 concrete made with Giant Portland cement and 2-inch broken stone mixed very wet by hand on platforms on top of the arch. Hot water was used to mix the concrete and it was covered with tarpaulins on the mixing platform to protect it from cold. Inside the aqueduct gasoline torches were kept burning to maintain a temperature above freezing.

The bottom of the aqueduct was thoroughly cleaned and dried and holes were cut through the first course of bricks in the side wall, as indicated by dotted lines in the cross-section, to bond the concrete to the brickwork. These holes were 12 inches long, 7½ inches high, and about 4 inches deep at the bottom. They were spaced 3 feet apart on centers and were made in the same transverse plane on both sides of the aqueduct. The invert reinforcement was made in sections 8 feet wide with spaces 4 feet long between them. These sections were laid with straight edges between templates, and it was found that these dimensions were best suited to rapid work, as it was much more difficult to trim the surface of the concrete in the intermediate sections after the 8-foot lengths had been put down. The concrete used in the invert amounted to about 5 cubic feet per linear foot of aqueduct, and therefore reached the cross-section of the waterway by 5 square feet. The work was done by six crews of twelve men, one crew working both ways from each opening and laying an average of about 100 linear feet daily.



Forms and Falsework for Aqueduct Detour Arch; Forms and Bracing for Side Wall of Detour.

The old masonry in the aqueduct was found to be in exceptionally good condition, with exceedingly hard mortar and sound bricks throughout. In some places cracks and other faults are found in the arch. Here the old brickwork is to be replaced by a new brick key. In these places the center courses of brick each side of the crown are cut out to make openings, usually about 2 feet wide, with sides toothed by 2x4-inch recesses 8 inches apart, to improve the bond between the old and the new work. So far only about 150 linear feet of the new key has been built, but it is not yet known how much more will be required.

In some places the old arch had already been reinforced with concrete, and will not be disturbed, but elsewhere new concrete will be placed on the outside, as shown in the cross-section, and will correspond substantially with the previous reinforcements. To prepare the arch for the reinforcement, the outer surface, which is covered with cement mortar about ¼ inch thick, is roughened by small holes picked in it a few inches apart to improve the bond with the concrete. Forms are then built up from the springing line to the hip and the concrete is rammed between them and the brickwork. Above this point the concrete is surfaced by straightedge and template over the crown of the arch, where no forms are required.

The concrete is laid continuously so as to form a monolithic mass from springing line to springing line and all joints are made transversely to the axis of the conduit. The sections thus completed at a single operation vary in length from 10 to 50 feet. The concrete required for this reinforcement is 17½ cubic feet per linear foot of the aqueduct, and the total amount of concrete required for the repairs of the old aqueduct and the construction of the new sections is about 20,000 yards. So far only a small portion of the arch-reinforcement concrete has been laid and it was mostly mixed by hand. For the remainder of it, it is intended to install ½-yard Ransome mixers mounted on cars which will move along the service track parallel to the aqueduct as the work progresses.

The general construction of the new sections of conduit is illustrated by the plan and cross-sections of the Orser Brook section. The concrete piers are carried down to level foundations on hard bottom and where the depth is more than about 5 feet below the invert, the continuous footing is replaced by a series of piers generally about 7 feet long and 11 feet apart in the clear. The tops of these piers are connected by full-centered concrete arches without reinforcement, and spandrel walls and filling are carried up to afford a continuous solid base for the conduit, which is constructed wholly of concrete with the inside dimensions corresponding to those of the old aqueduct and the exterior cross-section made as shown in the detail. In the deepest part of the valley there is often a wider arch and a culvert, as indicated in the elevation of the Orser Brook section. In all cases the junction of the old and new conduits is made as shown in the plan of the detour, and the new concrete is bonded into the old concrete and brickwork with racked and toothed joints. The sections are made in four separate operations. The first is the building of the piers and foundations; the second is the building of the invert; the third is the building of the side walls, and fourth, the building of the arch. No falsework is used for the concrete foundation arches. The earth is rammed hard and cut to template to fit the voussoir. The concrete is laid directly on the earth and the latter is left in position after the arch is completed and serves as backfill which would be required to be rammed in, if the arches were built over open spaces.

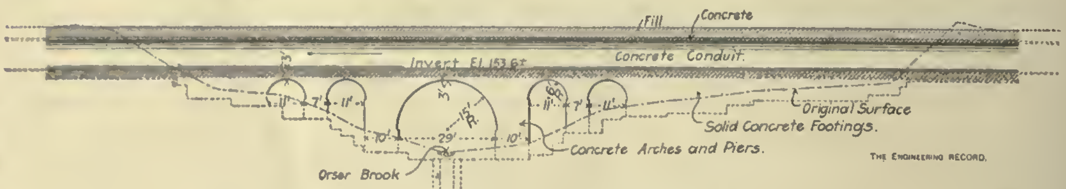
The pier and foundation concrete is rammed in ordinary molds, and longitudinal grooves are formed in the upper edges of the invert to bond it with the side walls. The inner faces of the side-wall molds are made in sections about 16 feet long with vertical boards nailed to horizontal longitudinal top and bottom strips, and are faced with horizontal 1x3-inch yellow pine floor boards. These are carefully set to line and fastened together by splicing the longitudinals and X-bracing them together in transverse planes about 4 feet apart. The forms for the outer faces of the walls are also made in 10-foot sections with vertical boards nailed to outer longitudinal strips, which are braced by inclined struts on the surface of the ground or the sides of the cut. Outer and inner forms are spaced by wooden cross-pieces, which are removed as the concrete is rammed in position. The ends of the sections finished each day are offset to form a transverse joint, which is Z-shaped in horizontal section, but the concrete is bonded together so as to make it as nearly monolithic as possible up to the springing line. At this level the tops of the side walls are deeply grooved to bond with the arch, and the latter is built in the usual way with timber centers and lagging. No paper or other covering is used for the lagging or the forms, but they are thoroughly smeared with a thick grease, which effectually prevents the adhesion of the concrete and secures a smooth and uniform surface.

The arch is built monolithic, in sections as long as can be completed by one gang in one day. These concrete sections vary from 25 feet to 75 feet, but will average about 50 feet in length. The end of each section is offset, as indicated in the general view, so as to be Z-shaped in cross-section and form a sort of hub and spigot joint. All but one of the detours have been built and the concrete for them was mixed in a 1-yard cubical mixer which, with the charging hopper and its engine and boiler, was mounted on an ordinary flat car. Coupled to this car was another filled with coal. Adjacent to them by the side of the track were set two guyed derricks, which delivered stone and sand from heaps on the ground to the mixing hopper and handled the concrete from the machine to the forms.

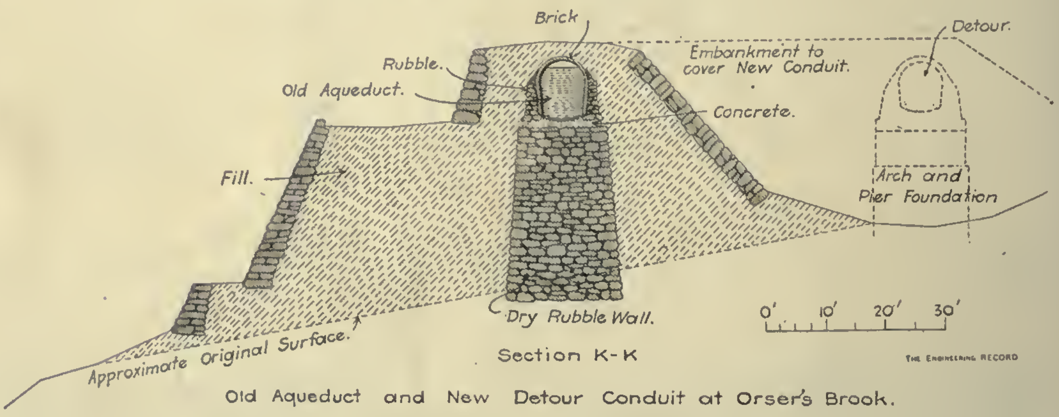
The cement was delivered to the machines on gondola cars covered with canvas tents. In some cases the concrete mixers delivered to buckets which were handled directly by the derricks, and in other cases delivered to dump cars which traveled on narrow-gauge tracks adjacent to and a few feet below the service tracks. The cars were run opposite the points on the aqueduct where the concrete was required and dumped it through chutes into the forms. The concrete for the last detour will be mixed in a Ransome machine mounted on a flat car which has a hinged flap or bridge at each end, which can be raised to allow the car to be drawn away and stored on a side track during the day, so as to leave the service track free for transporting materials. At night, when there is no traffic on the service track, the mixer car will be drawn to the required position and the hinged bridges will be lowered to connect it with a flat car at each end. On them stone, sand and cement will be stored and wheeled to the mixer as required. The mixer will discharge through a chute to the moulds.

Mr. J. Waldo Smith is chief engineer and Mr. Charles S. Gowen, resident engineer. Messrs. Coleman, Breuchaud & Coleman are the contractors, and Mr. J. B. Goldsborough is their superintendent.

A Cement Contract, which is said to be the largest ever made in the United States, has been entered into by the American Cement Company, of Philadelphia, and the Pennsylvania Railroad Company. It is for Giant Portland cement for the Pennsylvania Railroad terminals in New York, including the tunnels under the North and East Rivers and the terminal buildings in Manhattan and Long Island City. This is the third large contract of this nature made by the company for railway work in New York, for it has been supplying the cement for the undertakings of the New York Rapid Transit Railroad Commission and the new subway terminals of the New York Central Company. The contract is particularly interesting as indicating the growth in favor in New York of the practice of buying all the cement for an undertaking at one time and not in comparatively small quantities as construction proceeds.

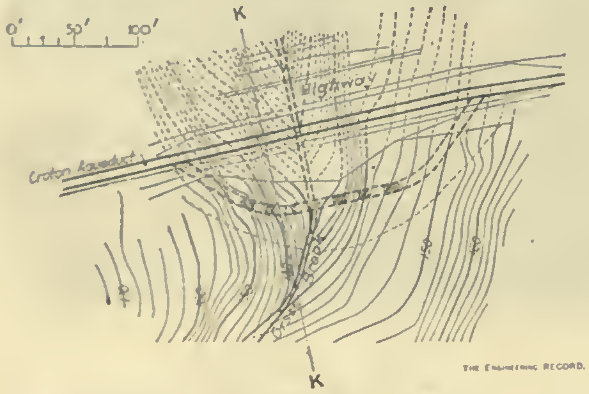


Sectional Elevation of Orser Brook Detour, Developed

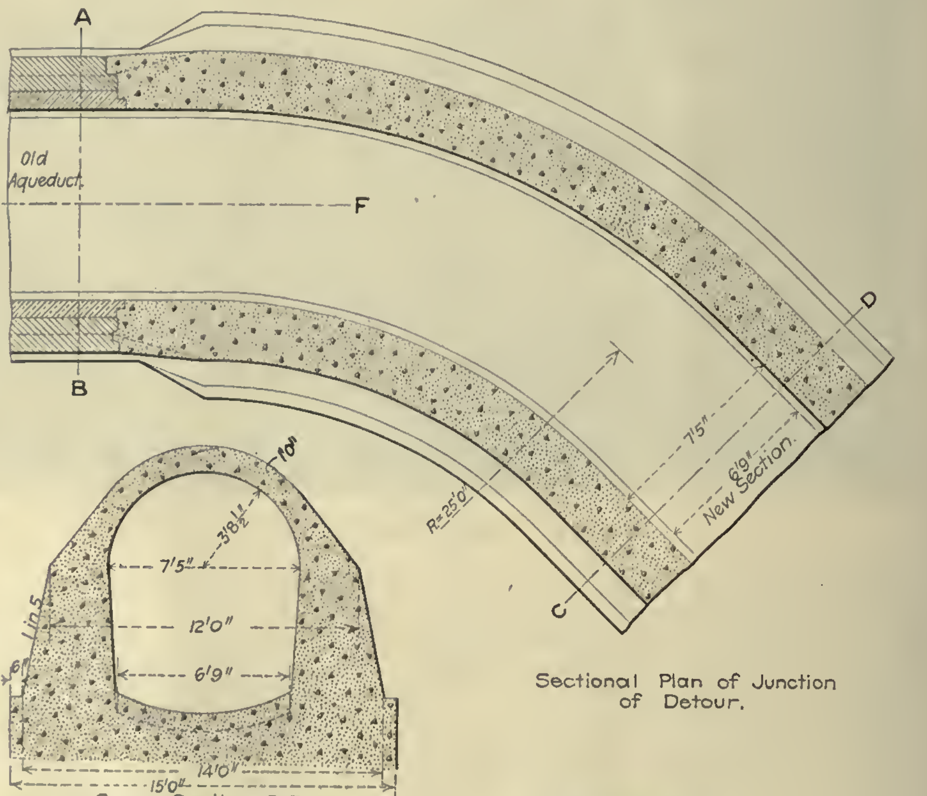


Section K-K

Old Aqueduct and New Detour Conduit at Orser's Brook.

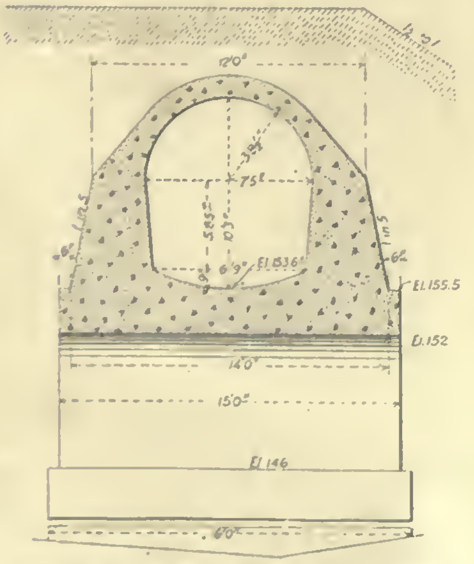


Location of Orser Brook Detour.

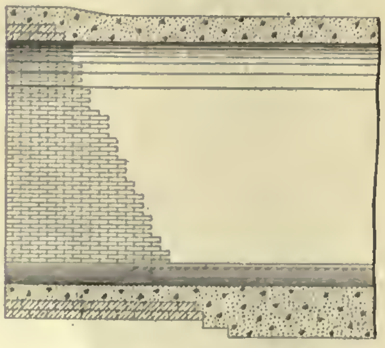


Cross-Section C-D.

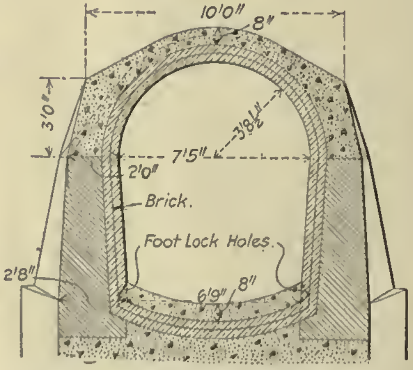
Sectional Plan of Junction of Detour.



Typical Section through Detour Conduit and Foundation Arch.



Longitudinal Section E-F. Construction of New Conduit.



Cross-Section A-B. Original Brick and Rubble Construction of Old Aqueduct and New Concrete Reinforcement.

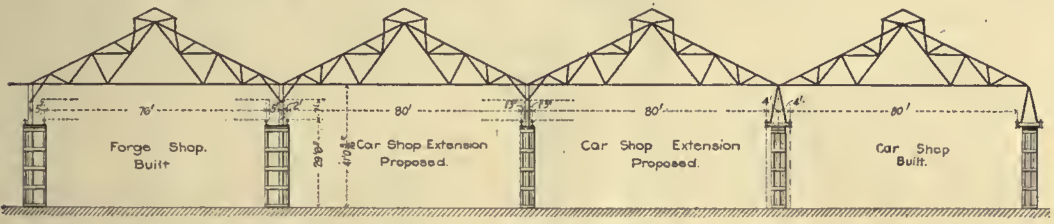
The Engineering Record

OLD CROTON AQUEDUCT: DETAILS OF REPAIRS AND CHANGES BETWEEN OLD AND NEW CROTON DAMS.

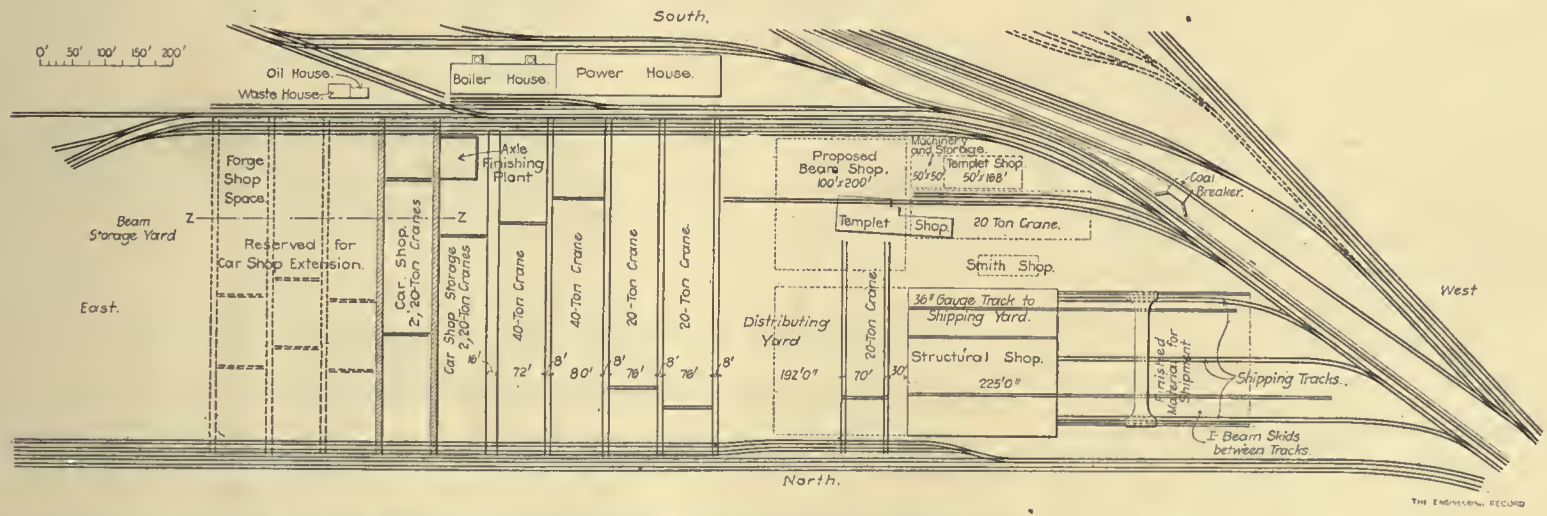
The New Structural and Car Shops of the Cambria Steel Company, Johnstown, Pa.—I.

History and Present Installation.—The Cambria works have grown by gradual enlargement from the time of their inception in 1852 to their present status. The first iron manufacturing plant at Johnstown was a small forge erected in 1809, which was operated until 1825. In 1852 the Cambria Iron Company, owning large timber lands and a number of widely scattered, small, primitive blast furnaces was organized, and in 1853 the erection of four coke furnaces to use local ores was begun at Johnstown. The operation failed, and in 1855 passed by lease for a period of seven years into the hands of Wood, Morrell & Company, who had a plant with a weekly capacity of 150 tons of iron rails. In 1862, at the expiration of the lease, the Cambria Iron Company was reorganized and operated the works from that date until the lease of the plant to the present operators, the Cambria Steel Company, in 1898. The Bessemer steel works were begun in 1869 and operated with great success.

The plant is at Johnstown, Pa., where it extends for about six miles along the Conemaugh River. The works and operations include, at the present time, the mining of iron ore, limestone and coal, the making of coke and pig iron, and the manufacture of Bessemer and open-hearth steel ingots, castings, blooms, billets, slabs, rails, axles, crank pins, large and small forgings, bolts, nuts, plates, beams, channels, bars of all kinds and sizes, steel cars and fitted structural steel work, agricultural bars and shapes, plow steel of various qualities and shapes, cold rolled steel, harrow disks, pressed steel seats, and many other products. The plant is completely equipped with shops for making or repairing all of the machinery needed in these operations.



Section Z-Z, on General Plan. Car and Forge Shops.



Cambria Steel Works: General Plan and Cross-Section of Bridge and Car Shops and Yards of the Franklin Plant.

The present plant is divided into three principal groups of shops and mills employing about 13,000 men, using about 4,000 tons of coal daily, and operating 94 miles of tracks with 51 locomotives, large and small. Except for some features of power and transportation, these groups are operated independently, but are all associated in the production of steel under the same management.

The lower or Cambria works occupy the original site and include the Bessemer plant, open-hearth furnaces and the blooming, billet, beam, rail, bar and shape mills at the lower end of the works, with a capacity of about 900,000 tons of ingots per year. The Gautier department is farther up-stream and largely devoted to the manufacture of small merchant bars, shapes, steel springs, and other products used in the manufacture of agricultural machinery.

The upper or Franklin plant, at the eastern extremity, on the Little Conemaugh, includes a 50-ton open-hearth plant, bloom, slab and plate mills, 260 by-product coke ovens, and shops for the manufacture of steel cars and of bridge and structural steel work. The open-hearth plant has a present capacity of about 400,000 tons of ingots per annum, thus making the total ingot capacity of the Cambria Steel Company 1,300,000 tons.

As a large portion of the output of the lower or Cambria plant is composed of beams and structural shapes, it was found expedient to construct a shop in which beams and columns could be cut, framed and riveted for architectural requirements, so that they could be shipped directly from the mills to the building site. The development of this work naturally included column and girder work, so that facilities were also provided for building general structural and bridge work, and the structural shops and plant have been designed for a present output of about 30,000 tons a year, besides 375 tons a month from the bolt and rivet shops, and about the same from the forge shop, making in all about 35,000 tons a year of finished material.

In connection with this work, there has also been recently installed a plant for building steel cars, which has a capacity of about 4,000 gondola, hopper and flat cars annually. These structural and car shops have been so located and arranged as to admit of future extensions without interfering with the present arrangement and operation. They occupy a graded level area about 600 feet wide and 1,700 feet long, including the storage and shipping yards. This area is served by several parallel lines of standard-gauge railroad tracks on both of the long sides, with spurs and narrow-gauge tracks running into the shipping yard at one end beyond the structural shop. A space about 700 feet long between the structural shop and the car shop, covered by six parallel lines of cranes of 20 and 40 tons capacity and from 70 to 80 feet span on elevated runways, is used for the storage of materials required in these shops. In the yards are two hydraulic shears equipped with roller and transfer systems which take the stock as delivered from the mills, shear it and pile it on skids, whence it is loaded for shipment on railroad cars or transferred by the traveling cranes to the shop stock cars on longitudinal surface tracks. This arrangement provides a simple and effective system of large capacity, either for shipping from stock or supplying the shops in large measure with materials direct from the mills with a minimum amount of hand labor or delay.

Power Plant.—All the power for the structural shop, rivet shop, forge shop, car shop, crane service and auxiliaries to these shops is developed in the stock yard power house, which, in fact, supplies the entire Franklin plant. It is a brick and steel building 64 feet wide and 406 feet long, in which are installed four batteries of Babcock & Wilcox boilers of 600 horsepower each, equipped with Murphy automatic furnaces. The soft coal used is mined by the Cambria Steel Company and delivered from their breakers on surface tracks to a hopper adjacent to the power house. From here it is elevated to storage bins above the boilers, which will hold four days' supply.

Four 400-kilowatt electric generators of the Westinghouse engine type are directly connected to four 18x36x30-inch Porter-Allen engines built by the Southwark Foundry & Machine Company, and furnish electricity for driving all machinery in the Franklin plant, one-third of it probably being used in the structural shops. A 220-volt direct current is used for all purposes, including the lighting system. The electric mains are overhead insulated copper wires. The majority of the motors are of Westinghouse make, although Crocker-Wheeler and General Electric motors are used for special machines. The principal machine tools are provided with separate motors and small machines are driven in groups by motors of from 5 to 10 horse-power.

All of the hydraulic machinery is operated by water at 450 pounds per square inch pressure, intensified when necessary, which is pumped through the distributing mains by a 15-23-38x9-inch duplex Worthington pressure pump with a 24-inch stroke. The hydraulic mains are proportioned to limit the velocity of flow to 4 feet per second, and are provided with spring buffers at dead ends and at bends to prevent water hammer. The mains are under ground and form a closed circuit to the power house.

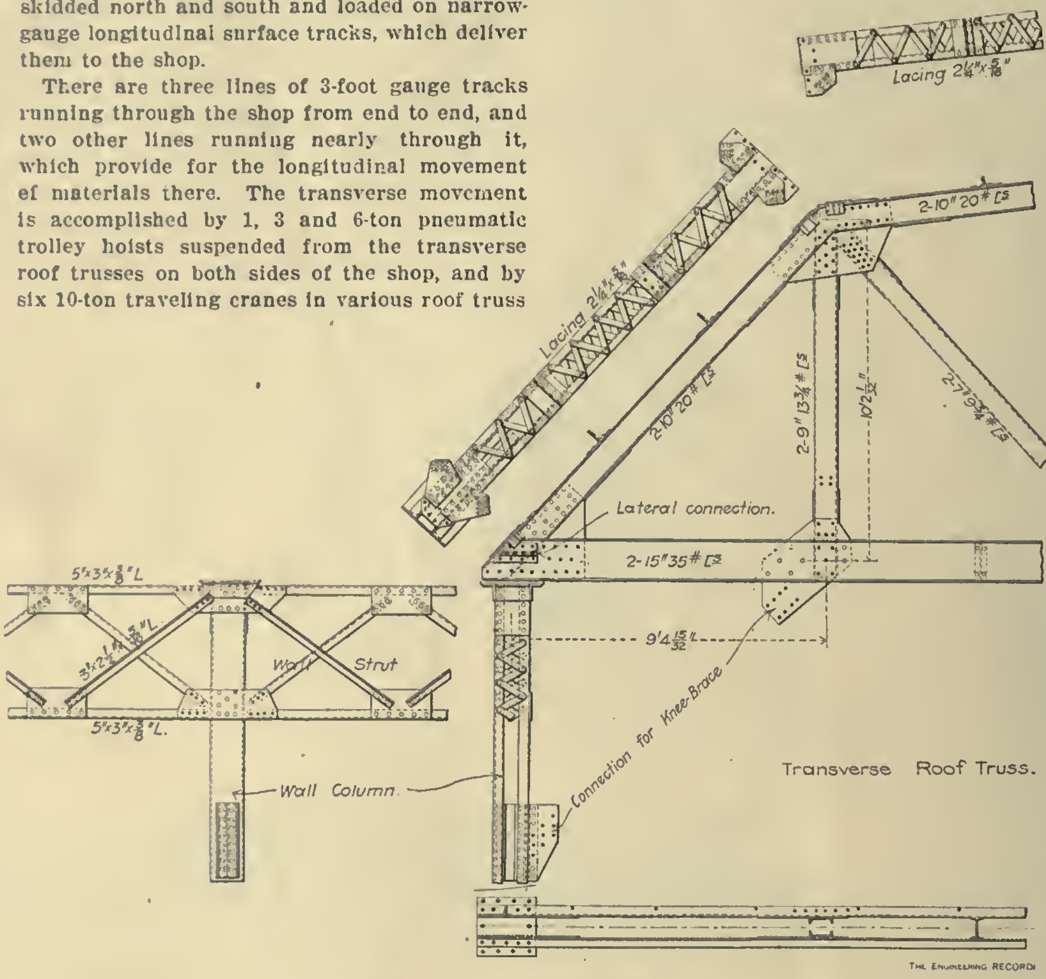
The spring buffers virtually serve as relief valves and save the mains from heavy strains without reducing the pressure or wasting the water. They are of very simple construction, as shown in the sectional view, and consist essentially of a solid steel plunger closing the end of the pipe and held in position by spiral springs which permit it to recede until the pressure is reduced to the fixed limits, but prevent it from entirely leaving the cylinder and allowing the escape of water. A special hub end is flange-bolted to the hydraulic pipe and is provided with hemp packing held by an adjustable brass gland, through which the solid plunger works, with a clearance of 1/32 inch in the pipe beyond the packing. The outer flange of the hub piece, for a 6-inch main, is connected by six 1¼-inch bolts parallel to the plunger fixed to a flanged headpiece and a movable disk parallel to it, which engages the outer end of the plunger. Between the disk and the headpiece there are from seven to twelve spiral steel springs made of ⅞-inch rods coiled to an outer diameter of 6½ inches, the number of springs being varied according to the size of the pipe. One spring is in the center line of the plunger and the guide rod of the latter passes through it. All are adjustable by nuts on the ends of their center rods, which serve as guides for the movable disk. The latter engages a stop on one or more of the rods and has a flanged seat for the end of the plunger to which it is firmly connected by the center rod, which is tapped into the end of the plunger.

The water supply is procured by gravity from four different sources and is stored in a reservoir of about 2,500,000 gallons capacity, which provides a pressure head of about 18 pounds in the yard hydrants. The hydrants are spaced at intervals of not more than 500 feet throughout the shops and yards and are each equipped with 200 feet of hose. Additional hydrants are connected with the hydraulic service and render the high pressure system available if necessary in an emergency. The feed pumps may be used to supply water to a few of the low-pressure hydrants when needed. The employes are instructed in fire drill and the plant is within the limits of the city fire service.

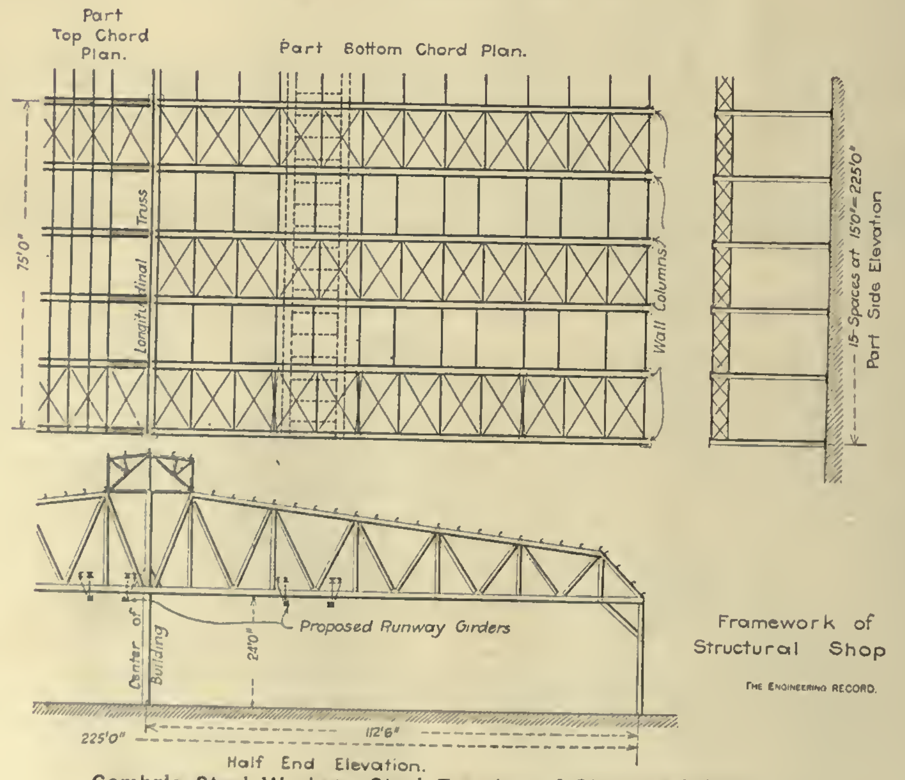
There are six cross-compound class G Ingersoll-Sergeant air compressors, each with a capacity of 1,700 cubic feet of free air per minute, which furnish air at a pressure of 90 pounds per square inch to the rivet hammers, hoists and other pneumatic tools in the shops. Each compressor is connected to a receiver of 100 cubic feet capacity, and all are valved to a 12-inch main in the engine-house cellar, from which overhead branches are taken as required. These are generally carried through the shops on the roof trusses. Two Weiss condensers, numbers X. and XII., built by the Southwark Foundry & Machine Company, are installed in the power house lean-to to receive the steam from all the engines and those pumps not used on the feed-water heaters.

Handling and Transporting.—The principal direction of movement is from the east to the west for the continuous progress of raw material from the stock yard to its final shipment as finished product. A secondary movement back and forth from north to south is provided for the requirements of storage and machine work. Shapes from the rolling mill are delivered by electrically-driven roller tables to special turret shears, which cut them to ordered length, after which they are distributed longitudinally to the storage yard by continuations, about 800 feet long, of the electrically-driven roller tables. At any given point on the line the materials are automatically removed from the tables by hydraulic throw-offs similar to those used in rolling-mill plants, and are piled on the transverse storage skids. From here they are handled by overhead cranes, which load them on railroad cars on longitudinal tracks at both sides of the yard, or they are delivered by extensions of the roller tables to the distributing yard, 300 feet long, at the east end of the structural shop. Here they are skidded north and south and loaded on narrow-gauge longitudinal surface tracks, which deliver them to the shop.

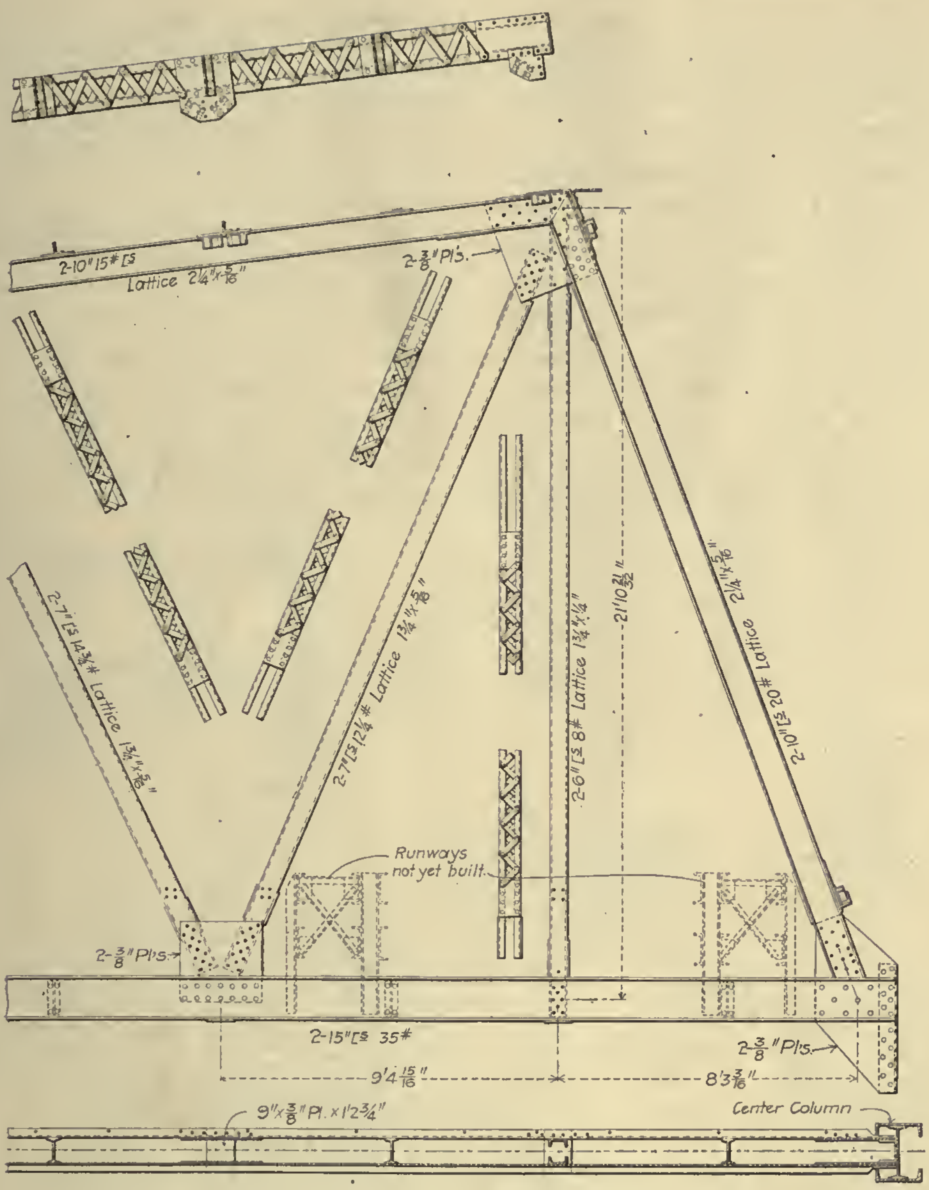
There are three lines of 3-foot gauge tracks running through the shop from end to end, and two other lines running nearly through it, which provide for the longitudinal movement of materials there. The transverse movement is accomplished by 1, 3 and 6-ton pneumatic trolley hoists suspended from the transverse roof trusses on both sides of the shop, and by six 10-ton traveling cranes in various roof truss panels on the south side of the shop. From the west end of the shop three standard-gauge tracks are run parallel with its longitudinal axis to connect with the main lines in the yard. There are also two parallel narrow-gauge tracks extended from those which run through the shop to the finished material storage yard, and all of these are commanded by a 10-ton traveling gantry of 200-foot span. This has tracks nearly 300 feet long and is used for loading the finished product, which is stored on permanent transverse skids underneath it between the longitudinal tracks. There are in the shop six 10-ton traveling cranes of about 14-foot span, and in the storage yards there are three 20-ton Morgan traveling cranes of 76-foot span and two 40-ton Sellers traveling cranes of 72 and 80-foot spans, and one 20-ton Sellers of 70-foot span. Each crane is equipped with three motors, except in the cases where there are two



OUTER END OF TRANSVERSE ROOF TRUSS.



Cambria Steel Works: Steel Framing of Structural Shop.

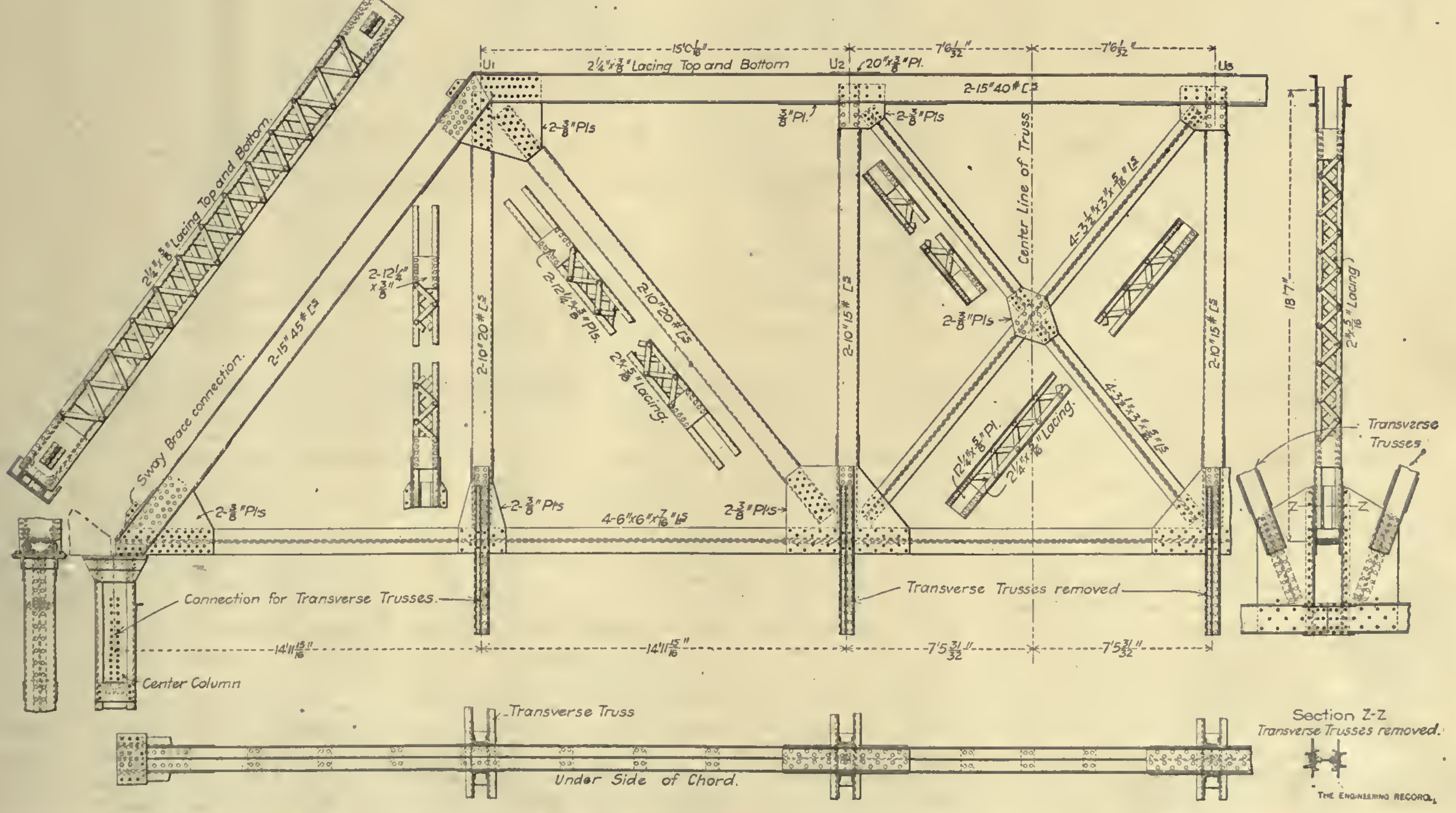


Interior End of Transverse Roof Truss.

independent trolley hoists, each provided with two motors, making five to the crane. The small cranes are constructed to be especially rapid in their operation. All cars on the standard-gauge track as hauled by steam locomotives belonging to the railroad, which is operated as a common system for the three plants.

Structural Features.—The structural shop is 225 feet square, with steel roof trusses and columns supported on concrete piers with footing courses between carrying the brick walls. The building is situated on a slag fill, which is 18 feet deep to the gravel bed of the river. All of the heavy piers are carried down to foundations seated on the gravel; the lighter ones have their footings near the surface. All of them were built in ordinary sheeted pits without trouble from ground water. The piers for the wall columns in the structural shop are about 15 feet apart on centers, are about 4 feet square, with vertical sides, and have stone caps. A concrete footing course 24 inches thick and 3 to 8 feet deep, with a stone top course connects the tops of the piers and supports the brick building walls. The upper edges of these footing courses are about 6 inches above grade, and their edges are beveled slightly so that the projection beyond the outer face of the brick wall provides a water table. The brick walls are 13½ inches thick, except above window arches, where they are reduced to 9 inches. They are built on the center line of the steel columns and are buttressed on the exterior faces to receive them. The columns are flush with the inner face of the wall and are built in solid.

In the structural shop the ground was leveled to sub-grade with crushed slag, surfaced with rammed earth and floored with 3-inch plank. In the templet shop there is a board floor, in the forge shop and bolt shop the floor is of cast-iron plates bedded on rammed sand, and in the other shops there are at present earth floors. As the ground here is comparatively high and thoroughly well drained, it is always dry, and this arrangement is found satisfactory for preliminary construction, and affords a good base on which any other floor may be laid if required



CAMBRIA STEEL WORKS: DETAILS OF TRANSVERSE AND CENTRAL LONGITUDINAL ROOF TRUSSES.

for special purposes. All roofs are sheathed with matched boards from 1 to 2½ inches thick, covered with slate laid on tar paper.

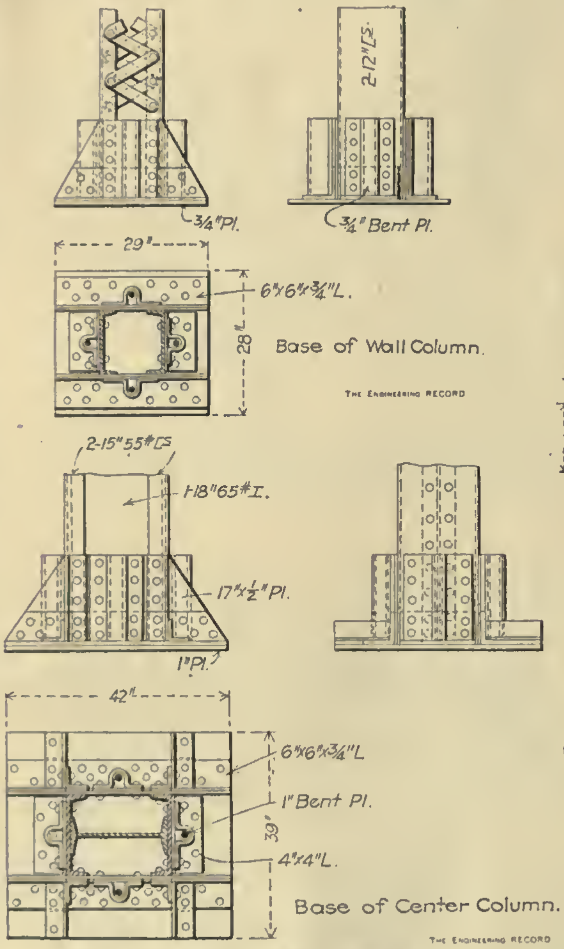
In the structural shop the brick walls are carried only as high as the tops of the side-wall columns, about 22 feet above grade. The end walls around the windows are closed in with temporary board sheathing, stripped, allowing for future extensions at either end. In the car shop and forge shop and in some other buildings the walls are brick to the gable; above this point matched sheathing, covered with slate, is used. In all buildings which are likely to be extended one end wall is closed with ⅞-inch boards, stripped, on timber framework instead of the regular brick wall, so that it can be easily removed if the building is enlarged by adding more transverse bents beyond this point.

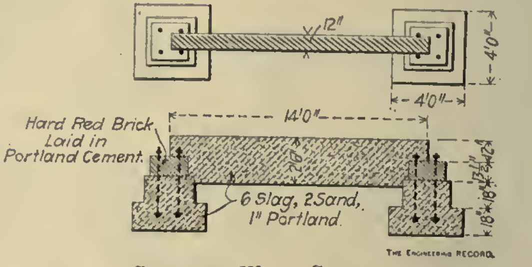
A monitor 20 feet wide extends from end to end of the center line of the structural shop roof. Its walls are about 8 feet high and are glazed throughout with pivoted sash, which fill the entire vertical surface. The flat roof of the monitor is pitched slightly in both directions from the center line, and in it there are three 11x36-foot hipped skylights. On each side of the main roof below the monitor there are seven similar skylights symmetrically arranged on the center line of each side, with their longitudinal axes parallel to the transverse roof trusses. The side walls of the buildings have large windows in each panel, thus giving a glazed area of nearly 50 per cent. of the whole wall surface. Nearly half of the lower part of the end walls is occupied by seven large double doors and by windows between them, while a double tier of windows extends continuously for nearly the full width of the building in the space above the eaves line.

Heating and Ventilation.—The structural shop is heated by an overhead hot-blast system, designed to heat the building to a temperature of 55 degrees Fahrenheit in zero weather, and to renew the air once in 20 minutes. In each corner of the building a 6x6-inch engine is direct-connected to a 6-foot fan 3 feet wide, which forces the air through a radiator stack containing 4,000 feet of 1-inch pipe heated by live steam. The apparatus is supported on a horizontal platform carried on the lower chords of the roof trusses, and the air is discharged through two horizontal circular ducts at right angles to each other, which are run parallel to the walls to the middles of the adjacent side and end of the building. These ducts diminish from 30 inches to 22 inches in diameter and are supported on the bottom chords of the roof trusses. Each of them has pairs of vertical branches 17 inches in diameter, spaced about 40 feet apart, which discharge the hot air at the level of the bottom chord of the roof trusses. The template shop is a small wooden building heated by steam. No system of heating has yet been found necessary for the car shops or the forge shop; the coke furnaces in which the rivet and bolt rods are heated are found to radiate sufficient warmth for the bolt shop.

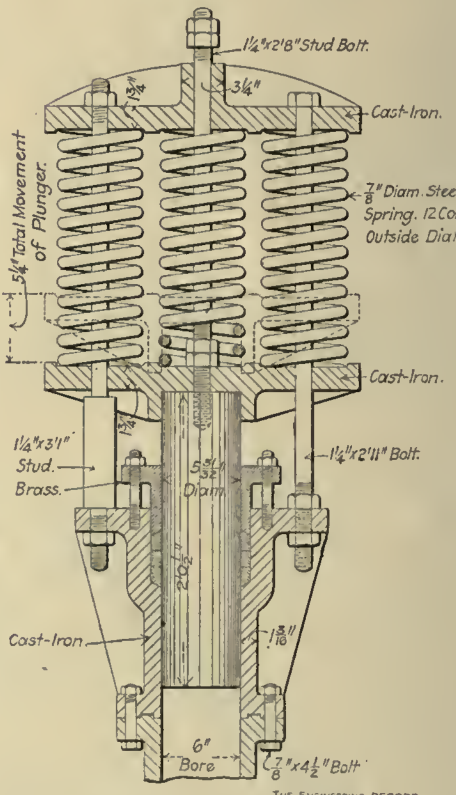
Structural Steel Work.—The roof of the structural shop is supported on sixteen lines of transverse trusses 15 feet apart on centers. Each line has two trusses of 112½-foot span on centers, which are supported in the longitudinal axis of the building by a line of center columns, and three spans of longitudinal trusses which divide the shop into two equal aisles. The outer ends of the transverse trusses are all supported on wall columns, the tops of which are connected by light lattice girder struts. The bottom chords of the transverse trusses are connected by eleven lines of continuous longitudinal struts in each aisle, and the first, third, fifth and eighth panels from each end are X-braced by horizontal diagonal rods between these lines of struts. The top chords have similar X-bracing in the same panels, except the third from each end, and have a continuous line of longitudinal X-bracing from end to end of the building in the eaves panels. They are connected by four lines of 10-inch channel purlins on each side of the hip portions and by twenty-one lines on each of the flat side roofs between the hip and the monitor.

The wall columns have open rectangular cross-sections made with a pair of channels having their flanges turned inward and latticed. The ends of the roof trusses are seated on their cap-plates and their feet have large square base-plates reinforced by wide flange angles and secured by four anchor bolts which engage the upper edges of U-shaped bent plates riveted to each side of the column, having their lower edges fitted to bearing on the horizontal legs of the flange angles, which are thus reinforced. Single connection plates are shop-riveted across the webs of the inner channels and field-riveted to the ends of the eaves struts. The four columns in the center longitudinal row are designed for maximum loads of about 500,000 pounds each and have H-shaped cross-sections made with an I-beam having each flange reinforced by a channel with the flanges turned inward and connected by tie-plates. The 39x42-inch base-plates are similar to those of the wall columns, and the tops of the columns are braced in both directions by the longitudinal and transverse trusses.




12″
4′0″
4′0″
14′0″
Hard Red Brick Laid in Portland Cement.
6 Slag, 2 Sand, 1″ Portland.
18″
18″
12″
The Engineering Record.

CONCRETE WALL GIRDER.



RELIEF BUFFER IN HYDRAULIC MAINS.

Cambria Steel Works: Details of Column Footings; Relief Device for Pressure Pipes.

The longitudinal trusses are of the ordinary Pratt type, with stiff members and riveted connections throughout. Each has 15-foot panels and is symmetrical about the center line with details, as shown in the semi-elevation. The stiff bottom chord has an H-shaped cross-section made with four 6x6-inch angles and tie-plates, and is spliced with horizontal web cover-plates at three points. Pairs of vertical gusset-plates are riveted across the flanges at panel points to form jaws for the connections of the web members. The vertical posts are made with pairs of 10-inch channels, with their flanges turned inward and latticed. At both ends plates are shop-riveted to the outsides of the webs and form jaws which engage the outsides of the lower chord flanges and the insides of the top chord webs, and are field-riveted to them and to the diagonals, except at the hip joints, where they are shop-riveted to the end posts and field-riveted to all other members. At the feet of the vertical posts pairs of vertical angles are shop-riveted to both of the jaw-plates and project about 3 feet below them, engaging the lower chords and providing field-riveted connections through their outstanding flanges for the support of the transverse trusses.

The transverse trusses are seated at their outer ends on the caps of the wall columns, to which they are knee-braced from the first panel points. At the inner ends the lower chords and end posts have projecting gusset-plates riveted to their webs, forming jaws which engage, and are field-riveted to, the extensions of the vertical posts, already described, in the longitudinal trusses. At the ends of the longitudinal trusses the connections of the transverse trusses are made to the center columns, and here the jaw-plates have vertical flange angles shop-riveted to them and field-riveted to tie-plates on the columns flanges. The top and bottom chords are each made with one field splice, all truss members are stiff pieces, and all connections are riveted to pairs of gusset plates shop-riveted to the webs of the chord channels, except the feet of the verticals, which support the centers of the bottom chord panels and are riveted directly to the webs of the chord channels.

All connection plates are shop-riveted to the chords and end posts and field-riveted to the web members. The bottom chord channels are connected by tie-plates across their lower flanges at panel and at sub-panel points, and by short vertical I-beams acting as transverse diaphragms at intermediate points. Horizontal plates are riveted to the top and bottom chords and have pairs of oblique angles, between which the diagonal lateral rods pass and take bearing on washer plates across their ends. The inclined top chords do not reach to the longitudinal trusses, and they are connected across the top chords of the latter by light horizontal struts riveted to bent plate connections at the center ends of the trusses.

Three longitudinal runways for riveting machines were designed to be supported by the lower chords of the transverse trusses and to extend from end to end of the building, as indicated on the cross-section diagram and by the dotted lines in the elevation of the transverse trusses, but these were finally omitted and a single runway 10 feet wide was suspended from the trusses 20 feet from the longitudinal axis of the building. This is not shown in the accompanying illustrations, but the detail of the support originally designed for the runway is shown with X-bracing, which was designed to give it transverse rigidity.

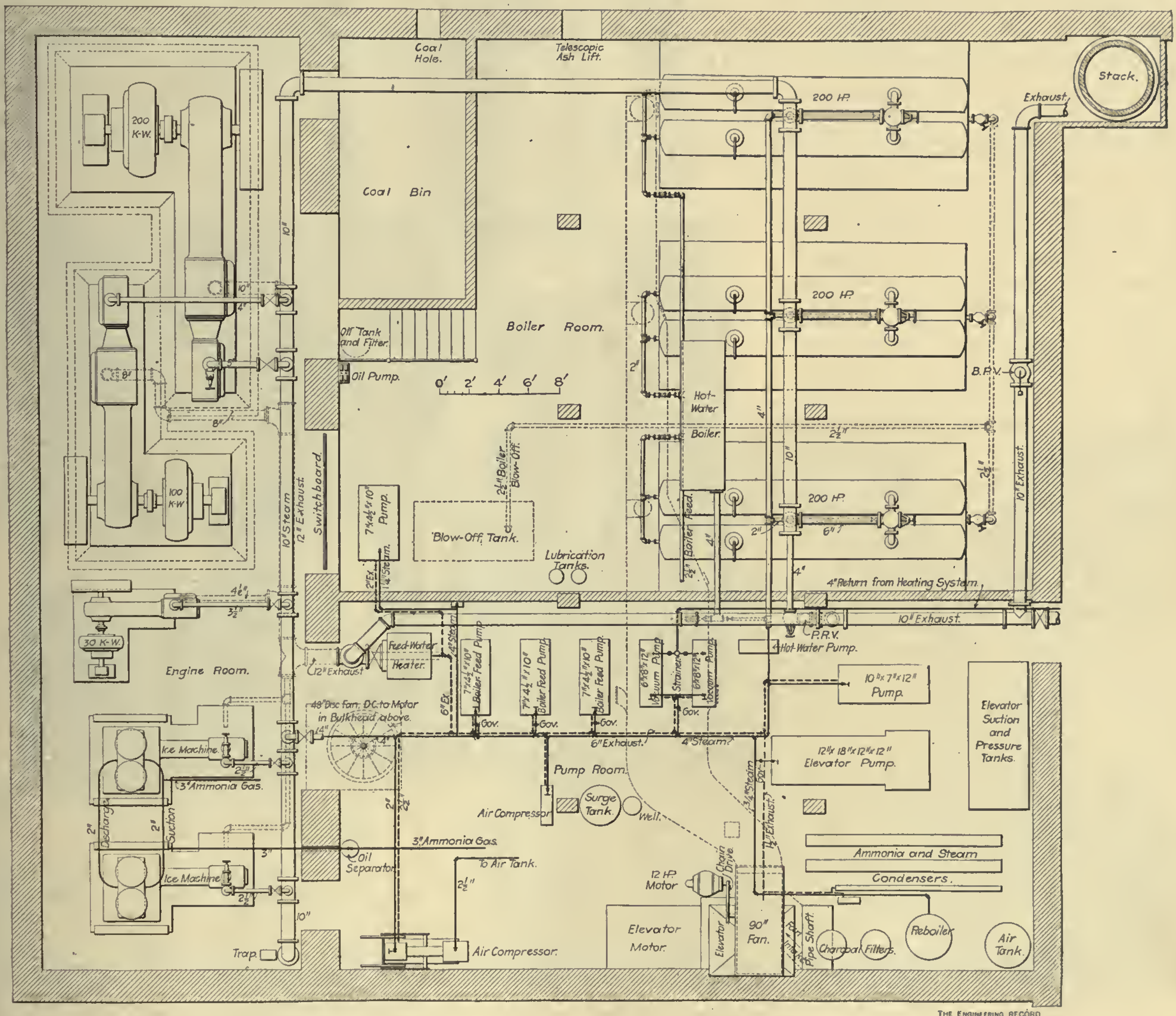
The 92x508-foot car shop is located in the beam storage yard, and occupies the space that was previously commanded by a pair of 20-ton traveling cranes of 76-foot span. These cranes form part of the series which have their runways supported on double pairs of columns 8 feet apart on centers, with spans of 76 and 80 feet, as mentioned before. In order to retain the crane service and utilize their runways and columns, the building has a roof with the trusses supported on short A-bents carried by the cross girders connecting the tops of the runway girders. The trusses are 24 feet apart and their lower chords are about 40 feet clear of the ground, thus affording more than 10 feet headway over the crane tracks. The sides of the buildings have brick walls containing three tiers of windows and the roof has a monitor with windows in the clere-story, and there are two rows of small skylights in each side of the sloping roof.

(To be continued.)

THE POWER PRODUCTION of the new central station of the Kansas City Electric Light Company is given in the following terms by Mr. E. A. Barth in the "American Electrician": When run condensing, 225 watts are obtained per pound of coal, and when run non-condensing, 165 watts per pound. The coal is a slack having a calorific value of 11,000 British thermal units, yielding 17 per cent. of ash.

The Arcade Building Power Plant, Dayton, O.

A power plant that comes in the class of the isolated, building, mechanical equipment designed to meet diversified demands is that installed in the Arcade Building at Dayton, O. In addition to the ordinary power and lighting service it includes an ice-making and cold storage plant. The building itself is of a T shape, about 400 feet long, with fronts on three streets. In the basement is located the power plant. The first floor is given up to stores on the streets and to the arcade passage within. At the center of the building at this level is a general market and above it rises a light well terminating at the top of the building in a glass dome 150 feet in diameter. Above the stores are offices, and then comes several floors of apartments, the uppermost arranged in bachelor suites.



Plan of the Mechanical Plant for the Arcade Building, Dayton, Ohio.

In connection with the refrigerating plant a fur storage is located in the basement, and brine coils are installed in the market iceboxes and in the restaurant, offices and apartments as a means of local refrigeration. The system regarded as most economical is that of a flat water tank within the brine coils. The water in this tank is frozen and then the circulation of the brine shut off until the cake of ice shall have melted again. The direct ammonia circulation was not used throughout the building because of the serious effect of any accidental leak. The necessary ammonia piping is instead confined to a small portion of the basement under the eye of the engineer, and an exhaust fan is there provided to care for any trouble from leaks in this space.

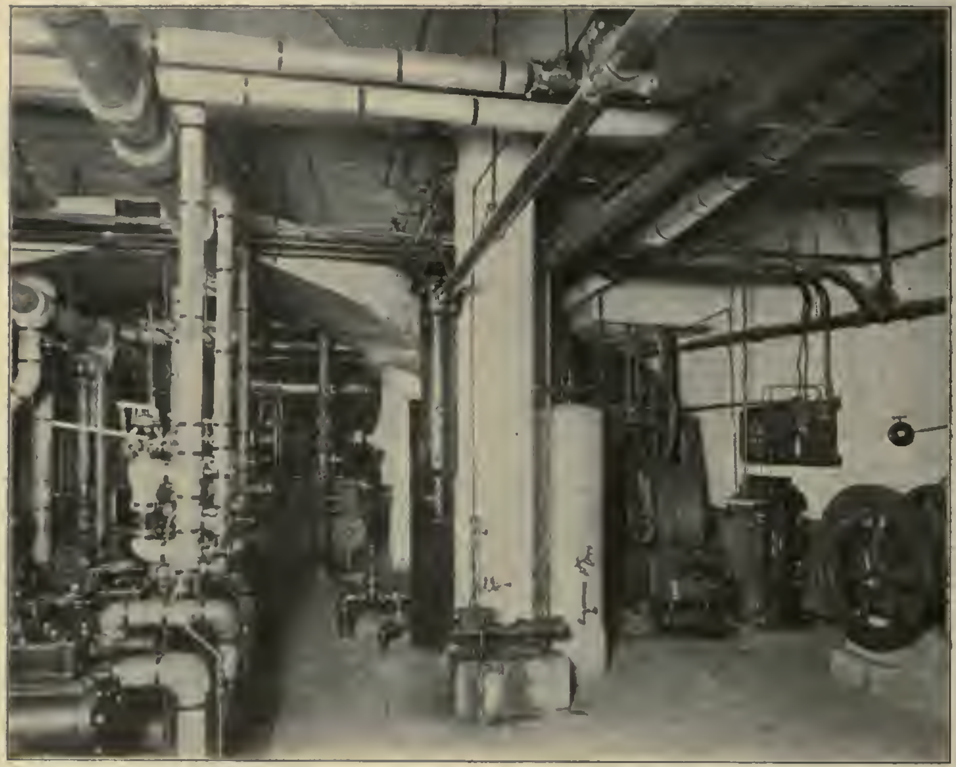
Because of the demand for the basement space for other purposes, the area reserved for the power plant is quite limited. While the plant is not cramped, it presents a well-considered arrangement of machinery and apparatus. Within a space of 60½x66 feet, of which 16 feet are under the sidewalk, is installed, as shown on the accompanying plan, the following equipment: Three Geary water-tube boilers, each of 200 horse-power, working at 125 pounds pressure; three direct-connected electric generating units, of 200, 100 and 30 kilowatts capacity, respectively; two 30-ton Frick compression refrigerating machines; hydraulic and electric elevator machinery, including two pumps, two elevator tanks and an electric hoisting machine outfit; three boiler-feed pumps, together with a feed-water heater; two vacuum pumps, in connection with the heating system; a hot-water circulating pump with a hot-water heater tank for domestic use; two air compressors with an air tank; a surge tank in connection with deep well; two fans; the switchboard; and the apparatus for the refrigerating plant, including condenser, re-boiler and filters.

The head room of the mechanical plant is limited partly owing to the fact that the building was erected on a wet subsoil, requiring a damp course in the foundation concrete. The height in the boiler room is 17 feet 6 inches, and in the engine and pump rooms 12 feet 4½ inches. Coal is received through a manhole in the alley and stored at one end of the boiler room, this having a capacity for about 75 tons. The ashes are removed by means of a telescopic ash hoist, extending through the building wall into the alley. This is provided with a 5-horse-power motor to drive the buckets and the frame is raised and lowered into position by hand.

The boilers are set singly and the piping is arranged to obviate the use of steam separators. Each boiler has two steam drums, and to the cross-over pipe on each is attached a vertical nipple 2 feet long; on the top of this is mounted a 6-inch angle valve. The steam branch from each boiler leads toward the front, rising on a sharp slope, and connects through an elbow into the main steam header, 10 inches in diameter, which it enters from below. Immediately outside of the angle valve a ½-inch drip valve is placed and piped to the drip tank. In the vertical nipple at each boiler outlet is screwed the end of a 2-inch auxiliary steam pipe, which connects into a 4-inch auxiliary header, carried over the boilers parallel to and almost directly underneath the main steam header. The main steam header is run around the plant, as shown, into and through the engine room, which is under the sidewalk, and at the extreme end at the refrigerating machines terminates in a 10-inch drop-leg for the collection of condensation. Throughout its run the header is given a uniform pitch in the direction of steam flow from the first bend at the boilers to the drop-leg; the latter extends to a point about 1 foot above the floor, and water is drained from it by means of a No. 5 Anderson steam trap, and is delivered into the feed-water heater. The auxiliary header is carried into the pump room and is run through the latter and connected into the main steam header, as indicated in the drawing. Two barrels of condensation water are collected in the drop-leg per day.

The generating equipment is of interest in that the larger units are compound, while the smallest employs a simple engine. The compound units are of the Buckeye tandem type. The 200-kilowatt generator is driven by a 14¼ and 25x21-inch engine, and the 100-kilowatt generator by 11 and 19x16-inch engine. The 30 kilowatt unit employs a 10x10-inch Ball engine. The electrical equipment is all of the Western Electric make and has a large lighting duty in addition to operating six Otis electric elevators. The consumption of current for the latter, it will be interesting to add, is given as 3.1 kilowatt hours per car mile with a random load. The switchboard consists of four panels. Three of these are devoted to the generating connections, and the fourth, of double width, is given up to the feeders. Alongside the switchboard is a gauge board with steam and water gauges.

An extensive hydraulic elevator equipment, in addition to the six electric elevators, is installed, comprising seven Otis machines. One of the hydraulic machines has a car 10x23 feet in size for lifting wagons from the coal storage department to the alley. The pumping equipment comprises two duplex pumps, one of the compound type. This is 12x18x12x12 inches in size, while the other is 10x7x12 inches.



Pump Room of the Dayton Arcade Building.

The refrigerating plant is served from a duplicate installation of 13x15-inch Corliss engine-compressor units, of the Frick manufacture, as already stated. As shown in one of the accompanying photographs, the machines are of a usual type, in that the steam ends are horizontal and the compression cylinders are vertical. The vault lights immediately above the latter, giving light and means for working at the cylinders in case of necessity, are shown. The freezing tanks, brine cooling and the brine pumps are all located in the cold storage portion of the basement, some distance away from the heat of the engine and boiler rooms. There are two brine circulating pumps, of the centrifugal type, one direct-driven by a motor and the other by a Dake steam engine. Besides these there is a booster pump to deliver a small amount of brine under the head necessary to reach all the apartments on the upper floors.

For heating, exhaust steam is, of course, utilized, with arrangements for supplementing the supply of exhaust steam when necessary by live steam through the usual pressure-reducing valve. The usual back-pressure valve is also provided in the exhaust line, to give automatic escape of the excess of exhaust steam over the demands of the heating apparatus. The run of exhaust mains is shown in the plan of the plant. The pipe leading to the outboard exhaust is located back of the boiler installation and the back-pressure valve is fitted in the horizontal run. The auxiliary live steam connection is taken from the end of the main steam header nearest the pump room in a 4-inch pipe, as shown. The two-pipe system of distribution for heating is employed, together with a vacuum return, according to the Webster system. There is a total of 25,500 square feet of heating surface in the building. The vacuum pumps are 6x8x12 inches in size, installed in duplicate; they deliver into the feed-water heater. There are three boiler-feed pumps, all 7x4½x10 inches in size, of the duplex type. These pumps are all under automatic control and are cross-connected on their water ends, so that any feed pump or one of the elevator pumps, for example, may be employed on the house service. The hot-water heater or boiler, it will be noticed, is supported above the steam boilers. The hot-water circulating pump is 3x4x5 inches in size.

Compressed air is furnished to the elevator tanks and to the building for cleaning purposes and to a barber shop and various dentists' offices in the building. There are two compressors, as already enumerated. Among other features of the plant may be mentioned a pipe led upward to the roof, where it connects into a pipe ring around the base of the glass dome with hose taps every 50 feet. This pipe is connected at the pumps so that live steam or cold or hot water may be delivered through it, allowing the glass dome to be kept free of ice, snow and dirt, besides constituting a convenient fire-fighting adjunct. A pressure tank system is in use for lubrication, the equipment including a hydraulic pump operated from the city water mains and the usual filter. Fresh air is provided to the basement by means of a 90-inch blower, which is chain-driven from a 12-horse-power motor. This draws air from the roof and delivers it into the boiler and engine rooms through ducts, some of which are shown in the accompanying photographs.

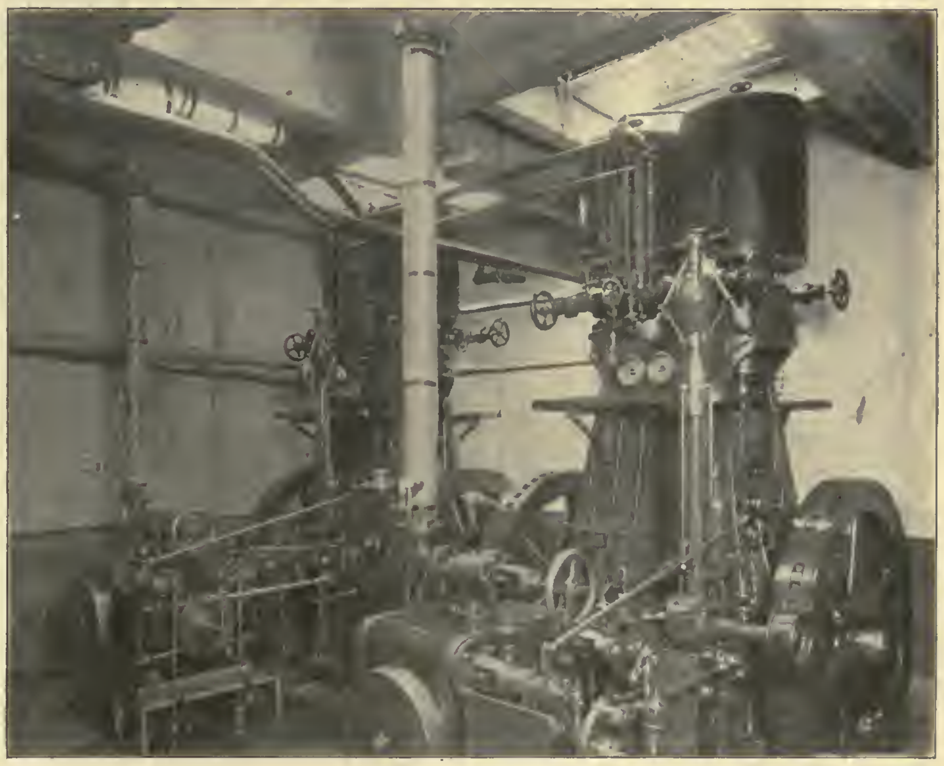
The plant was installed from the designs of the Illinois Engineering Company, of Chicago, by Messrs. Joseph McWilliams & Company, of Louisville, Ky., who contracted for the entire equipment. The work was done under the direction of their superintendent of erection, Mr. Luther E. Jenner.

The Engineering Profession.

Extracts from a commencement address by Foster Crowell, M. Am. Soc. C. E., at the Rensselaer Polytechnic Institute.

A profession is what its members make it. Your profession can be maintained and elevated higher and higher and made enduring for the life of the world, or it can be lowered and trailed in the dust and in the mire. The highest professional object of every engineer should be the profession itself and all that tends to ennoble it, in principle and deed and perfect work.

View in Engine Room.



Refrigerating Machines, Arcade Building, Dayton.

There has been a marked tendency of late, in this seething, strenuous land of ours, to extol the so-called "practical" man, and some quite noted exponents of the type have been hastening about, explaining the superior advantages of a limited education, while the current magazines, as you know, have been filled with pictures of so-called "captains of industry," who were said to have reached their well-deserved positions of great prominence chiefly because they had been untrammeled by misleading knowledge from books.

We in the profession have been hearing sung the superior merits of the practical man all our lives, and I suppose the song will still be heard as a lullaby for ignorance when the whole unbounded universe is connected up, but let me tell you, for your comfort, that the most practical men are the best educated and the only really practical engineer is the one who has the theory all right at the start. Afterward, a man may find "much in experience and little in books," but you may rest well assured that the fundamental knowledge you have acquired will not stand in your way. Yet, aim to be practical, to the uttermost, in your methods and in every result. There is a tendency to be resisted that every young engineer feels —the tendency to too great refinement in results of calculations and to superfluous elaborations of processes. In such respects especially you should be on your guard against the charge of being unpractical, always remembering that it is not worth while, or sensible, to try to refine a result beyond the degree of refinement of the data. The young engineer also is prone to forget that for his purposes mathematics is a tool and not an art. . . .

Not only will you do well to be practical, but you will find that it is important to cultivate the executive function.

The engineer who is a good executive is in demand. It is of prime importance, of course, to be able to design work correctly, but carrying it out in the best and most economical manner is scarcely less so. Study, therefore, to build up a reputation as a good executive, as well as a good designer.

We have been speaking among ourselves of the engineer's profession as if it were one that is thoroughly well defined and of accepted meaning. Such, however, strange to say, is not the case, and this is all the more surprising when we reflect that in the modern economic development the community has come to depend on the engineer absolutely and from day to day, for its very existence almost, and certainly for its comfort and convenience. Its food supplies, its water, its fuel and light, its business, its trades, its commerce, its manufactures, its intercommunications—all, in fact, of its physical activities, are bound up in the work of the engineer. . . .

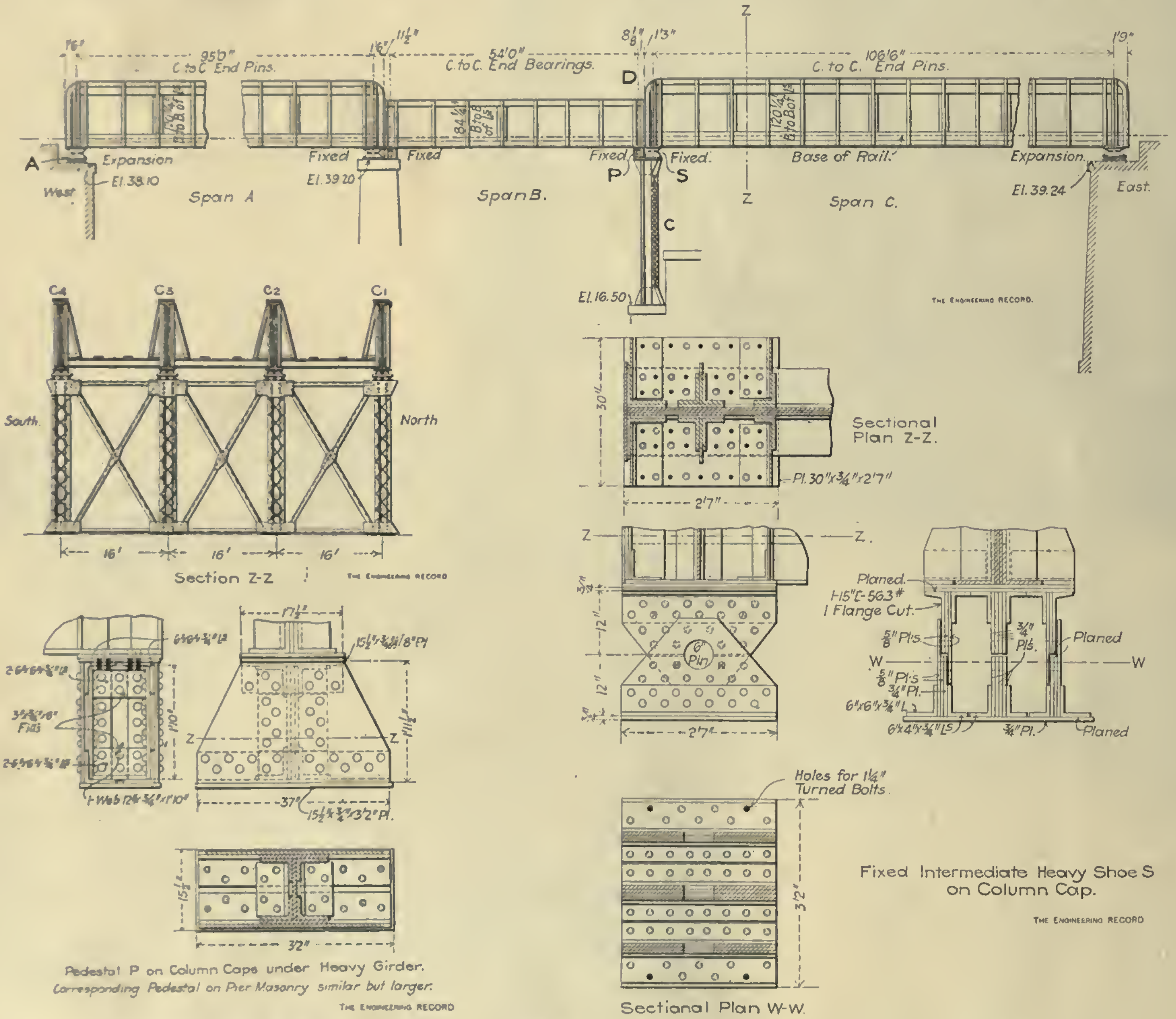
In Great Britain the modern engineer came to the front earlier than in this country, and the people know him better for what he does and what he is. But at first they did not. In 1818 was established the Institution of Civil Engineers and in 1828 it was incorporated by royal charter, the language of which states its object as "being the general advancement of Mechanical Science, and more particularly for promoting the acquisition of that species of knowledge which constitutes the profession of the Civil Engineer." To which were afterward added upon the diplomas of the Institution the significant words of Thomas Tredgold as an amplification, to wit, "being the art of directing the great sources of power in Nature for the use and convenience of Man," thus showing that the public had to be educated up to us.

It is very interesting to note that at the time this definition of the civil engineer was coined the age of steam had scarcely begun and the existence of electricity as a source of power for engineers to deal with was not suspected.

It was not until a quarter of a century later, in 1853, that the American Society of Civil Engineers was formed and that body seems to have taken for granted that a professional definition no longer was necessary. That perhaps was unfortunate, for, had it been otherwise, the present confusion in the public mind in America as to what particular kind of an engineer a civil engineer is might not exist. The present Constitution of this Society goes to the other extreme in providing that "a Member shall be a Civil, Military, Naval, Mining, Mechanical, Electrical, or other professional Engineer, an Architect or a Marine Architect." From the strictly professional point of view such segregations tend to destroy and not to up-build. In practice, however, it cannot be said that this Society, grouped as it is nominally, has not built up the profession in this country. Still the results fall short in solidarity of what is really needed to elevate it commensurately with the importance of the part it plays in the body politic.

A Three-Track, Beam-Floor, Girder Bridge.

The three tracks of the Central Railroad of New Jersey cross the tracks of the Pennsylvania Railroad at Newark, N. J., on a skew through plate-girder bridge with three spans of 95 feet, 54 feet and 106½ feet. Each span has four lines of girders 16 feet apart on centers which are supported on one vertical post trestle bent, one masonry pier and two masonry abutments. The abutments are in divergent planes, one of which is parallel to the trestle bent and the other parallel to the masonry pier. This makes all the girders in one end span of the same length and all those of the other end span of another length, but makes the girders in the center span all have different lengths, namely, 50 feet, 56 feet 9¼ inches, 63 feet 6½ inches and 70 feet 3¾ inches center to center of pier and trestle. The pier and abutments and the south line of girders are designed for the future addition of another girder and track south of the present south girder. The long-span girders have pin bearings at both ends and roller bearings at the abutments.



Pedestal P on Column Caps under Heavy Girder.
Corresponding Pedestal on Pier Masonry similar but larger.

Fixed Intermediate Heavy Shoe S on Column Cap.

Sectional Plan W-W.

Newark Bridge: Elevation of Girders and Details of Pedestals on Supporting Columns.

The principal structural peculiarities of the bridge are the support of the girders on the unusually wide and heavy column caps, the rigid connection of the ends of the adjacent girders one to another and the floor of I-beam joists without floor beams, stringers or laterals. All material is medium open hearth steel, and all rivets are ⅞ inch in diameter. The sheared edges of all bottom flange materials are planned ¼ inch, and the rivet holes through bottom flange plates over ⅝ inch thick are punched and reamed ⅛ inch larger. The girders in spans A and C are similar, but have different lengths and materials, girders C, B and A being proportioned for only half as much live load as the other girders in the same panels.

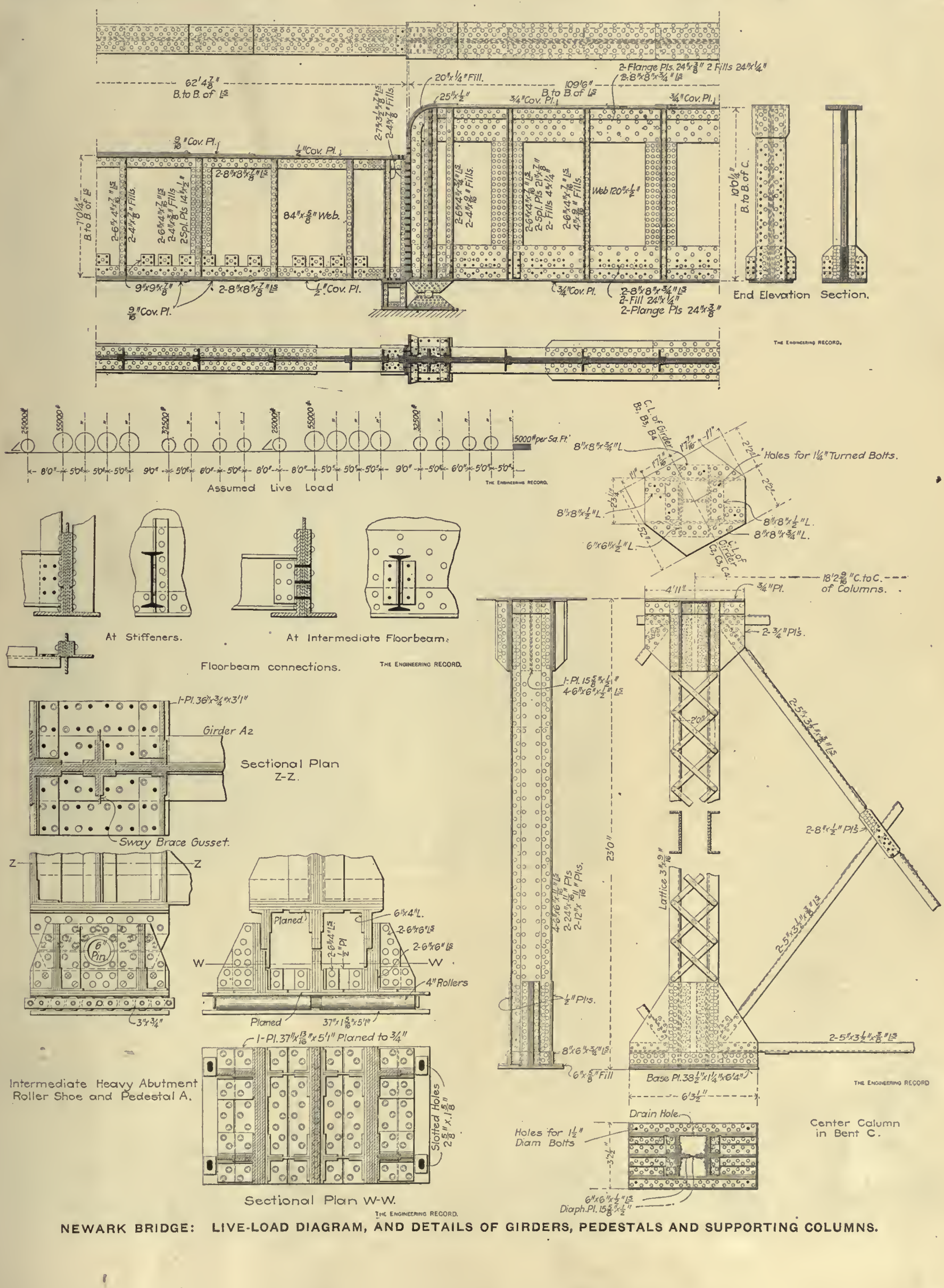
All girders are proportioned for a live load of two locomotives followed by a train load of 5,000 pounds per linear foot, as indicated by the load diagram. For the heavy 106½-foot girders this gives a maximum moment of 153,711,000 pounds. The corresponding maximum flange stress is 1,349,000 pounds, for which, at a unit stress of 10,000 pounds, the net required cross section is 134.9 inches; this is made up of two 8x8x¾-inch angles, two 24x⅜-inch and two 16x⅜-inch full length side plates, one 27x¾-inch and four 27x11/16-inch cover plates from 39 to 92 feet long, having a total gross area of 159.6 square inches. The maximum shears are 544,850 pounds, 434,000 and 346,000 pounds, at the end and at distances of 12 and 22 feet respectively therefrom. The web is 120 inches deep and has thicknesses of ¾, ⅝ and ½ inch, corresponding to the shears just mentioned.

Girder C is 106 feet 6 inches long on centers of bearings and 109½ feet long over all. The web is cut to give a camber of ¾ inch in the center panel and its splices are all made with 108 rivets in four vertical rows through two 14x7/16-inch splice plates. Each flange has a pair of full length 8x8x⅞ inch angles, but those of the top flange are cut 19 inches short at each end, so as to be tangent to the curves of the rounded upper corners and abut against the upper horizontal ends of the vertical end flange angles, which are the same size and are short pieces easily curved to conform to the corners.

The bottom flange angles 109½ feet long are remarkable for their great length for such wide flanges. The flange cover plates have four rows of vertical rivets through the flange angles and two rows of rivets through their edges outside the angles. The vertical web stiffeners are pairs of 4x6x7/16-inch angles with fillers. A 20x¾-inch sole plate is riveted to each end of the bottom flange to receive the triple-web riveted shoe, which is riveted to it and engages the 6-inch pin through the corresponding pedestal. The pedestal is secured with turned bolts to the column cap. The outer reinforcement plates in the side webs of both shoe and pedestal have full holes and form jaws locking each other together; the other webs have half holes and their upper edges are planed for ½-inch horizontal clearance.

The heavy girders C$_1$, C$_2$ and C$_3$ are made as shown in the part elevation and differ from the girder C in the thickness of the web, which varies from ½ to ¾ inch, in the web splices which have four vertical rows of rivets in the center of the girder and six rows at the ends, in the use of vertical side plates and wider cover plates for the flanges; in the extension of the sole plates and their stiffening by vertical transverse web plates and in the general difference in thickness of materials. Each flange is made with two 24x⅜-inch full length vertical side plates with six horizontal rows of rivets and two full-length 8x8x¾-inch flange angles. In the center the flange has one 27x¾-inch and four 27x11/16-inch cover plates. All of the girders were riveted up complete in the shops and shipped whole in single pieces, loaded on three cars each.

The longest of the heavy girders in the middle span is 62 feet 4⅞ inches long over all and is of simple construction throughout, as shown in the elevation of one end. The web has a uniform thickness of ⅝ inch, and the maximum flange section consists of two 8x8x⅞-inch angles, three 20x9/16-inch and one 20x2½-inch cover plates. The girder is made without camber and is seated at both ends on fixed riveted pedestals riveted to the column caps. Vertical transverse filler plates beveled to correspond with the grade are placed between the ends of this girder and those of the end spans, and



NEWARK BRIDGE: LIVE-LOAD DIAGRAM, AND DETAILS OF GIRDERS, PEDESTALS AND SUPPORTING COLUMNS.

they are field-riveted together through their vertical end stiffener angles, thus making each line of girders continuous from abutment to abutment.

On all three spans the floor is substantially the same and consists of 15-inch transverse I-beams, most of them 1 foot 4 inches apart on centers, varying from 1 foot 6½ inches to 11½ inches apart on centers at irregular spaces and panel points. The lower flanges of the I-beams clear the horizontal legs of the lower flange angles of the main girders and are cut on one side to clear the outstanding flanges of the vertical web stiffener angles, to which they are field-riveted by six rivets through their webs. At all other points the I-beams have a pair of 4x6-inch vertical connection angles shop-riveted to their webs at each end and field-riveted to the girder web. At alternate web stiffeners there are triangular gusset plates with single flange-angles on the horizontal and inclined sides, which are riveted to the I-beams and the web stiffeners, and reach to the top flanges of the girders, forming sway braces. The floor beam connection rivet holes were reamed to a cast-iron template. Under each line of rails there is a continuous longitudinal plate about 12 inches wide.

At the end where the skew is least the two end floorbeams are parallel to the abutment, and the third floor beam bisects the angle between them and the regular floor beam. At the other end of the bridge oblique I-beams nearly parallel to the axis of the abutment, with their flanges flush with the floor beams, are connected by bent web plates to the ends of the girders and receive the web connections of the shore ends of the latter. The columns in the trestle bent have unusually broad and long bases and cap plates, the latter being extended to receive the girder shoes and being set skew to correspond with the axis of the bridge, while the columns are set square with the tracks underneath. At the base there are wide web plates and vertical centre diaphragms reinforcing the base plates which are made of two pieces of plate ¾ inch thick and stiffened by six lines of flange angles which cover the entire upper surface. The cap plate is reinforced by only two vertical web plates, but has the horizontal flanges of its angles supported on the planed upper ends of four outside vertical angles. The bridge was designed and built under the direction of the engineering department of the Central Railroad of New Jersey, Mr. Joseph O. Osgood, chief engineer, and the American Bridge Company, of New York, Mr. Paul Wölfel, chief engineer, was the contractor.

Fatal Explosion in a Chicago Sewer.

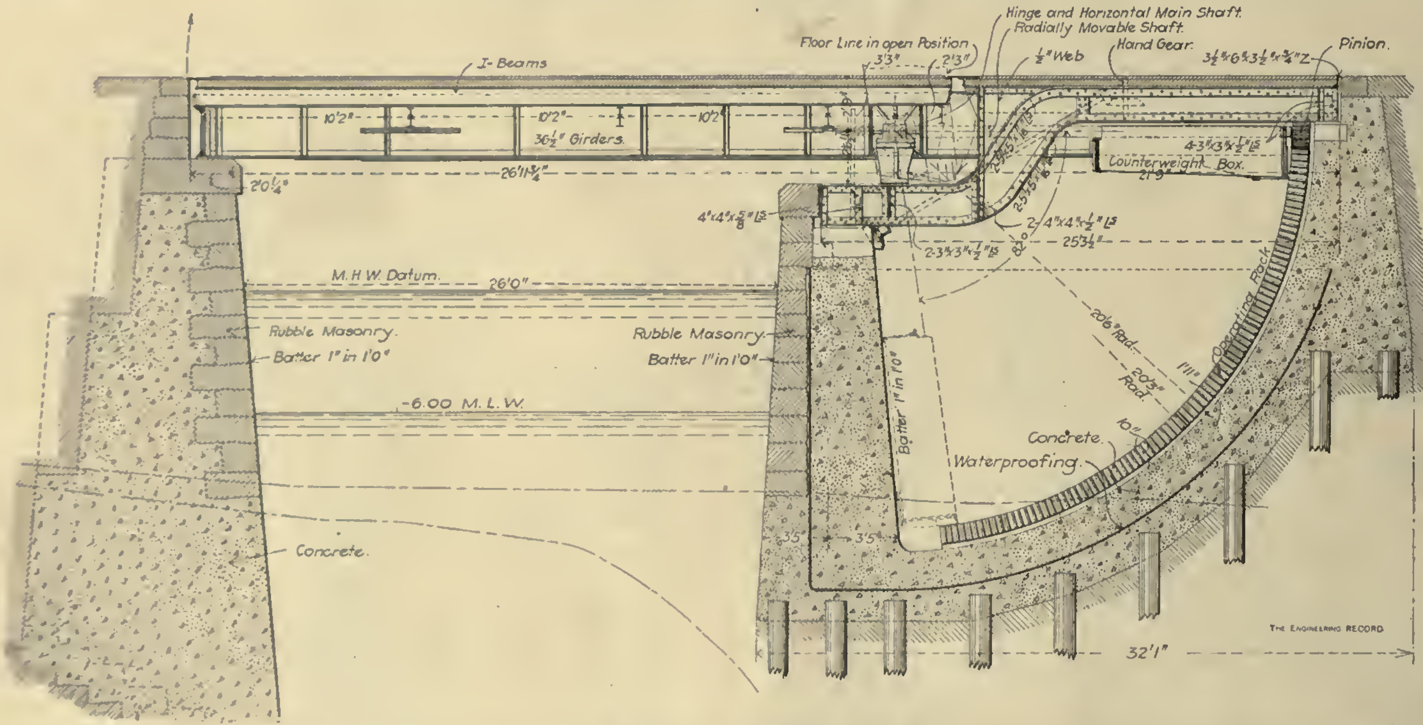
Last Saturday forenoon, June 11, an explosion occurred in the Thirty-ninth Street sewer, Chicago, one of the city's new large intercepting sewers, which caused the death of Assistant Engineer Guy Miltimore and three men. The explosion took place in the portion of the conduit between Butler and Halsted streets, which has a horseshoe-shaped cross-section 22 feet wide and 18 feet high. A full bulkhead had been built in the sewer at Butler Street and the portion of the sewer west of this point is 2,100 feet long, with a temporary pump well at the Halsted Street slip. This portion of the sewer has been in use about three years and contained a heavy deposit of bad material. Mr. Miltimore and the three men with him entered the pump well for the purpose of inspecting the sewer, and the explosion is reported to have occurred almost immediately after the men disappeared below the mouth of the well, which is about 25 feet deep. Manholes on the sewer were being opened when the explosion occurred, and many covers which had not been removed were hurled from their places. Frames, shafts and gearing of two 15-inch centrifugal pumps in the temporary pumping station were wrecked and with the piping fell into the well on the bodies of the men. Mr. W. S. MacHarg, consulting engineer, from whom the information for this note was obtained, says that the character of the gas has not been established. The sewer apparently was not injured. Additional facts may be brought out by the coroner's investigation, but this had not been undertaken at the time of going to press.

Two Surveyors were killed recently near Bingham, Utah, it is reported, by a high-potential electric current transmitted through the steel tape which they were using and which accidentally came into contact with an electric transmission line.

A Short-Span Bascule Bridge in New York City.

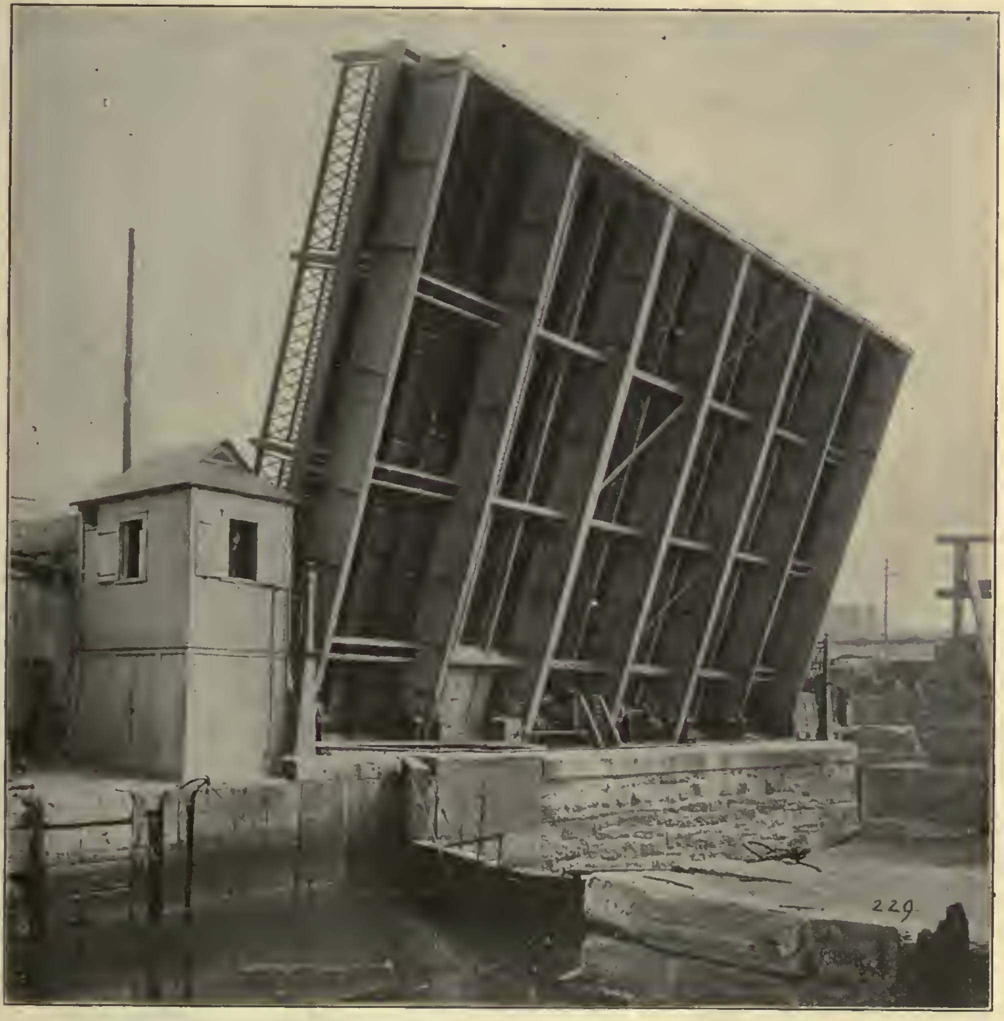
A small bascule bridge over Mott Haven canal at 135th Street, New York, has a clear span of 26 feet and a width of 66 feet over all, and carries a 42-foot roadway and two 11½-foot sidewalks. It is ingeniously arranged with a long and a short arm operated by a simple rack mechanism contained in the pit which receives the counterweighted shore arm and contains all the machinery, so that the bridge presents the external appearance of an ordinary plate girder span and has no tower nor other members projecting above the roadway deck.

The floor is supported by seven symmetrically arranged longitudinal plate girders, one of them on the center line, which have transverse I-beams web-connected to them, carrying light longitudinal beams across their top flanges to receive the double thickness of floor planks, which just clear the top flanges of the side girders and are crowned a few inches above the center girder. At the movable end all the girders are seated on flat bed plates on the abutment masonry; at the opposite end they are hinged so as to revolve upwards through an angle of 82 degrees from the horizontal. The outside four girders terminate at their hinges, but the center three girders extend nearly 22 feet beyond them to support the counterweight platform. They project under the fixed approach floor and revolve down into the pit under it when the bridge is opened. The hinges consist of 7-inch horizontal pins through the lower parts of ribbed castings bolted to both sides of each web between pairs of vertical web stiffener angles and are supported at their ends in pairs of cast pedestals. The pedestals for the four outer girders and the outside pedestals for the two adjacent girders are seated on the abutment masonry. Both pedestals for the center girder and the two inside pedestals for the two adjacent girders are seated on the top flanges of the curved drop girders which support the fixed roadway platform over the counterweight pit, as shown in the longitudinal section. This arrangement permits the bascule hinge to be offset clear of the abutment wall and allows the ends of the long girders to revolve clear of the masonry.



Mott Haven Bascule Bridge: Longitudinal Sectional Elevation of Main Girder, Tail Pit and Abutments.

The bridge is operated with a combination of horizontal and inclined shafts and miter gears. A very short vertical shaft nearly in the center of the pit terminates in a capstan head at floor level, where it is operated by detachable hand levers at an angle of about 45 degrees with the horizontal. The lower end of the shaft is connected by a miter gear with a longitudinal shaft inclined downwards, which has a miter gear on its lower end operating a vertical shaft seated on the abutment masonry. The upper end of this shaft carries a worm wheel gearing into a transverse horizontal shaft in the axis of the bascule hinge. This shaft is nearly 24 feet long and passes through holes bored through the hinge pins of the center three girders. Close to the bearings of the outer girders of this set the shaft has miter gears driving two longitudinal shafts about 15 feet apart, which are horizontal when the bridge is closed and extend to the rack quadrant bolted to the pit masonry on each side. Each shaft has a pinion engaging the rack teeth, and as it is radial to the rack when it is operated it follows the latter and traveling down on it revolves the counterweighted bascule leaf upwards, or vice-versa.



Mott Haven Bascule Bridge Open, Showing Main Driving Shaft and Gear.

The sectional counterweight consists of about 131,000 pounds of cast-iron, the machinery weighs 58,258 pounds and the structural steel weighs 133,324 pounds. The other principal quantities involved in the construction of the bridge include 2,870 cubic yards of excavation, 1,865 linear feet of piles, 8,336 feet board measure of creosoted under floor, 4,769 feet of upper floor, 759 cubic yards of Portland cement concrete, 116 yards of rubble masonry and 2,035 square feet of waterproofing. The bridge can be opened in 20 seconds by a 25-horse-power 500-volt No. 800 General Electric street car motor, seated on the abutment masonry and geared to the main vertical shaft. It is proportioned for the heaviest street roller and for first-class city traffic, and was built at a cost of about $30,000.

It was designed and its construction was supervised by the Department of Bridges when Mr. John L. Shea was commissioner and Mr. S. R. Probasco was chief engineer. Mr. G. R. Ferguson was assistant engineer in charge of the design and Mr. J. G. Theban was resident engineer. The contract was let to Mr. Augustus Smith, May 20, 1901, and the bridge has been duly completed and is considered satisfactory.

Arch Trusses for Aerial Circus Platform.

The Aerial Circus at Luna Park, Coney Island, Brooklyn, N. Y., is designed especially to afford amusement which will be, on account of its novelty, attractive to the pleasure-seekers who come in great numbers from greater New York to this day resort during the hot weather in the summer season. It provides for an open-air entertainment on a large scale with a combination of attractions, and is connected with an aquatic arena in a large enclosed court. The artificial lagoon has its axis coincident with that of the arena, and at one end of the former there is a tower from the top of which "Chute the Chutes" passenger boats descend on an inclined plane through artificial cascades to the arena. The boats, after arriving at the arena, pass onward through the center of it, turning at the opposite end and following around the sides to the lagoon and back to the tower, to the summit of which they are elevated for another trip.

The Aerial Circus, as the name implies, is an equestrian ring performance which is conducted in the center of the arena directly over the course of the boats and about 100 feet from the foot of the tower. The circus platform is used for the performers only and is a level wooden floor approximately trapezoidal in plan, about 120 feet long, from 35 to 65 feet wide, and about 15 feet above the water level. Tiers of raised seats on the sides of the arena provide accommodation for the spectators, who look down on the circus and see, underneath it and on both sides and ends of it, the attractions on the lagoon. These seats and the promenade around the arena are entirely separate and isolated from the circus platform, and the latter is like an island accessible by an inclined plane on a bridge across the lagoon at one end.

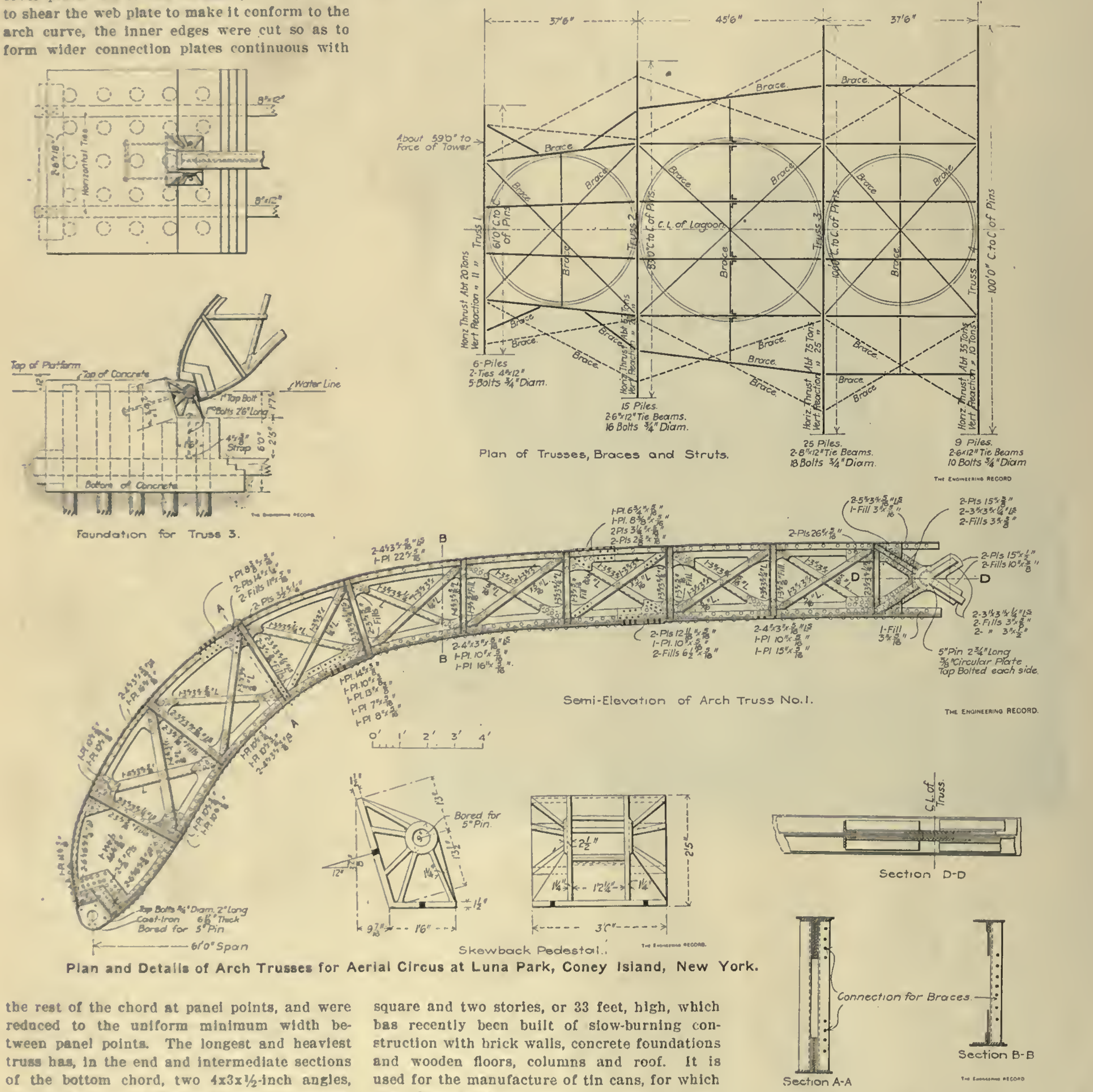
On the platform there is a main center ring 45 feet in diameter and two side rings 37 feet in diameter, all of which are intended to support only the weight of the performers and a few horses, so that the loads are very light, and the structure which supports the platform is proportioned only for the dead-load stresses and the specified live load, not exceeding about 2,000 pounds at any point, or for a total distributed load of 72,000 pounds, and for the assumed vibration and impact stresses. It is in a sheltered position surrounded by buildings and high walls, and no especial provision was deemed necessary for wind pressures. The wooden joists of the platform are carried on the top flanges of transverse and longitudinal lattice girders, which serve as braces connecting the four main trusses, and are web-connected to them similarly to trussed purlins in an arched roof. The general arrangement of the trusses and girders and the diagonal angle braces in their main panels are indicated in the plan diagram.

The main trusses are three-hinge riveted arches with spans of from 60 to 100 feet on centers and a uniform rise of 11 feet from skewback to intrados. The centers of the skewback pins are at water level. The skewbacks are seated on piers clear of the waterway on opposite sides of the lagoon, so that the trusses and all the superstructure are entirely clear of the lagoon, allow its unrestricted navigation, and do not necessarily obstruct the vision of spectators watching events there. The soil at the site is sand. The excavations for the lagoon, which contains 4 feet of water pumped from the ocean, have been lined with a wooden bottom and sides. The piers are rectangular masses of concrete enclosing the tops of the piles, which number from 6 to 25 in each pier. As the arches are very flat, there is a considerable horizontal thrust for the long spans, and this is transmitted directly to the pier masonry and provided for by horizontal tension members connecting the piers for the same arch on opposite sides of the lagoon. These ties are all pairs of 12-inch timbers, from 4 to 8 inches thick, with their upper edges flush with the bottom of the lagoon. They are spliced with wooden keys, side plates and steel bolts, pass through the concrete piers 4 feet in the clear below the skewback pin centers, and are bolted to horizontal transverse bearing timbers across the rear vertical faces of the piers.

All the arch trusses are similar except for the variations in curvature, dimensions and materials occasioned by the varying spans and loads, and all correspond in details and appearance to the shortest span, which is here shown in semi-elevation. In the end panels there is a solid, continuous web 5/16 inch thick reinforced to 15/16 inch for the skewback pin bearings, which are made with cast-iron blocks bolted to each side of the web and engaging the outstanding flanges of heavy angles riveted to the web. This provides a 14-inch bearing on the 5-inch pin, which engages a double-web cast-iron shoe, solidly bedded in the pier concrete This shoe has one horizontal bearing and one inclined bearing surface, the latter normal to the line of stress, and both of them secured by two 1-inch anchor bolts built into the masonry.

At the centre of the truss the semi-arches are connected by the crown pin through jaw-plates which lap each other from the opposite members. The top and bottom chords of the trusses are connected across the center panel by short pieces bolted to them through slotted holes at one end to allow for temperature variations. The outlines of the trusses are not made with broken lines, but are curved throughout. The top and bottom chords have T-shaped cross-sections made with a web plate 6 inches in minimum depth, two flange angles and a 10-inch cover plate. As it was necessary in any event to shear the web plate to make it conform to the arch curve, the inner edges were cut so as to form wider connection plates continuous with the rest of the chord at panel points, and were reduced to the uniform minimum width between panel points. The longest and heaviest truss has, in the end and intermediate sections of the bottom chord, two 4x3x½-inch angles, two 24x⅜-inch (maximum width) web plates, one 12x½ and one 12x5/16-inch cover plates. The upper section of top chord is made with two 4x3x5/16-inch angles, one 10x5/16-inch web plate, and two 16x⅜-inch cover plates. The heaviest diagonal members are single 4x3x⅜-inch angles with six to eight rivets in each end. Each semi-truss was shop-riveted in three pieces with field-riveted splices. They were assembled by three gin poles, which sustained them until the field splices were temporarily bolted.

The structure was designed by Mr. F. A. Burdett, consulting engineers, and the 160,000 pounds of structural steel were fabricated and erected by the Hudson Structural Company, Jersey City.



Foundation for Truss 3.

Plan of Trusses, Braces and Struts.

Semi-Elevation of Arch Truss No. 1.

Skewback Pedestal.

Section D-D

Section A-A

Section B-B

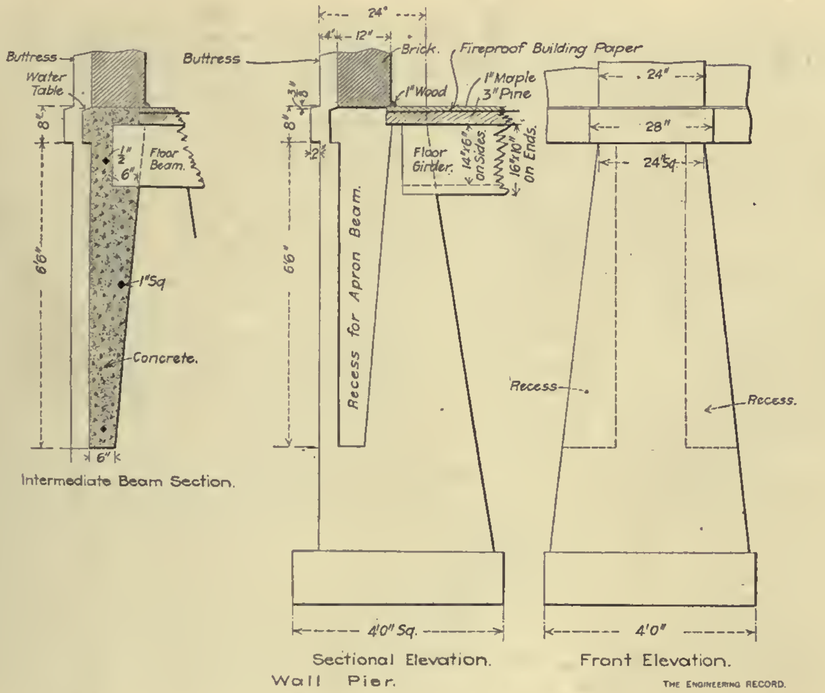
Plan and Details of Arch Trusses for Aerial Circus at Luna Park, Coney Island, New York.

A Factory Building with Reinforced Concrete Wall Girders.

The factory of the Passaic Metal Ware Company, Passaic, N. J., is a building 100 feet square and two stories, or 33 feet, high, which has recently been built of slow-burning construction with brick walls, concrete foundations and wooden floors, columns and roof. It is used for the manufacture of tin cans, for which powerful presses and other heavy machinery are used, so that the construction was designed for heavy loads and to resist vibration. The brick walls are 24 inches thick at the base and are divided into 12 and 18-foot panels by outside buttresses. Above the second-story windows the brickwork is corbeled out from the face of the wall to the face of the buttresses, to complete the panels and form a plain cornice under the gutters. Each panel contains a double window in each story, the lower windows having reinforced concrete lintels and the upper windows having three-ring brick arch lintels. All window sills are made of reinforced concrete. About 40 per cent. of the wall area on both sides and ends of the building is glazed, and this is considered to give satisfactory lighting without monitors or skylights.

The walls carry the outer ends of the floor-beams, and the remainder of the floor is carried on longitudinal and transverse rows of yellow pine columns 12 and 18 feet apart, respectively. In the first story the columns are 10 inches square, and in the second story they are 9 inches in diameter. The floors are proportioned for a live load of 150 pounds per square foot and are made with a 1-inch maple wearing surface and a 3-inch yellow pine underfloor supported on 6x14-inch joists 3 feet apart, which are suspended by stirrups from 10x16-inch transverse girders 12 feet apart. The roof is proportioned for a wind and snow load of 50 pounds per square foot, but is not required to support any machinery or other live load. It is made with 2-inch pine plank and 5-ply tar felt and gravel. All windows are glazed with ribbed glass and have the upper sashes arranged as transoms and the lower sashes hung on hinges opening outward, like blinds.

The original surface of the ground was regular and sloped about 4 feet in the length of the building. The soil consisted of 3 feet or less of dry black earth on a stratum of solid shale rock, to which the foundations were carried. In order to avoid making continuous trenches with wide footings for the wall foundations, a special system was adopted of piers connected by reinforced concrete wall girders. By this means it is estimated that a considerable saving was effected both in the materials and work required for the substructure. The piers are located at the buttressed panel joints in the walls, and are at the extremities of the column rows. They have a variable depth below the surface and a corresponding variation in height, the maximum being 9½ feet and the minimum 5 feet. The tops of the piers are all at the level of the bottom course of brickwork, which is 4 or 5 feet above the surface of the ground where the latter is the lowest. All the wall piers except those at the corners have bases of uniform dimensions, being 4 feet square and 12 inches thick, above which the shafts have a variable batter to receive the pilasters and wall girders, as shown in the typical detail. They are made with the outer face perpendicular and have pockets in both sides and in their inner faces to receive the wall girders and the floorbeams, respectively. The interior column piers have no footing separate from the shaft, and are uniformly made with a base 4 feet square and sides battered to about 24 inches square at the top, where they receive the girders laid directly on the upper surface, and have brick and cement filling to support the ends of the beams.



Concrete Foundation Piers and Wall Girders for Passaic Factory.

The wall girders are trapezoidal in cross-section with a uniform height of 6½ feet and a width of 6 inches at the bottom and about 14 inches at the top. They are made with a vertical outer face and a 2-inch exterior projection, as shown, to form a water table. They are reinforced by a single ½-inch square Ransome twisted steel rod in the upper and lower edge, and a 1-inch rod through the center. These girders form aprons connecting the piers and enclosing the cellar area, and extend about 6 inches below the surface of the ground. Each panel is pierced by two 10x20-inch ventilation openings protected by cast-iron gratings. The brick wall is carried directly on the upper surfaces of the girders, which are proportioned more for the requirements of construction than for a specific limited loading; their calculated strength, however, is much in excess of the maximum dead and live load which they will support. The window lintels are made with rich concrete mixed with small broken stone and reinforced with two bars of ½-inch twisted steel. They are 16 inches deep and the full thickness of the wall. The sills are similar to the lintels, but are 1½ inches wider and are 5 inches thick at the inner edge and 4 inches thick at the outer edge. Both lintels and sills were made in forms at the contractor's yard and were shipped finished to the site when about three weeks old. The concrete lintels were adopted instead of brick for the lower stories to avoid the rough surface usually found in brick window arches in mill construction.

Open pits were excavated for the separate piers and forms for two or three of the tallest piers were first built and the concrete placed in them. When the concrete was three days old the forms were stripped off and cut down at the bottom to the required dimensions for the next higher pier and so on, so as to involve the minimum amount of material and expense for the forms. All of the forms for the piers in the front wall were duplicates. Only two or three piers were under construction simultaneously, so that a few forms sufficed for the whole work. After the piers were finished, forms were built between them and supported on the bottoms of shallow trenches to receive the wall girders connecting the piers.

All concrete was made with Vulcanite Portland cement and unscreened crushed trap rock of 1½ inches maximum diameter. The proportions varied from about 1:2:5 to 1:3:6, and the concrete was mixed very wet in a Ransome drum machine. It was delivered to the piers in wheelbarrows, and as the molds were filled a rich cement mortar was rammed against the face to secure a smooth exposed surface. This was so successful that the continuous upper surface of the water table was so smooth that when additional doors were cut through the lower-story walls, it served satisfactorily without further dressing for their thresholds.

The construction of the building was considered to be very rapid and satisfactory, as the order for the plans was received on June 4, 1901, and on October 4, 1901, the first shipment of finished cans was made from the factory. Even this time would have been shortened from two to four weeks but for delay in receiving lumber. The building cost $16,000, including the fees of the engineer and architect. Mr. William Wallace Christie was the engineer and architect, who designed and supervised the building. Mr. Joseph Sharpe, Paterson, was the contractor for the concrete work, and Messrs. Steele & Hopper, Paterson, were the masonry contractors. The P. S. Van Kirk Company was the contractor for the carpentry, painting and the remainder of the work.

Report of the Committee of the American Water Works Association on Standard for Water Rates.

George H. Benzenberg, Chairman.

At the last meeting of the Association, at Detroit, the matter of water rates was brought to its attention in a special paper upon that subject, which was thereafter pretty generally discussed by many of the members. The different opinions which were presented upon this subject plainly indicated that there had as yet been no clear, definite or concise basis formulated which would and should be the controlling element in establishing proper water rates in all cases, or localities. This subject was therefore referred to a special committee to present such basis, if possible. It was also quite apparent that all speakers recognized the fact that no set of rates which might be fair and just at one place was for that reason necessarily right or reasonable for any other place, notwithstanding such opinion generally prevails among most water consumers and among those who, under the law, are vested with the power and authority to either fix or approve water rates. This general belief exists for the same reason that the idea is common that because a water supply has been successfully purified by a certain specific treatment, such treatment is equally suitable and will produce the same results with all other or even similar supplies. Both are fallacious.

The question of what are the necessary and essential elements that must be considered as constituting the basis for a fair and equitable rate for supplying consumers with water has been discussed at several of our conventions and also at the meetings of the New England Water Works Association. which latter at its annual meeting last January referred the matter also to a special committee.

Pure and wholesome water is one of the prime necessaries of life, and is also essential for personal comfort, cleanliness and sanitation, as well as for mechanical and industrial purposes. Its use is also indispensable to communities for the protection of health and property. The securing, maintaining and furnishing of an adequate supply of such water is therefore a business enterprise, pure and simple, whether undertaken by a private corporation under a franchise and contract, or supplied by the municipality under legislative authority. In fact, in cities which own water-works, the department having charge thereof, is, aside from municipal gas or electric plants, the only one which is engaged in procuring and selling a commodity, and, therefore, to be run properly, should be operated only on a strictly business basis; in other words, it should be operated as an independent department, receiving no aid or support from any general tax levy, excepting that to which it is entitled for water furnished for the general good, like fire protection, street sprinkling, park, school or other public purposes, nor should the department be expected to furnish these services without such compensation or at the expense of the regular water consumers.

The conditions being, therefore, practically identical, excepting as heretofore noted, the basis for rates, i. e., the various items and accounts which the rates must be made to provide for, should be the same whether the ownership be municipal or private. It is self evident that the elements forming this basis should be in themselves so comprehensive as to be generally, if not uniformly, applicable, either in whole or in part, so that the rates will provide a revenue which will not prevent a loss during the first few years of operation, but which will be sufficient in from four to six years to cover this loss and justify the investment. If it were practicable to change the rates every few years, they might be fixed so as to materially reduce the loss at the beginning, but such rates would be burdensome and retard the natural increase in consumers.

The committee has not undertaken to discuss or report upon the merits of apportioning the rates upon a frontage, valuation, number of rooms, fixtures, consumers or meter, or any other plan, but has confined itself to the consideration of the various items or elements of cost, for which the rates must be made sufficient to provide an annual equivalent. These elements will be taken up in their natural order.

First, the Cost of Construction.—This item represents the original investment for which the annual income must provide a fair rate of interest. This item will differ in amount with every water-works plant, depending upon the proximity, character and abundance of the supply, whether it requires pumping, storage and an expanded or contracted distribution system. These with many other construction features differ with each locality. Some plants must be constructed with a more generous capacity than others because of a more rapid growth, or because the locality is a manufacturing center, requiring water for industrial purposes. In each case, however, the local conditions being known, it is easy to determine the exact cost, and hence the amount of interest that must be provided for.

Second, the Cost of Operation.—This item of continuous expense must naturally be included in the revenue from rates, and its amount will also vary with the conditions of each water-works system, from one furnishing a supply of good water by gravity from an impounding reservoir in the hills to one, the supply of which must be filtered and pumped to several different elevations. This cost can also be arrived at without much difficulty, when all the different requirements together with the duty of engines and boilers and the costs of fuel, oil and waste, of services in connection with the pumping, distributing, collecting and superintending are known.

Third, the Cost of Maintenance.—By maintenance is meant those repairs and that supervision which are necessary to maintain the machinery, pipe system, buildings and all operating parts in good condition for efficient service, but not to the extent of replacing any unit element which constitutes a part of the water-works system with a new unit element, nor such as would properly come under the head of "Extensions or Betterments."

It is somewhat difficult to determine definitely in a new plant what this amount should be in each case, excepting by comparison in a general way with the experiences of other similar plants. Much depends upon the character of the material and workmanship employed in construction, if cheap and inferior, the cost of maintenance will be relatively high; if, however, it is high grade and first class the cost of maintenance will be materially lower, though the cost of construction is thereby increased. In either case, however, there is an annual expense of maintenance, which must be paid for out of the revenue, and hence, constitutes one of the elements which forms the basis for rates.

Fourth, the Element of Depreciation.—Many of the various parts necessary to a complete water-works system are more or less of a perishable character, while some other parts may be considered to be non-perishable. To the latter part belong well-constructed reservoirs, dams and tunnels, also conduits, aqueducts, filters and foundations, if constructed of first-class masonry. To this may be added cast-iron pipe and special castings if well coated and not subject to the action of electric currents. All other parts have a more or less limited period of service, due to their moving parts gradually wearing out, or due to a constant deterioration or because they become unserviceable, or no longer suitable for the service they were intended to furnish on account of inefficiency in capacity or economy, and for these several reasons require replacement or renewal at certain periods. Among these may be classed boilers, pumps, machinery in general, hydrants, valves, wooden structures and cast-iron pipe and castings subject to electrolytic action from stray electric street railway currents. Unless the cost of renewing these parts at the end of their several periods of serviceableness is provided for out of the earnings of the plant, the original investment will become depreciated and its value in the course of years greatly reduced. No capital would seek such investment, nor would it be good, sound business practice to permit such depreciation of the capital invested.

It is, therefore, necessary that the revenue be sufficient to permit a certain sum to be annually set aside as a sinking fund from which to pay for the renewals as they become necessary and thus maintain the plant constantly at a par value. This sum can be arrived at pretty closely when all of the existing conditions are known, by determining the life period and from that the element of annual depreciation of the several parts of the plant and setting aside annually for each such part a sum which at a fair rate of compound interest will at the end of the service or life period of such part, be sufficient to pay for its renewal.

These sums, however, do not provide for the renewal of any parts destroyed or injured by accident or the elements, nor for the payment of damages caused by such accidents or the carelessness of employes. Neither do they provide for depreciation due to faulty design, material or construction. There are perhaps very few, if any, water-works in this country which have not at some time suffered relatively very heavy losses due to one or more of the above indicated causes.

There is another cause of depreciation which cannot be taken into account, and therefore be provided for, until the depreciation has occurred, namely, the polluting of a hitherto pure and satisfactory water supply, necessitating either the abandoning of such source of water supply, and frequently of the works adjacent thereto, and of constructing or developing a new, often remote, source of supply or of erecting and operating a purification works. This depreciation, in either case, necessitates an additional expense in construction and operation, which cannot always be met by an increase in the rates.

The basis, therefore, which must govern in determining the annual revenue to be produced by the rates, charged for furnishing water service, must contain the following elements:

First—The cost of construction. Second—The cost of operation. Third—The cost of maintenance. Fourth—The depreciation. To the latter should be added an annual amount to produce a limited reserve fund to be used for the replacement of parts destroyed by accidents or the elements. This is a reasonable provision whether the works are owned by the community or a private corporation. In the latter case, however, it is necessary to consider an additional element in establishing the basis for water rates, namely, the amount of the annual tax which is levied against the water-works property, because this is as much a fixed charge in the case of such ownership as is the interest on the capital invested.

Another element, to which the committee desires to call attention in the case of private ownership, arises where the franchise ordinance limits the franchise or the use of public streets, alleys and grounds to a definite term of years, or where the contract for supplying water for municipal purposes is limited to a definite period without a guarantee of extending the franchise, or of continuing the contract upon a basis of fair and equitable rates, or of purchasing such works at the end of such period at its true and actual value. Without such guarantee the value of the investment at the end of such period is liable to be wiped out and the property destroyed by a duplication of said entire works. In such case the owners are justified in protecting their investment by taking such contingency into consideration when fixing the basis for water rentals.

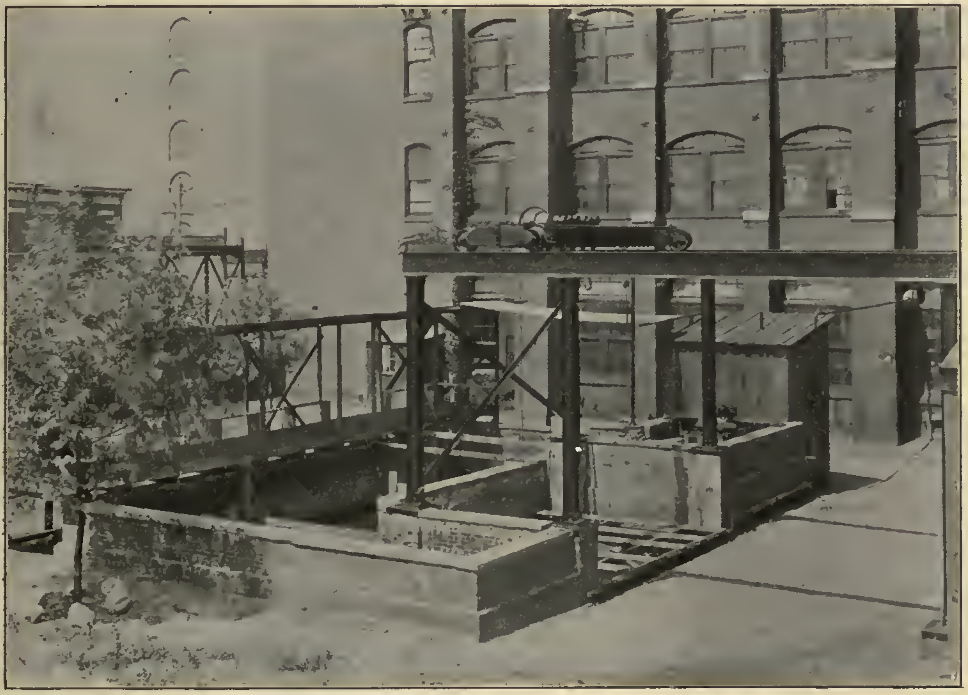
There are other items of expense, like that of litigation, which cannot be provided for in fixing a basis for water rates. It is possible that some of these items may be properly anticipated at the time of fixing rates, but many of them are a matter of development and cannot be foreseen. The committee, however, is of the opinion that no water rates can be considered as just, fair and adequate which do not take into consideration and provide for:

1. A reasonable interest on the capital invested in the construction of the water-works system.
2. The annual cost of operation.
3. The annual cost of maintenance as defined.
4. The annual amount necessary to provide a sinking fund from which to pay for the renewal of the several parts of the plant at the end of their respective periods of service.
5. The annual sum necessary to produce a limited reserve fund to be used for the replacement of parts destroyed by accidents or the elements.
6. A sum sufficient to pay the taxes, if any, and
7. Where the works are constructed under a limited franchise and contract period without a guarantee of a renewal of both, or of the purchase of the plant at its actual value at the end of such period, an annual sum sufficient to produce a fund which will equal the actual value of the plant at the end of such period.

Lightning Conductors of Iron are quite as efficient as copper, in the opinion of Sir Oliver Lodge. The intensity of action with copper is, he feels, more likely than iron to set up side-flash, which, in the case of protected buildings, is believed to have been the cause of most lightning accidents.

Tests of a Thirty-Inch Premier Meter, and the Testing Plant of the National Meter Company.

On May 18, 1904, the 30-inch Premier meter, described in the issue of The Engineering Record of May 21, was tested at the works, in South Brooklyn, of the National Meter Company, Mr. John C. Kelley, president, and the tests were witnessed by a number of waterworks engineers, practising in the vicinity of New York. For the purpose of testing large meters, the company has constructed a station which is fully equipped with facilities for accurately measuring the flow of water. This station was fully described in the report of Mr. Arthur S. Tuttle, M. Am. Soc. C. E., to the Board of Street and Water Commissioners of Jersey City, N. J., in 1899, on the accuracy of 20-inch and 36-inch Gem meters, for use on the Belleville mains, and also in a paper published in the "Proceedings" of the American Society of Civil Engineers for May, 1904, by Mr. Arthur H. Diamant, Jun. Am. Soc. C. E., on the "Installation of a Pneumatic Pumping Plant." From the former report the following description has been prepared, revision having been made to conform to later alterations.



National Meter Company's Testing Plant, at South Brooklyn, N. Y.

The testing station is a brick structure, about 24x40 feet in size and about 10 feet deep; the weir chamber is L-shaped and occupies the whole of one end, where it has a width of 8 feet, and all but about 6 feet of one side, where it has a width of 12 feet; the remainder is used in part as a catch-basin for the water passed over the weir, in part as a pump chamber, and in part as a meter vault. In operation, enough water from the city main is first admitted to the chamber for conducting the test; the supply is then shut off and the pump started, drawing its supply from the catch-basin and forcing it through the meter and into the weir chamber, whence it escapes over the weir and returns to the catch-basin to be used again. The pump is of the horizontal centrifugal type, with vertical spindle, geared to and operated by a 30-horsepower Nash gas engine. After leaving the pump and before entering the meter, the water is passed through a wooden screen which acts as a baffle to break up the eddies formed by the pump, and allows any air that may have been carried into the pump to escape. The meter is placed at such an elevation that the whole of its body is below the water line in the weir chamber.

The weir crest is formed from a cast-iron plate 25 inches wide and 1⅜ inches thick, extending the whole width of the weir chamber, with its inner face flush with the face of the brick wall on which it rests. For the tests of the 30-inch Premier meter, the weir crest was 5.742 feet long. The sides forming the notch of the weir were made of cast-iron plates of the same thickness as the crest plates and 30 inches wide; they were extended beyond the side walls of the chamber so as to give a tight joint, and were so placed that the edges of the notch on the opposite end of the weir were equidistant from the walls of the chamber. The lip of the weir was formed by beveling the downstream face at an angle of 45 degrees, leaving the edge ¼ inch in thickness and truly planed. The notch was rectangular, the edges true, and the crest level. This weir had full end contractions.

The apparatus for measuring the head on the weir consisted of two 12-inch cast-iron pipes set on end, located in front of catch-basin and cross-connected by a 2-inch pipe, from which a branch of the same size led through the side walls of the catch-basin, and then down and along the floor of the same into the weir chamber, then along the floor of the weir chamber, branching at right angles in both directions at a distance of 6.3 feet from the face of the weir, these arms being parallel with the face of the weir and extending completely across the chamber. This latter portion was raised about 6 inches above the floor and was perforated on the top with eighteen holes 3/16 inch diameter, and about 6 inches apart. The distance from the measuring boxes to the nearest perforations was about 24 feet with six right angle bends.

In one of the measuring boxes an automatic gauge, made by the meter company, was set up for obtaining a continuous record of the head on the weir. It consisted of a zinc float 10 inches in diameter by 6 inches deep, carrying a vertical ¼-inch brass pipe, to which a pencil was attached with its point pressing against a sheet of paper wrapped around a wooden drum 12 inches in diameter. The drum was connected to a clock movement giving it one revolution in two hours. A second pencil was rigidly attached to the fixed frame carrying the drum, and was set at the relative elevation of the weir crest, so that the actual head was recorded. In the other box a hook-gauge was set up; this instrument was made by Messrs. W. & L. E. Gurley, and was graduated to hundredths of a foot on a metal face for a length of 2.3 feet, with a micrometer attachment and vernier by which thousandths could be distinctly read.

For determining the correction to be applied to the hook-gauge reading to obtain the actual head, and for setting the datum pencil of the automatic gauge, the measuring boxes were disconnected from the weir chamber prior to the test and connected into the bottom of a water pail, which was hung under a fixed hook, carefully set to the exact height of the weir crest; water was then added to the pail until it reached the level of the point of the fixed hook, standing at the same elevation in the pipes used for the hook-gauge and float-gauge measurements, making it possible to accurately determine the datum for each and avoiding error due either to wave motion or a leveling instrument.

Table No. 1.—Results of Tests of a 30-Inch Premier Meter.

Head on weir, feet (five-minute readings.)			Gallons measured		Meter Record in Terms of Weir Measurement, Per Cent.	Velocity in Main, Ft. Per Second.
Max.	Min.	Avg.	Weir Record.	Meter Record.		
			Test No. 1.			
.794	.782	.7861	29,082	29,000	99.7	2.640
.786	.781	.7826	28,888	29,050	100.6	2.622
.803	.780	.7910	29,354	29,550	100.7	2.665
.801	.783	.7945	29,549	29,450	99.7	2.682
.808	.787	.7960	29,633	29,550	99.7	2.690
.803	.791	.7956	29,611	29,800	100.6	2.688
.803	.788	.7943	29,538	29,700	100.5	2.681
.802	.785	.7932	29,475	29,500	100.1	2.676
.808	.780	.7917	235,130	235,600	100.20	2.668
			Test No. 2.			
.671	.653	.6560	22,269	22,250	99.9	2.021
.662	.653	.6565	22,294	22,200	99.6	2.024
.657	.649	.6555	22,243	22,050	99.1	2.019
.664	.649	.6536	22,146	22,100	99.8	2.010
.660	.650	.6545	22,192	22,000	99.1	2.015
.668	.651	.6541	22,172	22,200	100.1	2.013
.661	.647	.6521	22,070	22,100	100.1	2.003
.669	.646	.6551	22,223	22,100	99.5	2.017
.671	.646	.6547	177,609	177,000	99.66	2.015
			Test No. 3.			
.585	.574	.5801	18,567	18,500	99.6	1.685
.587	.574	.5801	18,567	18,300	98.6	1.685
.589	.571	.5790	18,514	18,400	99.4	1.681
.583	.570	.5785	18,490	18,350	99.2	1.678
.583	.570	.5798	18,552	18,350	98.9	1.684
.593	.571	.5790	18,514	18,300	98.8	1.681
.586	.573	.5790	18,514	18,400	99.4	1.681
.589	.571	.5786	18,495	18,300	99.0	1.679
.593	.570	.5793	148,213	146,900	99.11	1.682
			Test No. 4.			
.466	.454	.4596	13,162	13,100	99.5	1.195
.469	.453	.4626	13,291	12,750	95.9	1.207
.474	.454	.4608	13,215	12,900	97.6	1.200
.478	.464	.4598	13,172	12,800	97.2	1.196
.472	.455	.4643	13,364	13,100	98.0	1.213
.465	.447	.4562	13,014	12,750	98.0	1.181
.468	.452	.4598	13,172	12,750	96.8	1.196
.464	.448	.4555	12,986	12,800	98.6	1.179
.478	.447	.4598	105,376	102,950	97.70	1.196

The wave motion in the weir chamber, due to irregularity in the action of the pump, was minimized by placing baffle boards at distances of 23 feet and 26 feet upstream from the weir, these extending the entire depth of the chamber. The boards composing each set of baffles were separated by about 1 inch at the joints, and the space between the sets was filled with closely packed brush.

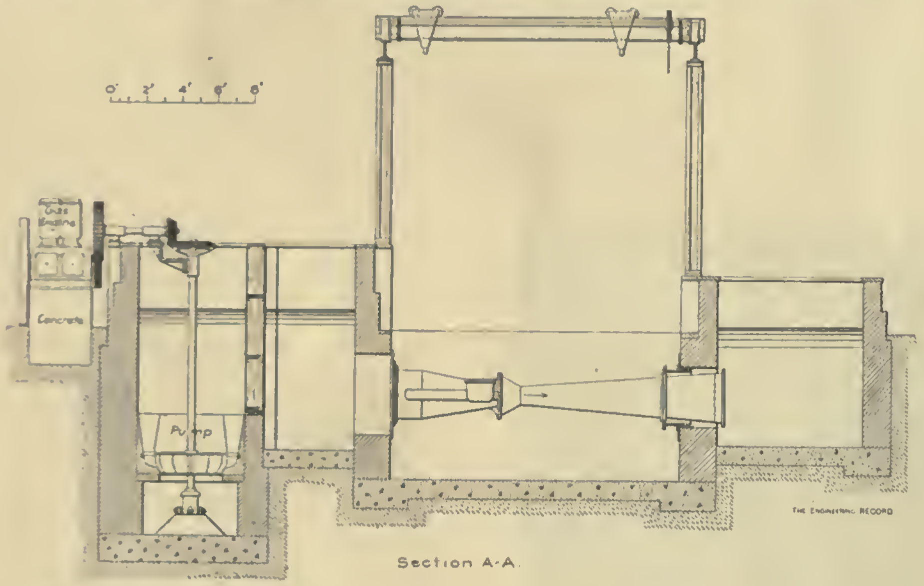
The entire equipment is shown by the accompanying photograph and drawings, the latter giving a plan and sectional view of the plant and showing the method of determining the level of the crest of the weir for the automatic recording apparatus. These drawings also show the meter in position for testing.

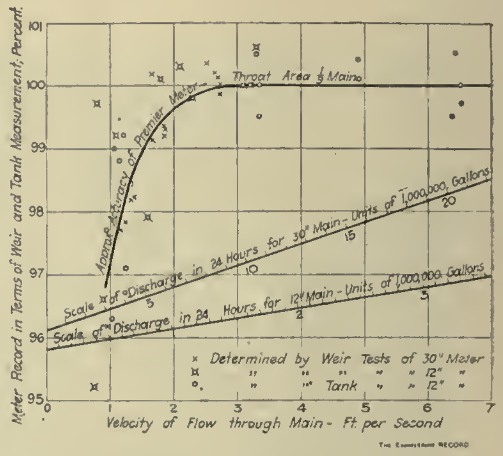
Four tests were made on May 18, each of forty minutes duration. The head on the weir was maintained as nearly uniform as possible during each test, and the velocity of flow through the main averaged about 2.7, 2.0, 1.7, and 1.2 feet per second, respectively. Owing to lack of power it was not possible to obtain a higher velocity of flow, the new engine planned for use in testing large meters and for higher velocities not yet having been installed. The engineers of the meter company, having found that the continuous automatic record of head on the weir is much more reliable than the occasional readings of the hook gauge, the latter were omitted from the record and reliance was placed entirely upon the automatic register.

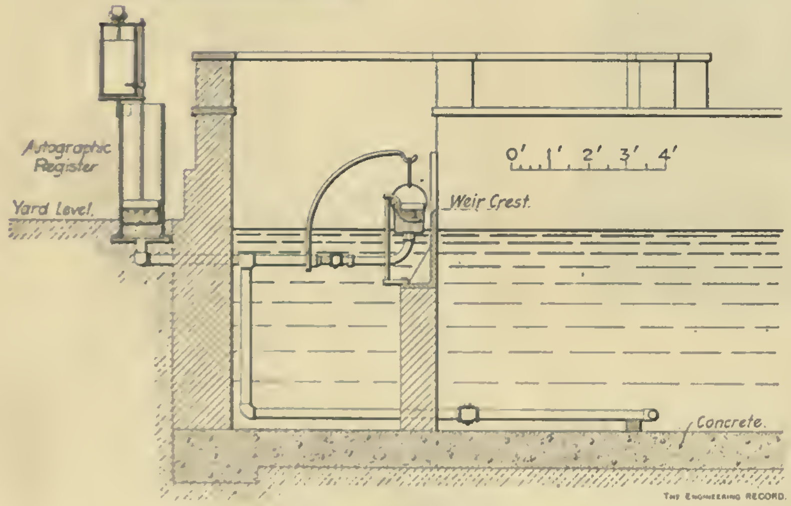
The 30-inch Premier meter register reads to 1,000 gallons, but by an independent dial on the upper right hand corner of the register face the reading can be made to 100 gallons and further subdivided by eye to 20 gallons. During the test the meter readings were taken at intervals of five minutes, but the rapid motion of the pointer made it impossible to read closer than 50 gallons, and even then was the cause of some uncertainty. The tests were in charge of Mr. Lewis H. Nash, M. Am. Soc. M. E., chief engineer of the National Meter Co., Mr. John H. Norris, M. Am. Soc. M. E., assistant engineer of the company, and Mr. Arthur S. Tuttle, M. Am. Soc. C. E., the inventor of the meter. The results obtained are shown by the accompanying table No. 1. Before shipping this meter to St. Louis, for which place it is destined as a part of the National Meter Company's exhibit at the Louisiana Purchase Exposition, thirteen additional tests were made under similar conditions to those previously described, and the results are shown by Table No. 2. The Hamilton Smith formula was used in computing the flow over the weir.

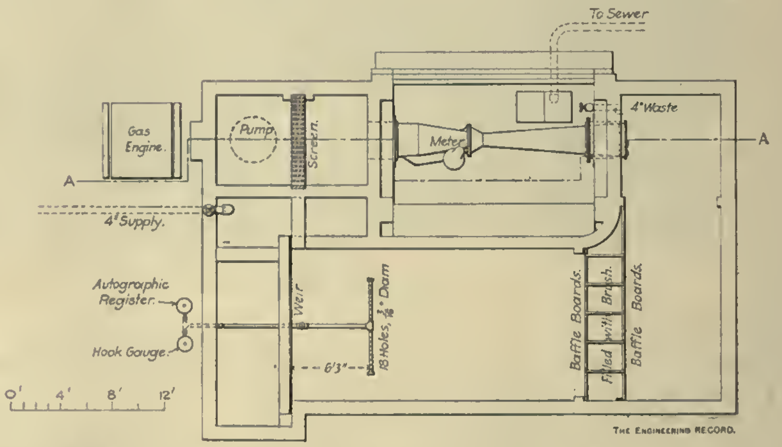
The Diagram shows the volmue registered by the 30-inch Premier meter during these tests, and by a 12-inch meter in previous tests, in terms of the volume determined partly by weir and partly by tank measurement. The tests of the 12-inch meter show that the meter registration for main velocities of from about 2.75 to 6.5 feet per second, practically corresponds with the volume shown by the weir and tank measurement, and that for velocities as low as 1 foot per second, the difference between weir and meter record is less than 3 per cent. The points located in the curve of comparison for a 30-inch meter show a similar relation as far as the tests have been carried, while the theory under which the meter is designed gives ample ground for assuming that for the higher velocities it will give results as satisfactory as those obtained with a 12-inch meter. For cases where an accurate measurement of flow is desired, when it is at a lesser rate than corresponds with a velocity of 1 foot per second, in the main, the National Meter Company proposes to increase the ratio between the area of the throat of the venturi tube and that of the main, thereby making the meter reliable for a stream of any size.

While the weir tests of the 30-inch meter were being made on May 18, tank tests of a 12-inch meter were also conducted. The water was admitted to the meter from a tank in the tower of the shop, giving a pressure of about 40 pounds, and the supply was controlled by quick-acting gates operated by hand. In each test the supply gate remained opened until 100 cubic feet were registered on the meter. The water discharged was collected in a calibrated tank, where it was readily measured, and the volume in each case and under varying rates of flow showed a close conformity with the meter record. It was noted in making these tests that the meter register responded immediately to all changes made in the control gates, showing that the meter is also particularly well adapted for use on force mains.









Meter Testing Plant: Plan and Sections Showing Arrangement; Diagram Indicating Accuracy of Meters.

Table No. 2.—Summary of Results of Tests of a 30-Inch Premier Meter, Based on Weir Measurement.

Test No.	Duration, Minutes.	Rate of Flow (Weir Meas'mt.) Velocity in Main, Ft. Per Sec.	Rate of Flow (Weir Meas'mt.) Discharge in 24 Hours.	Meter Record in Terms of Weir Measurement, Per Cent.
12.........	30	0.970	3,077,000	96.18
5.........	60	1.038	3,293,000	98.07
4.........	40	1.196	3,793,500	97.70
17.........	30	1.244	3,947,000	97.82
13.........	30	1.347	4,273,000	98.19
9.........	60	1.385	4,394,000	98.22
6.........	60	1.674	5,311,000	100.18
3.........	40	1.682	5,335,700	99.11
16.........	30	1.858	5,895,000	99.34
14.........	30	1.859	5,898,000	99.19
10.........	60	1.871	5,936,000	99.30
2.........	40	2.015	6,393,900	99.66
7.........	60	2.527	8,017,000	100.35
1.........	40	2.668	8,464,700	100.20
15.........	30	2.704	8,578,000	100.12
8.........	50	2.726	8,648,500	100.00
11.........	60	2.733	8,670,000	99.85

A Working Assay Laboratory has been organized by the Colorado School of Mines in the Metal Pavilion at the Louisiana Purchase Exposition. It occupies a 25x50-foot space and is equipped with one coal and two gasoline furnaces, four desks for chemical work and a dust-proof balance room. Regular assays will be conducted for visitors by the students of the school, under the supervision of a committee of the faculty. No charge will be made for these assays, as the work will be of the nature of an exhibit.

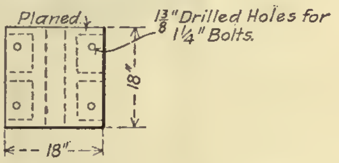
An Alternating-Current Power-Distribution system is to be installed for the Union Metallic Cartridge Company, at Bridgeport, Conn., by Mr. Samuel M. Green, M. Am. Soc. M. E., of Holyoke, Mass., as consulting engineer. Two Westinghouse-Parsons steam turbines, each directly connected to a 500-kilowatt, 440-volt, three-phase, 60-cycle alternator, form the initial generating plant. The current for general power and lighting purposes will be transmitted to the various shops located three or four blocks from the power station.

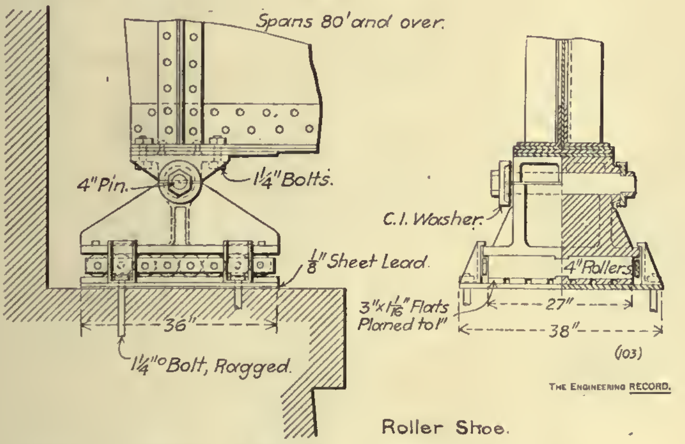
Types and Details of Bridge Construction; Plate Girders.—IV.

By Frank W. Skinner, C. E.

Roller Bearings.—For medium and long spans, especially where the loads are heavy, it is desirable to provide some means of facilitating the longitudinal movement of the expansion ends of the girders without throwing too great a buckling stress into the flanges. This is generally done in one of three ways, by seating the end of the girder on horizontal transverse rollers, by supporting it on a rocker bent, or, sometimes, by suspending it from vertical links. When rollers are used they may be either cylindrical or segmental, and may be inserted directly under the lower flange or its sole plate, or they may support a shoe which is pin-connected to the girder.

The rollers are usually notched in the center to engage upper and lower longitudinal guide ribs, which lock them transversely to the girder and to the bed-plate and prevent lateral displacement. They are generally held in place by shouldered bearings or tap bolts in side strips, which are sometimes also connected by tie bolts parallel with the rollers. The upper roller bed is usually additionally secured by anchor bolts passing through longitudinally slotted holes in it and rigidly secured to the masonry.





Standard Expansion Bearing for Long Girder Spans on Baltimore & Ohio Railroad.

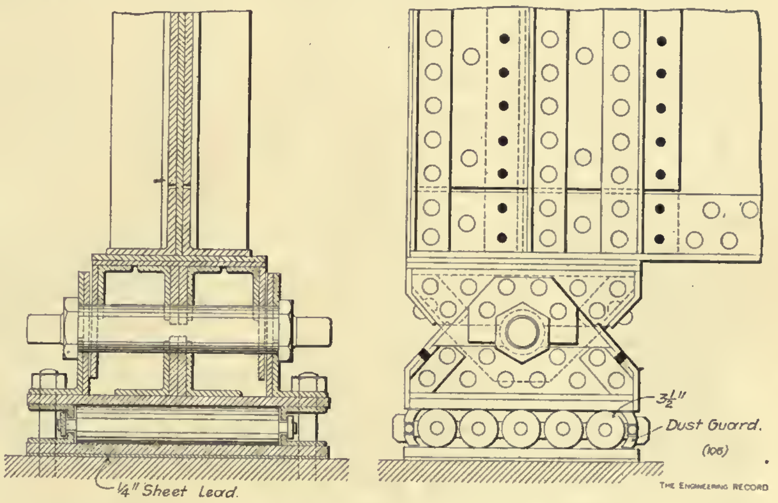
The roller bed-plates are made in several different ways, of solid thick rolled or cast-steel or cast-iron plates, or riveted steel plates. Cast-iron or steel pedestals, and sometimes where the loads are very heavy, I-beam grillages are used to distribute the loads and reduce the unit pressures on the masonry; these grillages have top and bottom cover plates countersunk-riveted to the beam flanges. Special pains are frequently taken to prevent the accumulation of dust and moisture around the rollers, both by excluding them as much as possible and by providing for their easy removal. Sometimes flanges or side pieces are made to enclose the rollers as tightly as possible, and sometimes the roller beds are made in the form of longitudinal ribs with wide open spaces between them to receive the dust and water. One prominent designer has used a case filled with oil, in which the rollers work.

When the span is long enough to make roller bearings necessary, the deflections become perceptible, and the accompanying distortion is often sufficient to seriously derange the end bearings on a long horizontal surface and to tend to concentrate it on the inner edge of such a support. The most common way of providing for this condition is to give the girder a pin bearing in a shoe similar to a shoe for a truss span, or by supporting it on a pin directly through the girder web. The shoes are generally bolted or riveted to the lower flanges of the girder and should provide a pin bearing in the plane of the girder web. They are made either of rolled plates and shapes, riveted, or of cast iron or cast steel.

The standard plate-girder roller bearing adopted by the Baltimore & Ohio Railroad for recent work, for spans of 80 feet or more, is made with a cast-steel shoe and pedestal and a riveted steel bed plate. The shoe is bolted to a sole plate on the lower flange of the girder, and has a full-length vertical transverse web reinforcing the semi-cylindrical bored bearing for the upper side of the 4-inch steel pin. This bearing is also stiffened by one center and two side longitudinal webs. The pedestal is essentially a reversed shoe, but is higher, with a base extended both longitudinally and transversely, having longitudinal and transverse vertical webs or diaphragms 2 inches thick. A finished rib on the center line of the planed under surface of the base engages the eight 4-inch rollers. Bosses on the outsides of the shoe and pedestal webs engage chambered disks that fit over the ends of the pin and are secured by nuts on its shouldered ends. The bed-plate has a finished thickness of 2 inches and is made with 3x1-inch bearing strips 1 inch apart in the clear. It projects 5½ inches beyond each end of the rollers to receive four 1¼-inch anchor bolts, which also secure the bottoms of flanged cast-steel pieces of Z-shaped cross-section, which have upper flanges engaging the base plate of the pedestal. Cast stops on the pedestal limit its motion each side of the clamps. The bed-plate is set on a thin sheet of lead and the ends of the rollers are shouldered into side strips, which are secured by cotters passing through the projecting ends of the long shoulders on the outside rollers.

A standard cast-steel pin-bearing roller-shoe for long plate-girder spans has been used on many bridges and, with pedestal, rollers, bed-plate and pin complete, of the dimensions illustrated, weighs 2,543 pounds. It has a capacity of 324,000 pounds when calculated as reducing the pressure to 250 pounds per square inch on the concrete masonry on which it is assumed to be seated. The shoe is a simple ribbed casting with a flat, planed top, which bolts to the bottom flange of the girder and has on the under side a long semi-circular bearing for the pin. The pedestal has a similar pin-bearing supported by longitudinal transverse and diagonal vertical ribs, which are made high enough to provide for a base large enough to distribute the load over a sufficient masonry area and diminish the intensity of pressure to the required limit of 200 pounds per square inch. The pin is made with a center rib, and this, with the recessed nuts engaging planed bosses on the webs of the shoe and pedestal, lock the latter in position and prevent relative transverse motion. The pedestal has low vertical flanges around the sides of the base-plate, which is planed on the bottom and has, for the expansion end, a transverse rib to engage the rollers. Four lugs with horizontal extensions of the base-plate, stiffened by vertical webs, are cast on opposite sides of the pedestals and have slotted holes to receive the 1¼-inch anchor bolts, which are clear of the roller bed-plates. The rollers have shoulders engaging the horizontal side strips which form the roller frame. Necks of alternate rollers project through these strips and are secured by cotters; the others are cut off flush with the outside of the strip. The roller bed is planed from a steel plate 2 inches thick and has a center guide strip 3/8 inch high.

The Northern Pacific Railroad standards of 1896 provided for the expansion ends of plate-girder spans of 70 feet and over, riveted shoes with pin bearings in riveted pedestals seated on roller nests with riveted steel bed-plates and sheet-lead bearings. The shoes were made with three reinforced longitudinal vertical webs, the center one being in the plane of the girder web and having a bearing of about 140 degrees on the large pin which engaged full holes in the side webs of both shoe and pedestal, thus locking them together. The ends of the pins projected far enough beyond the shoes to afford connections for hydraulic jacks, if it should become necessary to lift the girders for future changes or repairs.

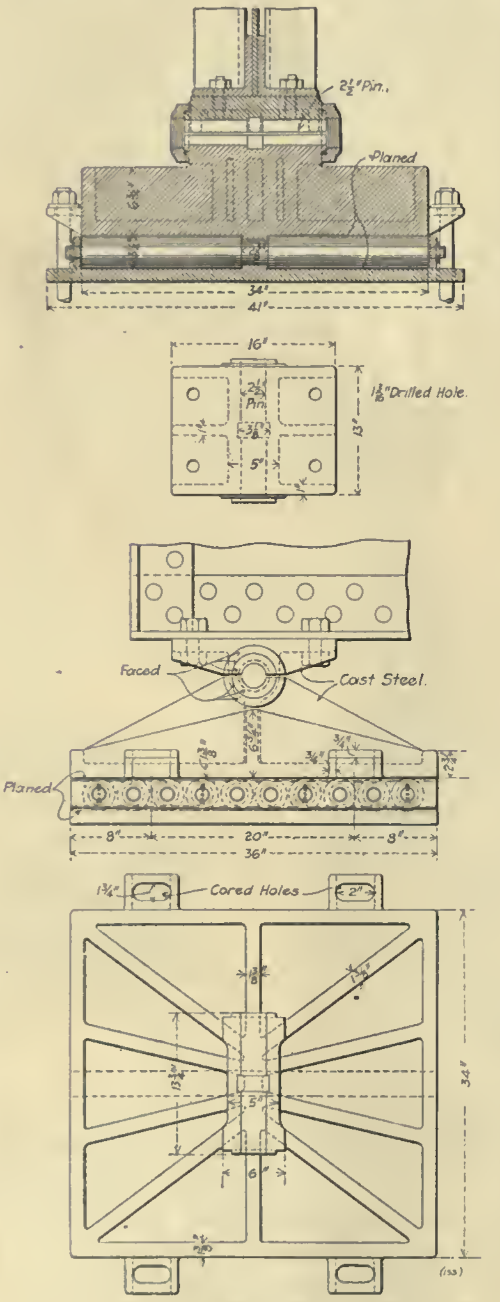


Roller Bearing for Seventy-Foot Deck Plate-Girder Span, Northern Pacific Railway, Standard of 1896.

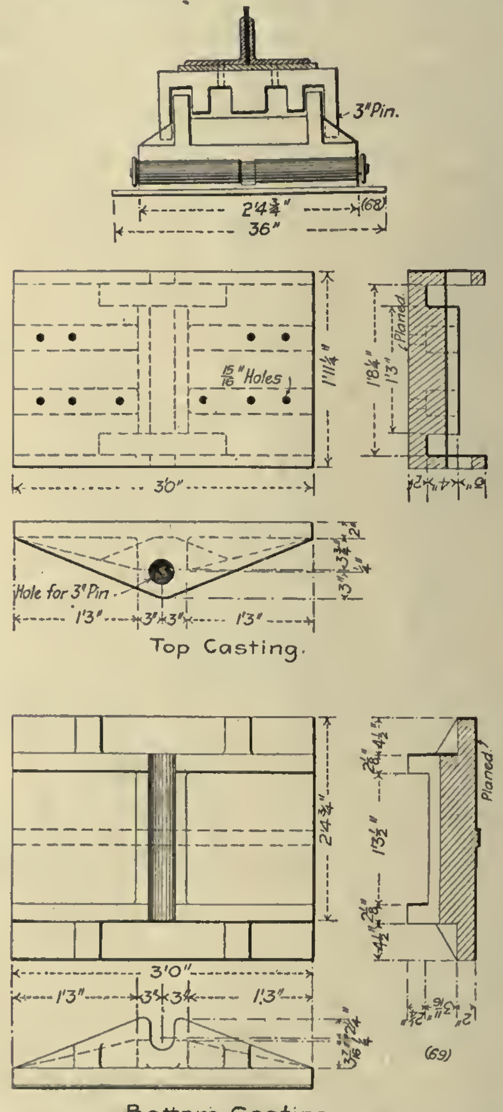
The pedestals were practically inverted shoes with their base-plates wide enough to project beyond the ends of the roller nests and engage the anchor bolts, for which they had slotted holes. The rolled steel bed-plates and the base-plates of the pedestals both had planed bearing surfaces without grooves and the rollers had no grooves for longitudinal guides. Transverse displacement was prevented by longitudinal angles riveted to the pedestal base and to the bed-plate in the same vertical plane with their vertical flanges planed to clear the roller necks and form a guard to exclude as far as possible the dirt and rubbish from the interstices between the rollers. The sides of the roller nests were protected by curved transverse bars bolted to the end roller strips and fitted as close as possible between the pedestal base and bed-plate, and moving back and forth with the rollers. The spaces between the shoe and pedestal webs were closed by transverse inclined plates riveted to them with angle clips. This type was illustrated December 4, 1897.

The expansion ends of bridge No. 7, Bradford Division of the Erie Railroad, a single-track plate-girder bridge about 128 feet long over all, have roller bearings made with cast-steel shoes and pedestals. The shoes are riveted to the bottom flange cover plates and project about 2 inches beyond them on each side. They are made with heavy metal throughout, thickened in places where the stresses are the greatest. They have a continuous semi-cylindrical bearing for the 3-inch pin nearly as long as the width of the girder flange, beyond which there are open spaces and then full hole bearings through the side webs of the shoe. The center bearing is stiffened with longitudinal webs and has a solid connection to the top plate. The pedestal is made wider than the shoe to give an increased length of rollers, and has a continuous semi-cylindrical pin bearing which is integral with the thick base-plate and has side webs engaging with clearance the notches between the shoe webs. The pedestal rests on ten 3⅛-inch rollers 29 inches long, with center grooves to engage guide strips on the pedestal base and on the riveted steel bed-plate. The fixed end bearings correspond to these, except that the pedestals are made 4½ inches higher and are seated directly on the pier masonry. This bearing was illustrated in The Engineering Record of June 16, 1900.

On the Fort Point highway bridge, Boston, Mass., Atlantic Avenue is carried over the yard tracks of the Boston Terminal Company by truss and girder spans seated on masonry piers and steel towers. The three lines of heavy plate girders have pin bearings on fixed and expansion pedestals. A 71-foot 9-inch girder is about 7½ feet deep, and has bearings on 6-inch pins 69 feet 7 inches apart, through the web near the lower flange. The web at the pin point is reinforced, and on each side there is riveted a cast-steel bearing with a horizontal top flange. The flanges engage the milled lower ends of web-stiffener angles, which distribute the load over about one-third of the depth of the web. The pedestal is an ordinary double-web riveted pedestal like the shoes usually provided for the end pins of truss spans. It is seated on a nest of rollers grooved in the center to engage the guide strips on the base-plate of the pedestal and on the bed-plate. In this design, although the shoe is nominally dispensed with, the side bearing castings are virtually equivalent to it, but have the advantage of receiving the load directly from the web where the shear is developed, and avoid subjecting the lower flange to shear. It also permits the girder to be set several inches lower than it could be with a shoe under the bottom flange.



Standard Pedestal, 324,000 Pounds Capacity
Boller and Hodge Engineers



EXPANSION BEARING FOR 128-FOOT PLATE-GIRDER SPAN, ERIE RAILROAD.

Typical Expansion Bearings for Long-Span Plate Girders.

Examples of the Long Life of Cast-Iron Water Pipes.

In the last issue of the "Journal" of the New England Water Works Association, Mr. C. Cavallier, director of the foundries at Pont-a-Mousson, France, contributes some interesting records of long service of cast-iron pipes. During the construction of the Metropolitan Underground Railway, of Paris, a 32-inch water main was taken up for a distance of three-quarters of a mile. This pipe was in 13-foot lengths with bell-and-spigot ends and had lead joints; it was coated with coal tar and laid in 1874. All the pipes had an interior coating of scale, about ¼ inch thick, which was easily detached with the hammer. The iron thus laid bare was in perfect preservation. Much of the coal-tar coating was still intact, and the numbers and weights marked in white lead were as clear as though just applied. The exterior of the pipe was also in good condition. The coating still remained on the greater part of the surface, while the balance had undergone a slight superficial oxidation. These pipes had been in the ground for twenty-eight years and were in nearly as good condition as when laid.

Recently the first pumping station erected for supplying Paris with water, the Chaillot station, was discontinued, the site being required for other purposes. Consequently the intake pipe extending out into the River Seine, being of no further use, was taken up. It was laid in 1802 and consisted of flanged cast-iron pipes. After an immersion lasting a little over a century, these pipes were in such good condition that they could have been relaid, but being of an antique type were broken up and remelted. After removing the scale and the shellfish which had accumulated upon the exterior, the words "Creusot, an 10," in raised letters, could be easily read. No alteration of either exterior or interior was apparent. Mr. Cavallier does not state, however, whether the pipes were coated or not. The metal was a gray iron of excellent quality, the fractures of which were as sharp as of a piece just from the foundry.

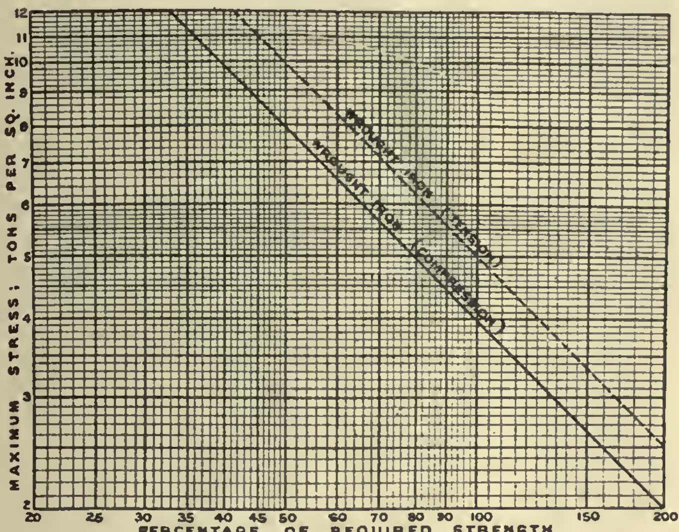
A number of ancient cast-iron pipe lines are also mentioned, which are still in use. The conduits which supply the water to the great fountains in the park of Versailles date from the same period as the park itself. Five pipes 20 inches in diameter and 10,000 feet long, two of the same diameter 7,500 feet long, and four 13½-inch pipes about a mile long, were laid in 1685, or 219 years ago. Another 13½-inch pipe 11,500 feet long was laid in 1687. Several more pipes of various sizes, having in all a length of five miles, were laid between 1664 and 1688. All these lines are made of pipes one meter in length with bolted flanges. They still serve their purpose satisfactorily, and the few repairs which have been required have generally been necessitated by the bad condition of the flange bolts.

In Rheims a system of water pipes was laid in 1748, the mains being of cast-iron and the service pipes of lead. In 1840, during the construction of a new system, some of the old cast-iron pipes were dug up and found in good condition. They were 8 inches in diameter and 4 feet long, with square flanges. In Clermont-Ferrand there is a line of pipes 5 or 6 inches in diameter and 3 feet long, laid in 1748-49. These pipes are 0.5 inch or 0.8 inch thick, according to the pressure in the different parts of the line. They were cast horizontally and have flange joints made with thick lead gaskets, some of them ⅞ inch in thickness. The system is under a considerable pressure.

PERFORATED FIRE DOORS in the partition between engine and boiler rooms are provided in the power station of the Central Electric Supply Company, Marylebone, London. According to a description in the "Electrical Review," of London, the holes are for fire-hose.

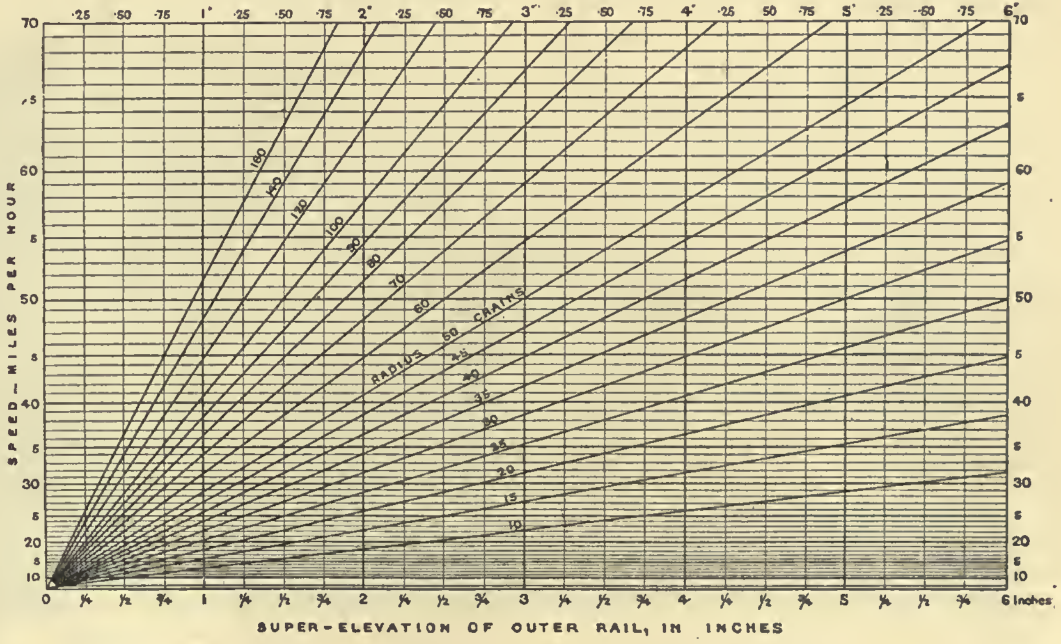
The Utility of Logarithmic Methods of Plotting Curves.

In the latest systems of instruction in technical schools, the students are taught many quick methods of ariving at desired results which were never mentioned in the good old days when the "rigorously exact" character of the instruction was the pride and joy of the faculty. The graphical solution of equations, the use of squared paper and the manipulation of the slide-rule are now practically taught in most schools. Among these modern aids there are few of greater convenience than the use of logarithmic scales in plotting curves, a subject which is familiar to some of the readers of this journal, but is not thoroughly grasped by others, as many letters show. Evidently this is also the case in England, the birthplace of the "new mathematics," for in the last volume of the "Proceedings" of the Institution of Civil Engineers there is a paper by Mr. R. S. Scholefield, which is the clearest explanation of the subject that has appeared in a long time. In the preparation of a diagram showing the variation of two quantities reciprocally dependent on each other, the work of plotting is much simplified and greater accuracy is attained, if the curve proves to be a straight line, as it is then only necessary to determine by calculation two points on the curve, whereas a comparatively large number of points must be fixed if the locus is a curved line. Should the curve, when plotted in the ordinary way with base lines at right angles and equal division scales, be found to require a large number of points for its complete determination it is often possible to simplify the work considerably by adopting specially arranged base lines on scales having unequal divisions such as logarithmic scales.



A Curve Plotted by Logarithms.

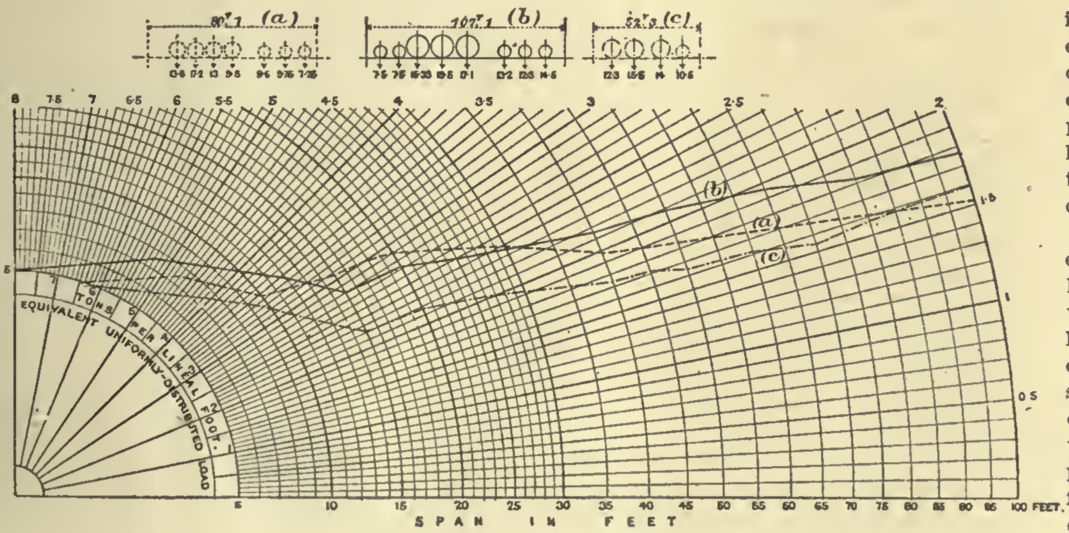
The advantage of such an arrangement is shown by Mr. Scholefield in three diagrams. The first is arranged to show what percentage of the strength required for a given load is possessed by a structure in which that load produces a certain maximum stress. It is evident that this percentage will be inversely proportional to the maximum stress. Therefore if a denotes the percentage of required strength and b the maximum stress, a=c÷b, where c is a constant, or ab=c. Hence, log a+log b=log c. Therefore, if the abscissas and ordinates used in plotting the curve are made proportional to the logarithms of a and b, instead of those quantities themselves, the diagram will be a straight line. In the accompanying diagram, which the author uses to show the relation between maximum unit stresses and the percentage of required strength in wrought-iron girders, it is assumed that the strength required will correspond to a maximum unit stress of 4 tons per square inch in compression or 5 tons in tension.



Curves Plotted to Ordinates Representing Squares.

The second example of special plotting is designed to show the relations between the quantities in the usual formula for the superelevation of the outer rail on curves, $x=kV^2\div R$. In this formula x denotes the superelevation, k a constant determined by the gauge of the track and weight of the train, V the speed of the train, and R the radius of the curve. There are, therefore, three variables. If R is assumed to be a constant, the curve obtained by ploting x and V in the ordinary way will be a parabola, and to draw the curve accurately it will be necessary to determine a considerable number of points on it. This parabola can be transformed into a straight line by plotting the V's to a scale of squares, so that an ordinate representing m miles per hour will be drawn proportional to m^2. For since y (the ordinate) is proportional to V^2, $xR=kV^2=k_1y$, which is the equation of a straight line passing through the origin.

Also, since $x\ R=k_1\ y$, the ordinate y is proportional to R; so that if the ordinate for a certain value of the radius is determined, it is evident that for double that radius it is only necessary to double the ordinate A value of x is therefore taken which will give a simple coefficient to V^2, the value of the ordinate is calculated for one value of the radius (say 50 chains), and the ordinate is then divided proportionately for all the other radii. Straight lines are then drawn from the origin O, through the points so obtained, and are produced indefinitely to complete the diagram.



Curves Plotted by Polar Co-ordinates with Logarithmic Divisions.

The author has prepared numerous diagrams of equivalent uniformly-distributed moving loads on railway bridges, and has found that, with the usual method of dividing the base-lines by equal divisions, considerable confusion ensued if several curves were plotted on the same diagram, and it occurred to him that some other system of base-lines might be devised, whereby the reading of the diagrams would possibly be rendered more convenient. It was found that the curves of equivalent uniformly-distributed loads for different spans approximated in many instances to curves of the hyperbolic form x y=a constant, and in order to transform the diagram so as to replace the hyperbola by a straight line, a system of polar co-ordinates was adopted, having the base-line divided logarithmically, as shown in the third cut. It was found that the lines so drawn were not straight from end to end, the actual curves of equivalent uniformly-distributed loads not being true hyperbolas, but probably the nearest approximation to a straight line is ob-equivalent load can be much more accurately tained, and any intermediate value of the determined than in the case of the hyperbolic curve.

The Cost of Operating Loft Buildings.

In The Engineering Record of December 19, last year, some figures were given on the cost of operating both office and loft buildings, based on studies made by Mr. J. D. Wilson, Jun. Am. Soc. M. E., of New York. Detailed figures in the case of some of the loft buildings have now become available, together with some additional data. Before presenting these analyses, it will be of interest to record his opinion in respect to charges that should be made for lighting service, particularly in the loft building, where the lighting expenses are higher per unit than in the office structure. When a tenant leases premises it is, of course, understood that a reasonable amount of electric light is to be furnished him, based on his requirements at that time. Subsequently, however, he may increase his office force and require a proportionate increase in illumination. Owners have heretofore made it a practice of installing the additional light without any charge, except in some cases, for the actual wiring. In other words, no charge is made for the increase in the amount of current furnished by the lighting plant.

In a building of the commercial loft type, it has been found that the average cost of supplying current to one 16-candle-power equivalent, making a suitable allowance for renewals, is $3.40 per annum. Assuming that at the end of six months ten tenants have enlarged forces to the extent that each requires twenty additional 16-candle-power lamps, the owner, in accordance with present practice, installs the equipment and furnishes current for it without any monetary return, although he is really giving them $68 worth of light on the basis of $3.40 per lamp per annum. Under these conditions Mr. Wilson believes that, as a general rule, unless agreements can be made to provide otherwise for any increase in the number of lights, it is better practice, in the case of the loft structure, to provide for a street service connection and thereby compel the tenant to pay for the actual current consumption. As a matter of illustration, a public lighting service corporation may be induced to furnish current for the owner and in his name at wholesale rates, installing for him one meter of ample capacity to record the entire connected load throughout the building and in addition separate meters for each tenant, and will agree to read all of these meters monthly, rendering the owner his net bill at wholesale rates and also furnishing him with separate bills for each tenant at the regular retail rates. He is thereby enabled not only to furnish lighting service in his building, but also to do so at a fair profit to himself. The alternative agreement referred to might, for example, stipulate that a sum based on the annual cost of a 16-candle-power equivalent be charged for each additional equivalent furnished. The situation outlined is the result of the curious fact that the rentable value of the loft is practically the same with or without light, or seems to be so regarded by real estate operators. A similar condition exists in an office building, but in this the unit cost is somewhat reduced, due to the betterment of load conditions; the average here is approximately $2.75 per 16-candle-power equivalent per annum.

The first loft building to be considered has 84,796 square feet of floor space, of which 9,598 are used for public halls, toilets, etc., leaving 75,198 square feet rentable area. There are in the building 1,526,050 cubic feet of contents. The total cost of operation is made up of the following items: Coal, 1½ tons daily for one half year and 1 ton for the other half year, at $2.77 per ton, or $1,261.74; oil, $150; elevator repairs, $150; other repairs and renewals, $700; making a total for the various supplies of $2,261.74. Insurance, $1,132; taxes, $7,800; water rent, $200; making a total for insurance and taxes of $9,132. Engineer's salary, $1,000; man for freight elevator, $520; man for passenger elevator, $520; making a total for the labor account of $2,040. The total cost of operation is, therefore, $13,433.74 per annum, or 17.9 cents per square foot of rentable area. In this plant the engineer is required to perform the duties of fireman. No provision is made for ordinary cleaning, as this work is done by the tenants themselves, each sweeping the landing immediately outside the entrance to his loft and one flight of stairs above or below the landing. Any additional cleaning is done by the passenger elevator operator.

There are four elevators, two of the steam belted type for freight and two of the hydraulic type, one of the latter for the passenger service, and the other of the hydraulic ram type, employed as a sidewalk lift. There are two horizontal return tubular boilers, a 14x12x10-inch duplex elevator pump and the usual accessory pumps.

A second loft building for which detailed data are at hand has a total rentable space of 71,913 square feet. The cost of operating and maintenance is as follows: Coal, 610 tons per annum, at $2.77, $1,689.70; oil, $125; elevator repairs, $175; other repairs and renewals, exclusive of broker's commission, $700; making the total charges for various supplies, $2,689.70. Insurance, $1,101; taxes, $7,322.74; water, $216; broker's commission, $210; making the total amount chargeable to insurance and taxes, $8,849.74. The labor account is made up of the wages of one engineer at $70 per month, or $840; one fireman at $50, or $600; two elevator men at $10 per week, $1,040; or a total of $2,480. The total cost, therefore, is $14,019.44, or 19½ cents per square foot of rentable space per annum.

The plant in this building consists of two 80-horse-power, horizontal, return-tubular boilers, two duplex steam pumps for the elevator service and a 30-kilowatt direct-connected generator. It is operated for ten hours per day for 305 days in the year. According to test, the average lighting load is 17.9 kilowatts, or, for the ten hours, 179 kilowatt-hours, which, for 305 days, is equivalent to 54,595 kilowatt-hours. At 10 cents per kilowatt-hour, such as might be charged for public service, this amount of current would cost $5,459.50. The generating unit is charged with the steam consumption of 12 pounds of coal per kilowatt-hour, so that in a year, on the basis of the average load reported, some 655,140 pounds, or, approximately, 292 gross tons of coal are required per annum, which at $2.77 per ton costs $808.84. The total coal consumption is approximately 2 tons per day, or 610 for the year. As 292 are consumed for the lighting service, the remainder, or 318 tons, are chargeable to pumping requirements. Approximately 90 per cent. of this amount is required for the elevator work, or 286.26 tons, at a total cost of $792.77. This makes the cost of the coal for the lighting and for the elevator pumping equal, so that the wages in the engineering department can be apportioned on that basis, in order to ascertain the cost of the services separately. The cost of the electric lighting is, therefore, made up of the coal charge calculated, one-half the wages of the engineering department, or $720, one-quarter of the supplies for the engineering department, or $32, maintenance for the electrical work, amounting to $40, and the cost of lamp renewals, also $40, a total of $1,640.84. For the elevator service, the coal charge is as calculated, and to this is added one-half the wages of the engineering department, the remainder of the cost of supplies to the engineering department, or $93, and the cost of elevator repairs, or $175, making the total cost of the elevator service, $1,780.77. In the building supplied by the plant there are 492 16-candle-power equivalents, so that the cost per lamp is $3.33. Of the total number of lamps, 69 are distributed over the public places—in other words, on distinctly the owner's premises. From the foregoing figures it is concluded that the proper rate to charge for the electric lighting service per annum for 16-candle-power equivalents is in this case $3.50, in order that a natural depreciation may be covered.

Detailed charges for another loft building, which really consists of a group of adjoining structures supplied from one plant and which contains 132,938 square feet of rentable space and 2,027,000 cubic feet, are as follows: Various supplies—Coal, $1,360; oil and supplies, $140.74; elevator repairs, $227.80; other repairs and renewals, $1,100; sundry expenses, $344.81; total, $3,173.51. Taxes, insurance and water—Taxes, $15,062.64; insurance, $853.52; water, $297.40; broker's commission, $365; total, $16,578.56. Labor account—Wages, engineering department, $1,419.84; wages, elevator department, $2,543.68; total, $3,963.52. The total expense of maintenance on operation is, therefore, $23,715.59, or 17.8 cents per square foot of rentable space.

POWER AND WATER CONSUMPTION IN REFRIGERATING WORK is guaranteed to come within the following figures by the Borsig establishment, which manufactures refrigerating machinery on the anhydrous-sulphurous-acid system. The consumption of the cooling water in U. S. gallons, as influenced by the initial and final temperatures, is given per ton of refrigeration as follows: With an initial temperature of 41 degrees, 192.8 gallons at 50 degrees final temperature; 100 gallons at 59 degrees; 68.6 gallons at 68 degrees; 52.7 gallons at 77 degrees; 44.8 gallons at 86 degrees; 37.8 gallons at 95 degrees, and 34.3 gallons at 104 degrees. With an initial temperature of 50 degrees, 100.3; 71.2, 55.4, 44.9 and 39.6 gallons, with the final temperature of the cooling water at 68, 77, 86, 95 and 104 degrees, respectively. With an initial temperature of 59 degrees, 105.6, 71.4, 55.6, and 47.5 gallons, with the final temperature at 77, 86, 95 and 104 degrees, respectively. With an initial temperature of 68 degrees, 108.3, 73.8 and 58.1 gallons with the final temperature at 86, 95 and 104 degrees, respectively. With an initial temperature of 77 degrees, 110.8 and 76.6 gallons, with the final temperature at 95 and 104 degrees. With the initial temperature at 86 and the final at 104 degrees, the consumption is 116.2 gallons; with the initial temperature at 95 degrees and the final temperature 104 degrees, the consumption is 232.5 gallons. The horse-power per ton of refrigeration is given as 0.57, 0.73, 0.87, 1.1, 1.3, 1.6, and 1.87, with the final temperature of the cooling water at 50, 59, 68, 77, 86, 95 and 104 degrees, respectively. These figures are given in "Engineering" in connection with a serial on the Borsig works in Germany.

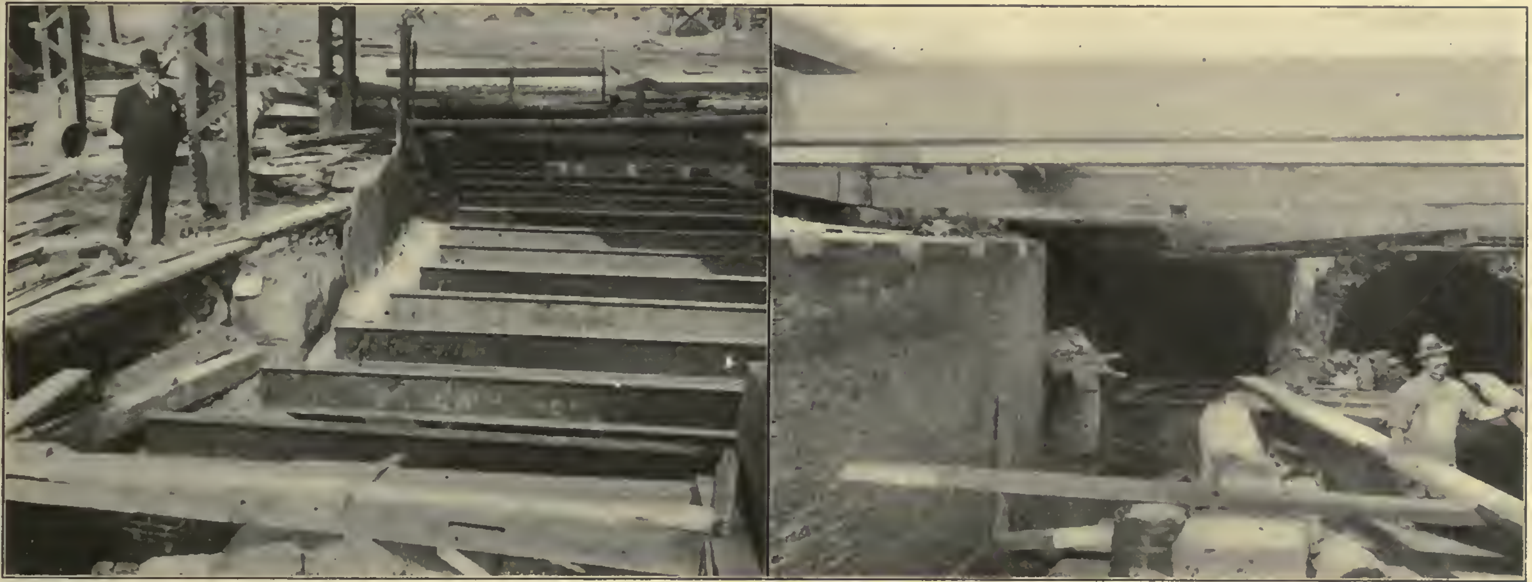
Letters to Editor.

Building a Sewer around the Columns of a Viaduct.

Sir:—I enclose two photographs showing construction work on the Peddie Street sewer under the Lehigh Valley Railroad bridge. Your readers may remember that a detail drawing of this was published in your issue of March 12. The columns of the bridge did not leave sufficient room for the two sewers, but made it necessary to throw the old and new sewers into one. One photograph shows the old and new sewers, old sewer on the right, with arch removed and part of old wall still in place. The wall on the left is the new wall which supports the roof beams. The other photograph shows the 15-inch I-beams in place, with the two bridge columns which necessitated this form of construction.

Very truly yours, Edward S. Rankin,
Engineer of Department of Sewers and Drainage.
Newark, N. J., June 10.

[The new sewer parallels an old storm-water sewer, affording additional relief to a low-lying territory formerly frequently flooded. At the point in question the outer side wall of the new sewer, if continued on line, would have passed through the center of the bases of the two bridge columns shown in the photograph, consequently the new sewer was "necked," reducing its width nearly one-half. To compensate for this reduction of area the old wall has been torn out for a short distance and the double channel roofed with 15-inch 55-pound steel I-beams and concrete. The difficulties of the situation were somewhat increased by the fact that the top of the sewer is close to the street surface, as clearly indicated in one of the pictures.]



Building a Large Sewer around the Column Footings of a Railroad Bridge, in Newark, N. J.

Reinforced Concrete in Building Construction.

Sir:—I read with interest an article in your issue of May 28 concerning the design of reinforced concrete in building construction. In this article the author assumes that in a concrete beam a section plane before bending remains plane after bending, and that the stresses are uniformly varying across the section, and he supports this assumption by saying that it is the practice of French and American engineers. Going on from these two assumptions, the author very naturally comes to the conclusion that the coefficient of elasticity for concrete is always the same, and about one-twentieth of that for steel.

Later on in the article is given the formula $t = P \times E_t \div E_c$, in which P is the safe unit stress for concrete under compression, E_t is the coefficient of elasticity for steel, E_c the coefficient of elasticity for concrete under compression, and t the stress for which the steel reinforcement must be designed. In this formula the value of $E_t \div E_c$ is given to be 20, and it seems to the writer that there must be some mistake here, the ratio of the two coefficients varying much after the nature of the stresses.

It is correct that almost all engineers design concrete beams under the assumption that the stresses are uniformly varying across the section, but the reason thereof is that it is very nearly right for concrete under compression, and, the effect of concrete under tension being neglected, it does not matter whether the assumption is right or not for this part of the concrete.

The value of E_c is nearly constant for the same mixture, and is found to vary from 3,000,000 to 3,800,000 pounds per square inch. E_t being about 30,000,000 pounds per square inch, $E_t \div E_c$ will accordingly vary from 10 to 8, but can never be as much as 20. For $E_t \div E_c = 10$ and $P = 500$ the value of t will now be $500 \times 10 = 5{,}000$ instead of 10,000. The coefficient of elasticity for concrete under tension is not constant, but varies with the stress. Calling this coefficient E_s, it is found that for very small tension stresses E_s will be equal to E_c, but when the tension stress increases, E_s decreases, and for stresses near the ultimate tensional strength of the concrete E_s will be about half of E_c. We have now:

$$\frac{E_t}{E_s} = \frac{E_t}{\frac{1}{2}E_c} = 2\,\frac{E_t}{E_c} = 2 \times 10 = 20.$$

From this it will be seen that the value 20 of the ratio of the two coefficients is only right for concrete under tension; for concrete under compression in columns the ratio will be only 10. Yours truly, H. Kruse,
M. Sec. Danish C. E.
Pittsburg, Pa., June 7, 1904.

Sir:—Answering Mr. H. Kruse's statements relating to the coefficient of elasticity of concrete in compression and tension as compared with that which appeared in the paper written by me, I would state that he is correct in his statement of the fact that the coefficient of elasticity varies much after the nature of the stresses; and I would also add that it varies with the nature of the mixture and also the age of the concrete. However, for the practical application of formulas to the designing of reinforced concrete beams and columns, some definite ratio between the coefficient of elasticity of steel and that of concrete must be established and, as authorities differ as to the proper value to use, the question resolves itself down to which authority is to be followed. In the beam formula for bending a variation in the ratio does not affect the result as much as in the column formula, and M. Considère, the French engineer, who has made numerous tests on reinforced concrete, states that the practical results in a beam are influenced very little by the variation in the coefficient of elasticity of the concrete.

In the formulas in question, the value of $E_t \div E_c = 20$ was used as it is the one recommended by Mr. Edwin Thacher in his pamphlet on "Bridge and Concrete-Steel Construction," after his having investigated the behavior of concrete under tests made at the Watertown Arsenal by Mr. George A. Kimball, chief engineer of the Boston Elevated Railway, in 1899. Also, it is the value established by the Bureau of Building Inspection of the City of Philadelphia. However, I would be pleased to have any of the readers of The Engineering Record who have reliable data on this subject give their opinion as to the value they would recommend.

I desire to call your attention to a typographical error in one of the formulas in the article on "Reinforced Concrete in Building Construction," written by me, which appeared in the May 28 issue of your magazine. The formula is question is the first one on page 672. The last y is in the wrong position; it should be in the denominator of the fraction, and the formula should, therefore, read:

$$x = 20y\left(-1 + \sqrt{1 + \frac{1}{12y}}\right).$$

Yours truly, Emile G. Perrot.
Philadelphia, June 14.

Uses of Vandyke Negatives.

Sir:—The usefulness of Vandyke negatives, made from a tracing by a process similar to that by which the ordinary blue-print is made, does not seem to be generally appreciated, and so I venture to offer the following brief description of the negatives and some of their uses. The tracing and the prepared paper are placed face to face in making a negative, so that the resulting print shows the drawing reversed, that is, reading from right to left. In color the negative is a dark brown, the black lines of the original tracing showing white, this white being the natural, uncolored surface of the prepared paper, and therefore partially transparent. When taken from the printing frame the negative is first washed in water; then, with a brush or sponge, a solution of "Vandyke salt" is applied to it, the effect of which is to intensify the brown color, and to "fix" it against fading. The negative may then be used as an ordinary tracing is used to make "white" prints, the same prepared paper being used that is used in making the negative, the result being a print showing brown lines upon a white ground; or it may be used with the ordinary blue process paper, the resulting print showing blue lines on a white ground. But as the negative shows the drawing reversed it is placed face down upon the printing paper, thus giving prints reading from left to right, and producing lines which are sharper than would result from a direct negative placed face up. The paper ordinarily used, however, for making white prints is used directly with the tracing, requiring no intermediate negative, the lines being of a dark purplish color upon a nearly white ground.

The white prints thus made have been recommended as superior to blue-prints in point of greater legibility. The principal use made of them, however, is for special purposes where the white ground offers a superior opportunity for making additions or changes in the drawing. They are very useful, too, when data are to be shown in tabular form, as additions can be made more legibly and neatly than on blue prints. Unfortunately the paper ordinarily used for making white prints is easily torn, the fiber seeming to have been injured by the solution with which it is coated. But, as suggested above, the Vandyke paper may be used for making the prints, in this case using the negative instead of the original tracing. This paper is strong, but is quite thin, in order that the white lines on the negative may be as transparent as possible. Some special advantages may be derived from the use of the negative, two of which will be mentioned.

In the case of plans relating to the transfer of land, where the original tracing must be filed with the deed, a considerable number of copies of the plan are often needed, to be used from time to time. If blue-prints are made before the tracing is filed, the tendency is to make a larger number, to cover all possible contingencies. These must then be stored. The other horn of the dilemma is retaining too few prints, thus perhaps necessitating a new tracing. If a Vandyke negative is made from the tracing before filing it, prints may then be made at such times and in such numbers as may be required. The objection is urged against this course that unless there is perfect contact between the tracing and the paper while the negative is printing, there will be places on the latter where lines and figures will not appear. It is true that this will happen, and if there were no remedy it would be a fatal defect; but the missing parts may be restored by the use of alkaline solutions such as are used to bring out white lines on blue prints. For this purpose sodium carbonate works well, as does also solution No. 2 of "Collins ink eradicator," and of course any white lines or spots that may be present accidentally on the negative may easily be removed by the use of any dark water color, preferably Vandyke brown.

The other special use of the negative is in obtaining prints from a tracing when most, but not all, of the portions of the latter are required to appear in the print, and at the same time it is desired that the tracing itself shall not be changed. Suppose a tracing showing a number of views, as indicated in Fig 1. It is desired to get prints which shall retain all these features except those at a and b, and the title. It is desired also to add a schedule, another view, and to introduce a new title. The new features are drawn on tracing cloth. Vandyke negatives are then made from the original tracing, and from the tracing showing the schedule and new title. But since there is some space between b and the title, Fig. 1, the new view may be introduced at once in the corresponding space on the negative by placing the tracing of the new view beneath the original tracing, and printing both together. All negatives should be made at the same time, and treated exactly alike, so as to get them of uniform color and density. The portion a and the title are now cut from the large negative, on the fine dotted lines shown in Fig. 2, and are replaced by the negatives of the schedule and new title, which are cut about ¼ inch larger all around, as shown by the broken lines, and are secured in place by pasting at a few points.

Unless great neatness is required the portion b may be canceled by drawing lines across it in the negative with an alkaline solution, or lines may be drawn across it on the original tracing, using a soft pencil, and erasing the pencil lines after the negative is made. If it is desirable to obliterate entirely such a portion it may be cut from the negative, and the hole covered with a piece of plain negative paper which has been printed when the rest of the negatives were made. Prints may now be made from the patched negative, Fig. 2, using either white or blue-print paper. It is not claimed that the prints will show no evidence of the patching. The double thickness of negative between the dotted and broken lines will be in evidence, for neither sort of printing paper will give a perfectly white ground. But if care be taken to get dense negatives the evidence of patching will be very slight.

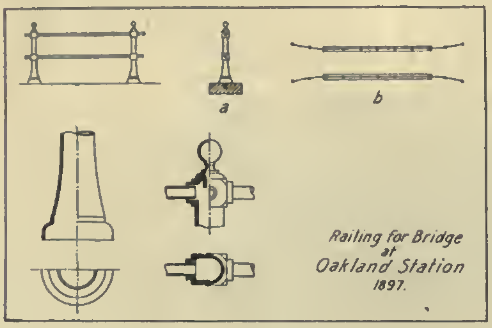


Fig. 1

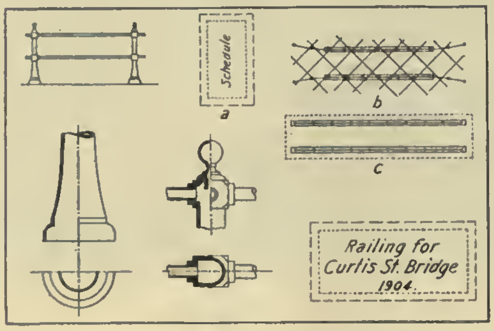


Fig. 2

Yours truly, Frank T. Daniels.
Boston, Mass., June 9.

Results of Sewage Filtration at Clinton, Massachusetts.

The sewage filter beds at Clinton, Mass., connected with the Metropolitan Water Works, cost for operation during the year 1903 $7.82 per million gallons filtered, according to the recent report of the Metropolitan Water and Sewage Board, while the cost for the preceding year was $8.29. During the warmer portion of the year sewage was applied to the beds at a rate which averaged about 29,000 gallons per acre per day. For the first half hour after beginning pumping in the morning, when the applied sewage contained more sludge than during the latter part of the pumping period, the sewage was turned upon a selected bed, which was frequently cleaned. The other beds were used in rotation; but after May 21 the sewage was allowed to run upon a single bed for only a half hour, instead of 1½ hours, as in previous years, making the amount per application about 62,000 gallons, and causing each bed to be used about once in two days. The surfaces of the beds were frequently loosened with a harrow. Using smaller doses of sewage and loosening the bed surface had the effect of materially increasing the percentage of organic matter removed in comparison with the previous year, although the results were not as favorable as in the years 1900 and 1901; but there is a storage of nitrogen in the soil, as shown by the smaller percentage of free ammonia removed and the small amount of nitrates in the effluent. Some of the results obtained during the past four years are shown by the accompanying tables of analyses, stated in parts per 100,000:

The quantity of sewage pumped and filtered during the year averaged about 3,000 gallons per day less than during the previous year, notwithstanding that a number of additional house connections were made with the system. The extensive introduction of water meters on the house services by the Clinton water department is stated to have been an important factor in preventing an increase. The daily average quantity of sewage pumped was 783,000 gallons. The cost of pumping was $9.37 per million gallons, or $0.21 per million gallons raised 1 foot; 610 gallons were pumped per pound of coal.

Methods employed in operating this plant during the cold weather were fully explained in this journal November 14, 1903. The beds are situated on a gravelly formation, and most of them were prepared by removing the top soil and sub-soil. Underdrains of vitrified pipes were laid beneath some of the beds. The whole plant, including intercepting sewer, reservoir, pumping station and filter beds, was described and illustrated by articles published January 14, 1899, and March 3, 1900. It is in charge of Mr. Thomas F. Richardson, engineer of the Dam and Aqueduct Department. Mr. Frederic P. Stearns is the chief engineer.

Results of Sewage Filtration at Clinton.

July to December, inclusive.	1900.	1901.	1902	January to June, 1903, inclusive.	July to December, 1903, inclusive.	Whole year, 1903.
Albuminoid ammonia, sewage	1.51	1.0800	1.0917	.7650	1.0817	.9233
Albuminoid ammonia, effluent	.0763	.0454	.1009	.0846	.0718	.0782
Per cent. removed	95	96	88	89	93	92
Oxygen consumed, sewage	15.70	11.40	7.77	7.98	9.32	8.65
Oxygen consumed, effluent	.93	.58	1.29	1.20	1.04	1.12
Per cent. removed	94	95	80	85	89	87
Free ammonia, sewage	4.5033	3.8667	5.0617	2.7983	4.8600	3.8292
Free ammonia, effluent	.5722	.2525	.6709	.9802	1.0567	1.0185
Per cent. removed	87	93	85	65	78	73
Nitrogen as nitrates, effluent	1.2788	1.3212	1.2130	.4375	.3961	.4168

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The American Society for Testing Materials.

The annual convention of the American Society for Testing Materials is an event which is looked upon with unusual interest by all who have to purchase large quantities of engineering materials, as well as by those who manufacture them. For a number of years the organization has been developing rapidly, because it is the one association in the United States where manufacturers and engineers can get together and freely discuss all features of their common interests without resorting to subterfuge. If a manufacturer desires to present a paper concerning one of his products in this society, he is not obliged to select as a title of the paper something which has no connection, except an extremely remote one, with the real topic under discussion. For this reason it has been said that the Society was a manufacturers' organization, but this is a wholly unjust criticism. It is no more a society of manufacturers than is the American Institute of Electrical Engineers, and the part which manufacturers play in its proceedings is intentionally made an openly frank one.

In the preparation of specifications for any material it is just as necessary to understand the limitations of manufacturing processes as the requirements of the consumer. It is as natural for the manufacturer to endeavor to keep his products within limits which enable him to make them readily as it is for the consumer to require materials possessing higher properties than those employed in the past. The American Society for Testing Materials affords an opportunity for all interested in any product to discuss frankly the possibility of its improvement. Most manufacturers openly admit that it is the constant raising of the requirements in specifications which improves the quality of their product, and that without the incentive of these more strict requirements, the advance in the quality of materials used in engineering would be very slow. This was well brought out in an interesting address by Mr. Robert W. Lesley, president of the American Cement Company, who pointed out the influence of strict specifications on the building up of the Portland cement industry in this country until to-day the quality of the product is unexcelled.

All the specifications which have been put forth by the Society up to the present time have been the result of the careful mutual discussion of engineers and manufacturers organized into special committees. Some of these specifications represent the results of several years of very careful work. During the past twelve months other organizations have discussed similar specifications. The American Railway Engineering and Maintenance of Way Association, which represents the largest purchasing capacity of engineering materials of any organization in this country, has prepared specifications for structural steel and for steel rails which differ in some respects from those of the American Society for Testing Materials. Other organizations have adopted specifications which also differ in minor respects from the Society's standards. A number of attempts have been made to have the Society's committees in charge of such specifications take up the matter of their amendment, so as to make them conform with the latest practice, but the committees have refused to do this. The ground for this refusal has not been made public, but there are many indications that the reason for it is to be found in the impossibility of securing a quorum of the committees for the purpose of reconsidering the specifications. At the convention last week, the members took a decided action on this subject and ordered the committees to consider all changes in the various specifications which are proposed, and to report fully concerning the advisability of adopting them at the next meeting. In other words, the Society has practically voted that its specifications are open to change at any time and that it is the duty of its standing committees to furnish definite information concerning all modifications which are suggested.

The importance of the Society's work is well shown by the fact that while its membership at the last convention was only about 350, it is now over 500, an increase of about 43 per cent. in a year. As engineers throughout the country recognize the exceptional value of the work of the organization, and appreciate that its transactions are invaluable to any one called upon to prepare specifications for materials of construction, its growth in numbers may be expected to be very rapid. It was interesting to observe at the convention the large number of those in attendance who expressed their strong appreciation of the business and technical importance of the information they obtained during the meetings. This is not surprising when it is considered that most of the large manufacturers of engineering materials were represented by high officials, and that the large purchasers of such products were represented by the men whose business it is to test such materials and to play the leading part in drawing the specifications for them. As will be seen in the report of the convention, published in the "Current News Supplement" this week, the discussions range over a wide field and embrace apparatus and methods of testing and the behavior of materials under special conditions, as well as the preparation and interpretation of specifications.

The organization is of such direct benefit to everybody connected with engineering work that The Engineering Record has no hesitation in repeating its recommendation of last year that all engineers who are users of metals and cement should apply for membership to the secretary, Professor Edgar Marburg, University of Pennsylvania, Philadelphia. The annual dues are only $5, a sum which is ridiculously small compared with the benefits which are derived from membership.

The Growing Importance of Details.

For a number of months The Engineering Record has been storing away among its notes statements received from time to time concerning the small things in the manufacturing world which are fast becoming very important matters. The development of all lines of manufacture and the specialization of the professions no longer permits the head of a business or an office to allow details to slide along the groove of least resistance. Now that the best grade of fire hose is largely made of discarded galoches and the first-quality olive oil served in many leading hotels is a refuse proposition of the petroleum industry, to mention only a couple of instances of the details of modern business, it goes without saying that the largest measure of success can only be attained when every detail of an industry is analyzed to its ultimate parts. It often happens that the old school of managers resents as useless and extravagant any suggestion that the details of business should be reported regularly with more completeness than in the past. In fact, many of them state that such a system will lead to vexatious delays and worthless complications. Yet the fact remains that the most prompt reports are almost always to be had from the companies which adopt the most complete systems of keeping tabs on all parts of their business. For example, in one industry a company which separates its manufacturing costs into about twenty items is able to tell on the first day of each month just what its product has cost to make during the last month, while another company of about the same output, which divides its cost of manufacture into less than half a dozen items, cannot give such figures for more than a fortnight. At the present time it is all-important to know what every part of a manufacturing process costs, and how it fluctuates from time to time, for only in this way is the utmost economy possible. In this particular industry competition has only recently become severe, so it is not surprising that old methods inadequate to meet present conditions are still followed; the important fact is the refusal of some of the older people in the industry to acknowledge that such a thing as progress is possible in their systems of management.

Only a few weeks ago a prominent manufacturer of heavy apparatus stated that he much wished he could build one of his leading specialties along the lines he considered best, without any regard to the purchasers' opinions of beauty in the general arrangement of the apparatus and in the form of the parts. He frankly stated that the apparatus would not have any attraction whatever to an æsthetic eye, but he was confident that it would have the two-fold merit of low cost and high efficiency to a degree never before attained. The high cost of such apparatus and the fact that it is generally bought by commissions and not by engineers, will doubtless prevent any early fulfilment of this manufacturer's desire, for committees are not given to allowing marked changes in general designs, however much latitude they may permit in minor details of which they are no judges. It costs money to smooth off castings and to plane and mill surfaces, and if this work is unnecessary the money might just as well be saved. That this idea is growing is evident from the finish on many machine tools made to-day as compared with that on similar tools of fifteen years ago. It will generally be found that the modern product is fine finished only where necessary, while formerly the surfaces were machined and tooled in many places for no other purpose than to improve their general appearance. The condition in which many parts of the best steam engines are left to-day would horrify some of the old builders, while the surprise which Englishmen showed when they saw the rough surfaces of some of the smaller parts of pneumatic tools was only recently reflected in numerous comments in their technical journals. In short, there seems to be no question that the time has passed when unnecessary machine work, so-called graceful curves, and elaborate painting are desired.

Another aspect of modern conditions which has been brought very forcibly to the attention of this journal lately concerns certain features of the relation of a selling department and the engineers whom it strives to reach. A large industry was taken over by new owners a few years ago, and the proprietors began the overhauling of their new property at the sales department. It so happened that this department was well known for the lavish expenditures of some of its men, and considerable interest was displayed concerning the view of such expenses which the management would take. It is stated that while some reduction in the total cost of the department was effected, this was not attained by any paring down of the money used by the leading men. According to generally accepted reports, the investigation showed that the money used by the leading men was spent in perfectly legitimate ways, but some of the minor employes ran up large expense accounts which had no other result than to prove the lack of caliber of those responsible for them. The only reason for mentioning this matter is that while this company was not able to make any considerable reduction in what most people considered its most wasteful branch, it effected a large saving in its office expenses. A careful analysis was made of the amount of space really needed by each employe to do the work allotted to him, and of the space required for a reasonable display of the company's products. When this was completed, it was found that the rentals paid by the company could be cut down very largely, and considerable money was available for real aids to the office staff which had not previously been purchased because it was well known that the expenditures for the department were very heavy in comparison with those of similar companies.

Still another case, typical of a good many which have recently been reported, is afforded by the present unemployed condition of a number of salesmen who are well known among their trade. These men have been generally credited with selling an unusually large quantity of the products of the company employing them. About a year ago a new general manager took hold of the business and instituted a system of accounts by which he could ascertain what was done by each of his men. Little by little he discovered that some of the salesmen who were drawing the most money were earning the least. Some of them turned in a large number of orders, but a considerable proportion of them were thrown out by the credit department at once, and the company was afterward sorry that others had not followed them into the discard pile before they were filled. Other men were found to be making a big stir with their voluminous correspondence and rapid-fire notes to possible purchasers, but when the cost of their work was compared with the direct and indirect returns from it they were found to be expensive luxuries. The particularly interesting fact about this case is that the weeding out of the incompetents was done by an engineer who had never before been in a strictly commercial position.

These cases are cited as examples of the value of paying attention to details. No man in a high executive position can spend his time wholly on minor affairs, but it is incumbent on him to be sure that his staff is so organized that the moment there is any lost motion anywhere the reports which reach him shall show it. In the best engineering offices to-day this same rule holds; one of the most impressive sections of the regulations of the construction department of the Illinois Central Railroad, reprinted recently in this journal, is the direction to the assistant engineers to be on the watch constantly to detect opportunities for reducing the force required on their work, and thereby saving money for the company. This idea is fast finding root everywhere, and the man who does a thing well is rapidly being displaced by the man who does not accomplish the thing quite so well, but can finish it very much more quickly. These suggestions are made because so many young men enter upon their engineering work at this season for the first time, and they cannot be too strongly urged to form the habit of estimating the cost of all work they see done, the cost of different classes of work, and particularly the opportunities for decreasing such expenses. Such a habit is a thoroughly good one to form.

The Bending Test for Steel.

One of the most interesting subjects of discussion at the recent convention of the American Society for Testing Materials was the bending test for steel. It is perfectly well known that many of the physical tests for structural material are not completed until long after the steel has left the mills for the bridge shops. Moreover, the customary tests do not satisfactorily indicate brittleness, which is the one great defect that consumers are desirous of detecting. The old-time bending test for this purpose has been greatly neglected, although it certainly gave valuable information. It has been evident for some years that many leading purchasers of steel were desirous of reinstating this bending test in some form or other. At the convention last week of the society mentioned, this desire found expression in a valuable paper by Mr. J. P. Snow, bridge engineer of the Boston & Maine Railroad. He showed very clearly that such a test could be made to reveal brittleness in steel, and all but one of the gentlemen who discussed the test were in favor of it.

The great purpose of the proposed test is to facilitate the progress of the steel through the manufacturing processes, by affording a quickly-made method of detecting material which should not be employed for structural purposes. The apparatus proposed is simple, and its great advantage lies in the fact that it will be employed in the mill at the point where the inspector ought to be stationed. Its manipulation is apparently fairly simple, and intelligent inspectors should be able to make the tests in a satisfactory manner. The great trouble with all such work lies in the tendency to entrust inspection to incompetent men, puffed up with a sense of their knowledge and importance. Such men are as undesirable to the purchaser as to the manufacturer, although unfortunately the manufacturer loses more money at the outset by their ignorant conceit than does the purchaser. Nevertheless, there seems to be no reason why this test should not be adopted if it will accomplish all that Mr. Snow expects, and will at the same time render less necessary other tests which require much more time for their proper manipulation.

It goes without saying that the greater the simplicity of testing operations, the less opportunity there will be for differences of opinion concerning their results. The preparation of specifications, like every other work of such a character, proceeds according to the usual laws of evolution. The requirements are at first few, then gradually become more complex until their multifarious nature renders them burdensome to both purchaser and manufacturer, and finally there is a backward swing of the pendulum which drops off one by one many of the unnecessary details and finally leaves a certain number of requirements which are satisfactory until the purchaser demands material having new properties and therefore requiring new tests.

At the present time there is a marked tendency toward the production of steels of uniform quality for most purposes, and reputable manufacturers are desirous of turning out products which will answer all requirements. The fact that they are so sure of their product that they ship it from the mills to the finishing shops before it is tested and even begin work on its fabrication before these tests are made, indicates their complete confidence in its quality. If they were not sure that the material would be satisfactory, they certainly would not expend considerable labor on its manufacture before it was actually accepted. The bending test conducted in the manner suggested by Mr. Snow in his paper, printed elsewhere in this issue, will really be a check on the quality of the steel of equal value to the manufacturer and purchaser. On very important work the bending test can be made on more samples of the product than any of the present tests, without delaying the manufacturing processes, and in this way the quality of material as respects its brittleness, the one property concerning which engineers are now most in doubt, can be detected without much additional cost and no additional delay. The fact that men like Mr. H. H. Campbell, representing some of the largest steel mills in the country, spoke in favor of such a test is an indication of the probability of its adoption before long. The actual method of conducting it remains to be settled; in fact, one or two points in the paper by Mr. Snow called for features of manipulation that were strongly criticized. These were details, however, and the general proposition was in no way affected by them.

Notes and Comments.

Wood Gas is used in the power plant of the Montezuma Copper Company, at Nacozari, Mexico, to drive gas engines. There are eight all told, of the Crossley type, 18.5x24 inches in cylinder sizes, each belted to a 65-kilowatt direct-current 250-volt generator. The gas is manufactured in Loomis-Pettibone producers, and to secure an adequate fixing zone in the producer a bed of coke is employed, as it was feared that apertures might be burned through a bed of charcoal alone, allowing tar to pass through untransformed into fixed gas. The analysis of the gas, given by Mr. J. Langton in a paper before the American Institute of Mining Engineers, is as follows: Carbon monoxide, 14 per cent.; hydrogen, 20 per cent.; marsh gas, 2 per cent.; carbon dioxide, 16 per cent.; oxygen, 0.1 per cent.; nitrogen, 47.7 per cent. Calorific value per cubic foot at sea level and 60 degrees Fahr., 132 British thermal units.

A Pipe Covering for Overhead Steam Pipes that is advocated by Mr. Robert Watt in a contribution to the question box of the Ohio Gas Light Association is described in the "American Gas Light Journal." The pipe is enclosed within a molded covering and wrapped in canvas, and the canvas is painted with two coats of tar boiled down to the consistency of soft pitch, having a little slate flour, slaked lime or hydraulic cement added to it. It is applied with a brush, the second coat two or three days after the first.

A Scheme of Street Numbering for Newton, Mass., inaugurated in 1888, was completed during the past year. In all 728 plans have been prepared for this purpose, covering the entire area of the city. Numbers have been assigned to each space of about 25 feet, according to the report of City Engineer Irving T. Farnham, spaces being numbered from the north end of the street, southerly and from the east end westerly, except in a few cases of courts, in which the numbering has been from the main street. Odd numbers are on the right in the direction of increase.

The Plates of an Old Boiler that had been in use since 1859 exhibited, on tests of 812 test-pieces cut from it, a marked lack of elasticity. According to the report in the "Zeitschrift" of the Society of German Engineers, the boiler had been fed with pure water and never overstrained, so it was concluded that its unsatisfactory condition was the result of prolonged stress, and that subjecting it to a strain might have led to an explosion. It was felt that the tests showed that a boiler should be discarded at the end of 35 years' service and even if apparently in good condition should be replaced by a new one.

Acetylene for Town Lighting is in use in 250 towns and villages in different parts of the world, according to "The Engineer," of London. On the basis of the fifty-odd public supplies in Germany it is calculated that the average population served is 2,558; the number of houses, 302; the number of houses supplied, 53.7; the length of mains, 2.92 miles; the number of private burners, 456; the number of public lamps, 56; and the estimated annual consumption, 147,500 cubic feet. These data can readily be referred to the mile of main, or lamp, or consumer, as, for example, the number of consumers per mile of main, which is 18.4. The average price charged for the gas is, in French villages, $1.76 per 100 cubic feet to private customers and $1.58 for public lighting. At Strelitz, in Mecklenburg, the first place in Germany to be lighted, the charge is $1.25 per 100 cubic feet.

A Steam Turbine to exhaust into a public heating system is to be installed in the plant of the Merchants' Heat & Light Company, Indianapolis. The business of the plant, which was started on January 1, 1903, with an initial installation of 500 kilowatts in engine-type direct-connected units, has grown so rapidly that two 750-kilowatt Westinghouse-Parsons turbine generating units have been purchased. The turbines are to work at a back presure of 3 to 5 pounds during the winter months and probably 8 pounds during extremely cold weather. With this back pressure, it is stated that the turbine will develop 20 per cent. in excess of their rated capacity. During warm weather they will operate condensing upon a Worthington condensing system, with cooling towers maintaining a vacuum of 27 inches referred to a 30-inch barometer. The steam boiler plant when completed will aggregate about 4,220 horse-power in eleven units of the Stirling and Wickes types, partly equipped with the Roney mechanical stoker.

Wagon Transportation between Tepehuanes and Guanecevi has been inaugurated by the Mexican International Railway. As a rule, railway competition is confined to hauling which can be done with locomotives, but in the part of Mexico where these towns are located there is such a sharp rivalry between the road mentioned and the Mexican Central Railway that the struggle has been extended even to the highways. As a matter of fact, this project is merely an extension of the good roads assistance offered in some parts of the United States by railways endeavoring to build up their local business as rapidly as possible. It is an interesting indication of the fact, often stated of late, that a railway line is not an undertaking by itself, but must be considered in connection with the means of transportation by which the people along its route may reach its stations. As interurban electric lines extend over the country more completely, the importance of good roads to the steam railways will become more noticeable, for unless the means of access to stations are made much more easy the electric lines will prove more convenient for local use in many cases.

The Cost of Ventilation in several notable buildings in Great Britain was referred to in a recent paper by Mr. William Henman before the Royal Institute of British Architects on the plenum system of ventilation. The Glasgow Art Galleries, supplied with 9,050,000 cubic feet of air per hour by electric power requiring 66 horse-power, costs for power about $1,450 per year per 1,000,000 cubic feet. The Manchester Technical School, supplied with 12,000,000 cubic feet per hour, providing for 3½ changes hourly and requiring 80 horse-power, is charged with $1,308 per year per 1,000,000 cubic feet. The Manchester Midland Hotel, ventilated at the rate of 3 changes of air per hour, corresponding to a supply of 6,000,000 cubic feet in that time is charged with 40 horse-power electrical energy at an annual cost per 1,000,000 cubic feet of $1,308. The Birmingham General Hospital, with 7 changes per hour or 13,000,000 cubic feet supplied per hour, requires 19 horse-power electrical energy and costs about $287 per annum per 1,000,000 cubic feet. The Royal Victoria Hospital, at Belfast, designed by the author, is provided with ventilation in turns of 7 changes, corresponding to an hourly supply of 5,000,000 cubic feet, and is charged with but 5¼ horse-power in a steam plant, costing $97 per 1,000,000 cubic feet per annum.

Trackless Electric Railways seem to be growing in favor in Germany. The town of Monnheim, in Prussia, has recently built one about 2½ miles long, with a couple of branches for freighting purposes. The cars used are automobiles taking their current from a double overhead trolley line. Portable connections from these wires can be run into the farm yards along the route as desired, and cars can be thus hauled electrically directly to the places where they are to be loaded or unloaded. It is intended on this line to use a motor car and one or two trailers, and to furnish means for hauling ordinary farm wagons. In addition, passenger omnibuses are proposed. In Bavaria there are two of these lines which have been in operation some time, but mainly for passenger traffic; they do not seem to be so profitable that capital is rolling over itself in its hurry to take up new projects of a similar nature. There are also several of these lines in Westphalia. Mr. Charles L. Cole, our consul-general at Dresden, states that the cost of operating them has been found to be unexpectedly high, and this fact should be carefully considered in case a similar enterprise is discussed in the United States.

A Serious Epidemic was probably prevented last year by an investigation made by the United States Geological Survey. At Quitman, Ga., while the authorities of the city were sinking an artesian well, they encountered a large cavity full of water under a considerable head. This cavity was cased off and the well sunk to a second water-bearing stratum, where it was stopped. The cavity suggested desirable potentialities to the official mind, and so a second well was sunk a few hundred yards distant. This also revealed the presence of a large cavity, and after the water of a small pond had been allowd to run into it without making any visible impression on the deep water in the first well, it was decided to utilize the second bore-hole for the disposal of the sewage of the city. Fortunately some people put up such a vigorous protest against this course that the Geological Survey was requested to report on the practicability of the plan. Two tons of salt were poured into the proposed receptacle for the sewage, and for a number of weeks the water from wells in the neighborhood was regularly analyzed. These analyses showed that the brine had contaminated the supply in three wells in Quitman, and, had sewage been poured into the bore-hold instead of brine, the result is not pleasant to think about.

Rope Transmission of Power was the subject of a paper by Mr. F. S. Greene before the New England Cotton Manufacturers' Association, an abstract of which recently appeared in this journal. This paper and a similar one before the Southern Cotton Manufacturers' Association have attracted so much attention and adverse criticism that the following announcement has recently been made: "The American Manufacturing Company, of 65 Wall Street, New York, which manufactures transmission rope and other cordage, will agree to furnish the necessary rope, sheaves, rope and driven-head shafts for the main drives of any cotton mill using 500 or more horse-power which is developed at the mill site, at one-quarter the price for which any responsible company furnishing electrical apparatus will agree to install the generators, motors and motor shafts, switchboard, wiring and other appliances necessary to electrically transmit the same power. Where the power is generated at a distance, if the mill will install one central motor, the American Manufacturing Company will agree to distribute the power from the same to the main line shafts with rope drives for half the cost of electrical apparatus to distribute the same power." This is one of those knockdown arguments which, when made by a company of such standing as the one in question, call for the display of science in delivering the counter blow. The American Manufacturing Company evidently means to keep in this particular field of power transmission, and the publicity which it desires for this challenge will doubtless receive the attention of some of the many advocates of electricity for like purposes.

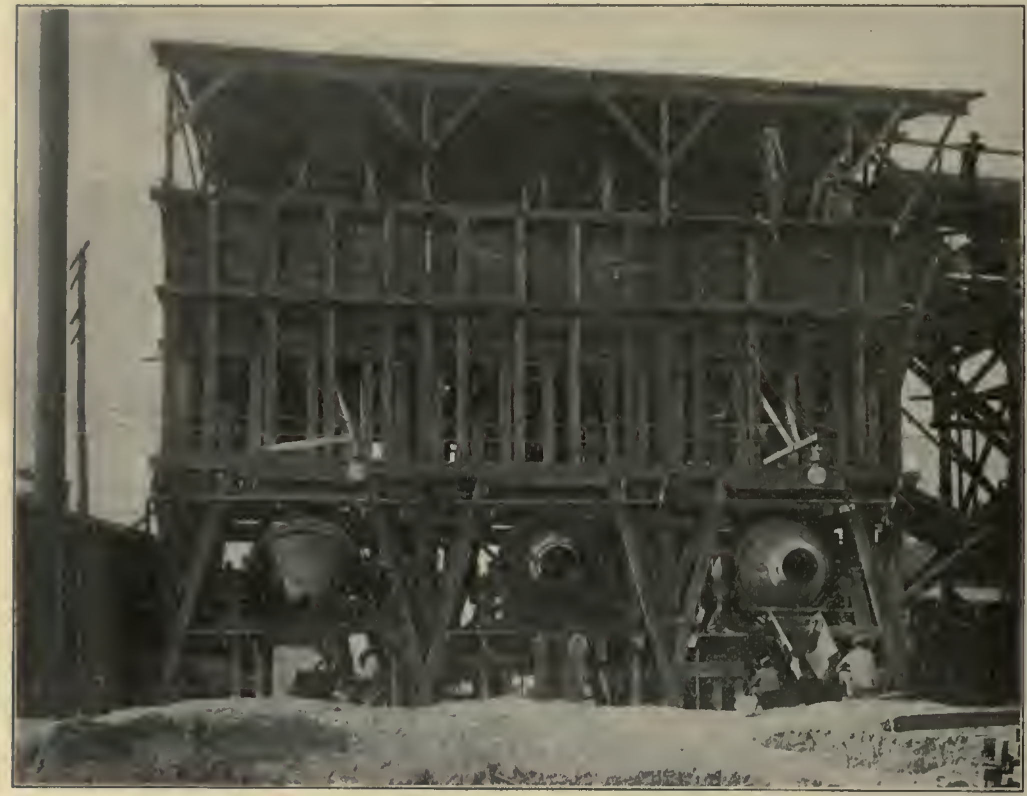
Concrete Work on the Washington Filtration Plant.

By E. D. Hardy, U. S. Assistant Engineer.

The work of placing the concrete masonry for the Washington aqueduct filtration plant was begun in March, 1904. Only a small amount was done during the months of March and April, however, as the concrete plant was not completed, and the work consisted of placing the concrete in the central under-drains, on which progress was necessarily slow. The under-drains consist of 24-inch terra cotta pipe surrounded with concrete. In laying these drains about 4 inches of concrete was placed in the bottom of the trench and carried level to about the elevation required for the bottom of the bells of the pipe. The pipe was then laid accurately to line and grade on the base thus prepared. All joints were made by first pressing an oakum gasket saturated with neat cement into the bells and around the spigots, and then making a joint of 1:2 Portland cement mortar, completely filling the joints inside and out. Concrete was then placed in the trenches and surrounding the pipe, care being taken to make the concrete rather wet and to have it worked well under the pipe.

The filter plant consists of 29 filter beds of an effective area of one acre each. The filters have the usual concrete groined arch inverts for floors, 22x22-inch concrete piers spaced 14 feet center to center, and concrete groined arch vaulting for covering similar to those in the Albany plant. All concrete masonry is to be of Portland cement and the amount required for the floors is 39,250 cubic yards; for the walls, 26,250 cubic yards; for the piers, 8,180 cubic yards; the vaulting, 37,430 cubic yards; the court paving, 4,860 cubic yards; the regulator houses, 1,300 cubic yards; and the pumping station about 2,500 cubic yards, making a total of 120,000 cubic yards, in round numbers, for the entire plant.

The specified mixture for concrete is 1 barrel of Portland cement, 11 cubic feet of sand, and 19 cubic feet of ballast. The ballast may consist of gravel or broken stone, or a mixture of both, at the option of the contractor. It must all pass a screen having 2½-inch openings, be graded from fine to coarse, and have all dust and grains less than ¼ inch screened out. This mixture requires about 1.23 barrels of cement per cubic yard of concrete rammed in place. It is found that this mixture gives such a surplus of mortar after filling the voids in the ballast that the surfaces can easily be troweled smooth without the use of additional mortar for finishing.



Washington Filters: Concrete Mixing Plant.

Washington Filters: Screening and Washing Plant for Sand and Gravel.

The contract prices for the various classes of concrete, not including the cement, which is furnished by the United States, are as follows per cubic yard: Floors, $4.50; walls, $5.10; piers, $6; vaulting, $6.50, and granolithic paving 5 inches thick, 90 cents per square yard. As the contract price of the cement is $1.635 per barrel, the additional cost for cement is about $2.10 per cubic yard of concrete, making the actual cost for the concrete per cubic yard in the floors $6.60; walls, $7.20; piers, $8.10, and vaulting, $8.60.

The pumping station and regulator houses are being done by the United States by day labor. Old Dominion Portland cement is being used on all the work and is tested under the standard specifications of the Corps of Engineers, U. S. A., the principal requirements being as follows:

Average weight, not less than 380 pounds net per barrel.

Fineness: At least 92 per cent. shall pass through a sieve made of No. 40 wire, Stubbs gauge, having 10,000 openings per square inch.

Specific gravity shall be between 3.10 and 3.25.

Soundness: "To test the soundness of the cement at least two pats of neat cement, mixed for five minutes with 20 per cent. of water, by weight, shall be made on glass, each pat about 3 inches in diameter and ½ inch thick at the center, tapering thence to a thin edge. The pats are to be kept under a wet cloth until finally set, when one is to be placed in fresh water for 28 days. The second pat will be placed in water which will be raised to the boiling point and kept at that temperature for six hours, then allowed to cool. Neither should show distortion or cracks. The boiling test may or may not reject at the option of the engineer officer in charge."

Time of setting: The cement shall not acquire its initial set in less than 45 minutes, and must acquire its final set in 10 hours.

Tensile strength: Briquette made of neat cement, after being kept in air, under a wet cloth, for 24 hours, and the balance of the time in water, shall develop a tensile strength per square inch, of 175 pounds after 1 day, 450 pounds after 7 days, and 540 pounds after 28 days. Briquettes made of one part of cement and three parts of standard sand, by weight, shall develop a tensile strength per square inch of 145 pounds after 7 days, and 220 pounds after 28 days.

The sand and gravel used in the concrete are procured from a bed at Hyattsville, Md., a distance of about eight miles from the filtration plant. A branch railroad has been built between the filtration plant and the sand and gravel bed, so that these materials are shipped on steel cars from the screens to the work.

Washington Filters: General View of Floors and Forms for Piers.

The sand and gravel are loaded onto 4-yard dump-cars with a steam shovel, hauled about ½ mile and dumped into a canal directly opposite the screens, for separating them. From this point in the canal they are raised, together with the necessary amount of water, by means of two centrifugal pumps, to the screens, which are so perforated and arranged that all stones larger than 2 inches are rejected, and the remaining sizes to ¼ inch are carried in chutes to cars and used as aggregate. The grains less than ¼ inch size are carried to a sand-washer, washed and used as sand.

One of the accompanying photographs shows the suctions and end of the screens for separating the sand and gravel, but does not show the sand washer, which is located to the left of the screens, and at a lower level. The method of handling the concrete materials from the cars to the storage bins was described in The Engineering Record of May 28, 1904.

The plant for mixing and placing the concrete consists of three 1-yard Smith concrete mixers, one standard gauge and three narrow gauge locomotives with the necessary small flat cars for carrying the buckets of concrete, one 600-foot Lidgerwood cableway which is erected and in use, one 400-foot Lidgerwood cableway which is in the process of erection, and three traveling derricks.

The work now in progress consists of placing the concrete in the filtered water reservoir and a block of ten filters which is entirely surrounded by courts and streets. Tracks are laid around the block of filters on which the concrete is taken by means of the locomotives and cars from the mixers to the cableway and derricks. The cableway spans the block and is used for placing most of the floor, some of the piers and walls and will be used for placing the concrete in the vaulting. The traveling derricks are used for handling the concrete placed in the outside floor sections and walls, as well as some of the outside piers. No concrete has yet been placed in the vaulting.

For the purpose of keeping a record of the progress of the work, sheets are made to a scale of 1 inch to 40 feet. One sheet shows the floor blocks and the number of blocks placed on any day is indicated by printing on each square the date on which its block was put in place. Another sheet shows the rate of progress on the piers and walls in the same manner, and still another that of the vaulting.

The quantities of concrete of the several classes placed are accurately computed each morning for the work done on the day preceding and posted in a book ruled for that purpose.

Washington Filters: Forms for Floor and Blocks under Dividing Walls.

The Mingo Bridge Approaches.—I.

The Mingo bridge carries the double-track Cross Creek Railroad over the Ohio River near Mingo Island and consists of three long channel spans, which were described in The Engineering Record of October 3, 1903, and an approach on the Ohio shore. The approach has a total length of about 2,500 feet and is at present made up largely of a heavy timber trestle with four spans of deck plate girder and truss construction at the river, and other similar spans over the Pennsylvania Railroad and Cross Creek. Although the rail is in many places more than 75 feet above the original surface of the ground, the structure has been designed with the intention of making a solid fill to enclose the timber trestle and support the tracks after the trestle shall have decayed. After the completion of the fill, the trestle will be left in the ground to gradually disappear, although of no further service in carrying the tracks. There are in the approach nine plate-girder spans, one 203-foot through truss span, one 80-foot deck-truss span, and one 120-foot deck-truss span, all of which are supported on concrete piers and pedestals.

The diagrams showing the structure at the overhead crossing of the Cleveland & Pittsburg Railroad (Pennsylvania System) are typical of the general arrangement of the superstructure and substructure, and indicate some of the special features of the approach masonry. The most notable characteristics are that it is made entirely of concrete without stone facing, that the increased bottom sections are secured entirely by horizontal offsets without the use of inclined or battered surfaces, and that the piers, instead of being made in solid masses, have openings through them transversely, which give them the effect of double or triple shafts united by deep, full-centered arches at the top. This feature allows the high embankment, which reaches to the tops of the abutment piers, to slope at the natural angle through the piers in the line of the bridge axis and thus relieves the great pressure which would otherwise be developed by the action of the abutment as a retaining wall. This effects a considerable economy in the amount of masonry and was intended to reduce the cost of the substructure. Although it requires the use of additional girders, with a length proportioned to the height of the embankment to carry the track from the main pier to the top of the slope, it was calculated that the cost of the abutment and girder combined was less than the construction would have cost without the short span if the abutment pier had been made heavy enough to resist the full pressure of the high embankment acting upon it as a retaining wall.

The abutment piers are made with face walls carried up above the girder seats nearly to the level of the rail base, so as to protect the superstructure from the earth in the upper part of the embankment. This construction, like the rest of the piers, is carefully dimensioned in all parts to the proportions required for the calculated service and involves a considerable amount of variation in the cross-sections. This is effected in all cases with rectangular offsets, and although the arrangement is as simple as possible it involves more elaborate work than is usually found in either masonry or concrete construction of this type.

Adjacent to the main lines of the Pittsburg, Toledo & Western Railroad there is, for several hundred feet of the approach, a parallel track of the Wheeling & Lake Erie Railroad, which is carried close to the other tracks, but has a grade in the reverse direction. All three tracks are supported on the same structure; the difference in grades causes an unusual type of piers, which are made long and in some instances designed with one end much higher than the other, so as to conform to the different levels for the girders. This feature is clearly shown in the elevations of pier and abutment 9 and 10, which are typical of all of the substructure work except that at the shore end of the approach, where the Wheeling & Lake Erie track reaches the surface level and diverges from the other tracks, so that it is no longer supported on the piers. One of these piers is, therefore, made to carry two tracks only and is built with only two shafts, which are connected by the usual arched top. Piers 12 and 13 are made with four shafts, but their details correspond to those of piers 9 and 10. All of the arches are reinforced by 1-inch twisted steel horizontal rods embedded in the concrete just above the intrados. All concrete in the foundation and above the springing line was made with proportions of 1:2:4½; concrete in the shafts was made 1:3:5, and all concrete was deposited in open molds or in dry pits. The pits were, of course, excavated with vertical sides and the spaces between them and the concrete were back-filled and rammed after the latter was laid. The embankments and back-fill were riprapped with slag or cinder up to high-water lever.

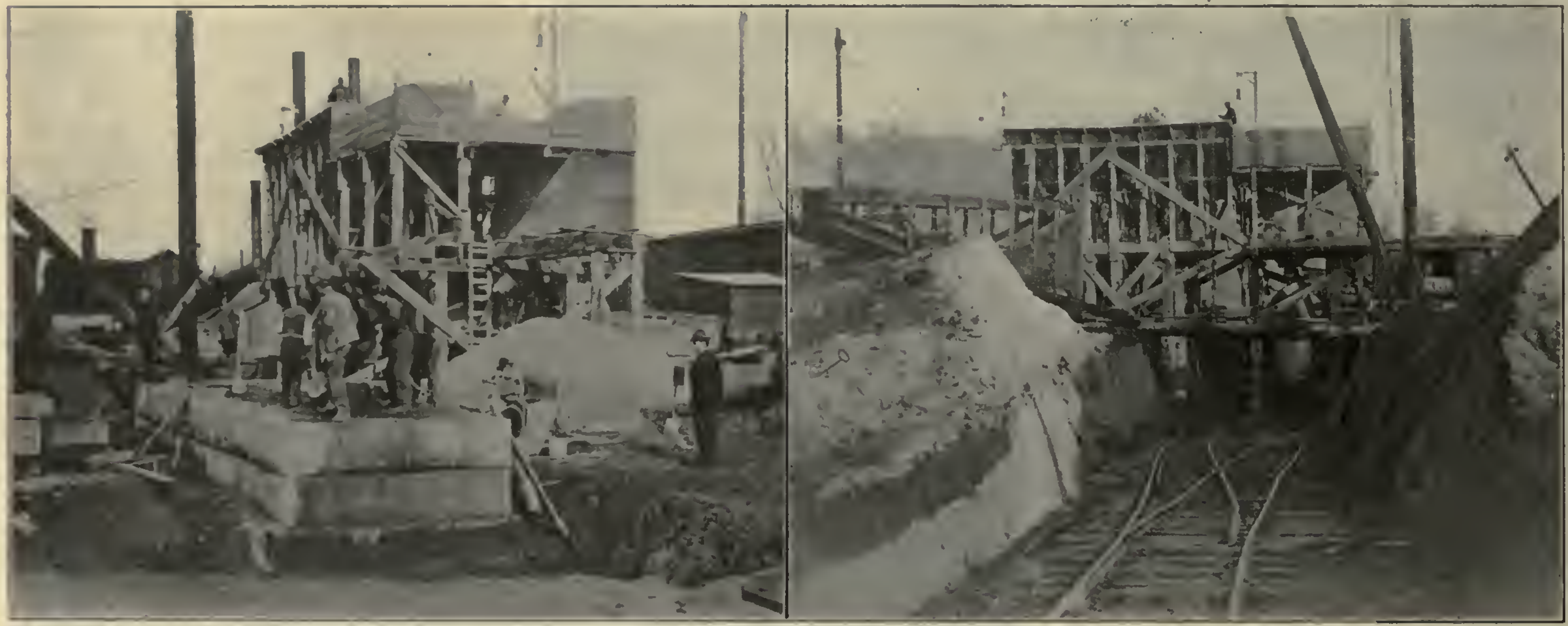
The 80-foot-span plate-girders are of standard construction with 96x⅜-inch webs shop-spliced in lengths of abont 20 feet. They are divided into panels from 5 to 8 feet long by pairs of 3½x3½x⅜-inch angles at the splices and at intermediate points. At the ends of the girders there are two sets of vertical angles 2½ feet apart and three additional angles in the center of this short panel to afford extra reinforcement for the maximum shear above the bearing. The web splices are made with a pair of 13x⅜-inch plates with four vertical rows of rivets. Each flange consists of a pair of 6x6x¾-inch angles, one 14x⅝-inch cover plate 58 feet long and one 14x⅝-inch cover plate 42 feet long. In each double-track span there are four girders spaced 3 feet 3 inches and 9 feet 9 inches from the center line. The two center girders are connected together by horizontal transverse angles at the center and end of the span and at four intermediate points, but have no sway-bracing between them. The girders of each outside pair are connected together by sway-brace frames in the planes of the above-mentioned transverse struts, and are also connected together by zig-zag lateral bracing of single 3½x3½x⅜-inch angles, with horizontal connection plates field-riveted to both top and bottom flanges.

The girders have triple-web riveted shoes field-riveted to the lower flanges at both ends. These shoes engage 4-inch pins, which lock them to the pedestals of corresponding design. In both shoes and pedestals the center webs have half-hole bearings and the side webs have half-hole bearings in the angles and full bearings in the plates, which project so as to form jaws and lock both members together. The side connection angles are arranged with their horizontal flanges in reverse directions in the shoes and in the pedestals so as to give the latter extended bases and allow the anchor bolts through them to clear the rollers.

At the expansion ends the pedestals are seated on nests of eight 3-inch rollers. These rollers differ from the ordinary pattern in that their sides are perfectly straight without any notch to engage the center guide rib generally riveted to the top and bottom plates. The base plate of each pedestal has longitudinal guide ribs on both edges, and the bed plate for the roller has a pair of corresponding guide ribs, all of which have planed edges engaging the ends of the rollers so as to keep them in position. At the fixed ends of the spans the pedestals are seated directly on granite blocks, which are bedded in the tops of the piers and abutments, the heights being varied to correspond with the differences involved by the expansion rollers. The capstones are set with great accuracy and grouted with cement to secure satisfactory bearing.

Pier 9 was located so close to the tracks of the Cleveland & Pittsburg Railroad that one side of the excavation was wholly in the slope of a fill for the two-track line of the railroad. This involved a cut about 40 feet deep in the slope of the fill, and in order to make it a slight triangular excavation was terraced in the slope with its bottom about 10 feet above the surface of the ground. Stringers transverse to the embankment were placed in this excavation and were blocked up from the surface of the ground beyond it to receive a pile-driver, and a row of permanent round piles 40 feet long were driven, about 3 feet apart on centers, for the full length of the excavation. Six of these piles equidistantly spaced were anchored by steel cables passed over the embankment under the tracks and attached to a single-track pile trestle parallel to and on the opposite side of the embankment. A waling piece was then laid against the piles on the embankment side and sheet piling was started on the outside of it and driven down by mauls as the pier excavation was carried through the slope on the other side of the round piles. In this way the bank was retained until the excavation was made to water level. The foundation piles were then driven in the usual manner, and afterward an inner row of short sheet piles were driven around the excavation to permit it to be carried down to the cut-off, after which the pier was constructed. The special advantage secured by this system was the avoiding of any horizontal braces to retain the embankment slope, which would have seriously obstructed the operations of the pile-driver.

Piers 15 and 18 were excavated to a total depth of about 35 feet to the surface of the



Mingo Bridge: End View of Sand and Gravel Storage Bins; Side View of Storage Bins and Concrete Mixer.

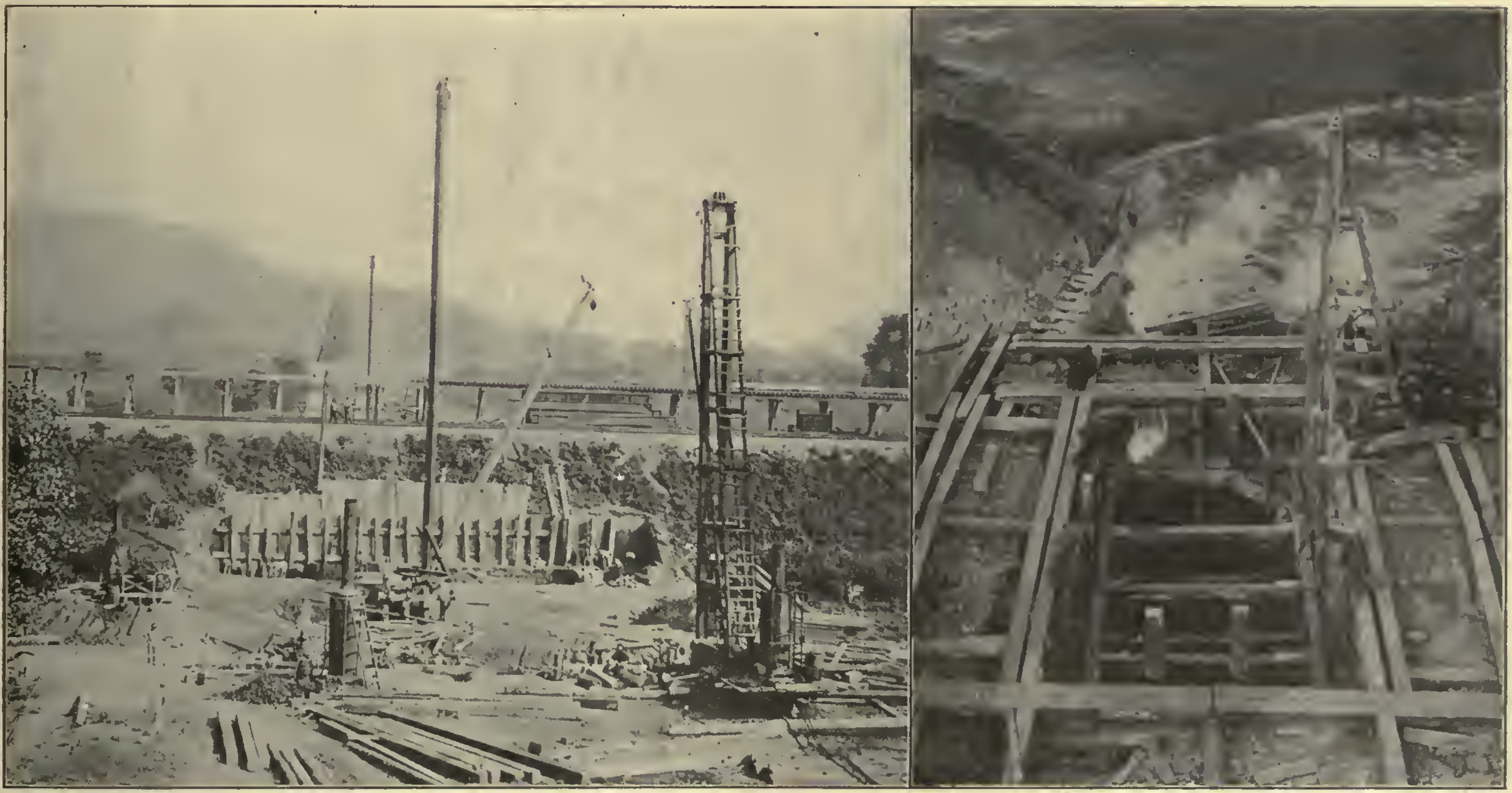
rock. The excavation was carried through 15 feet of hard yellow clay, below which the clay was mixed with more or less gravel and saturated with water. The excavation was commenced with 3x12-inch square-edge sheet piles driven in the usual way between inside and outside rangers. These were driven by hand and each of the three lower tiers of rangers were braced with three transverse struts and kneebraces in the corners. The excavation was 42 feet long and 22 feet wide on top inside of the sheeting. The clay was dry and hard and would stand well for a few days after being exposed to the air, but when it had time to become saturated with moisture it commenced to shove, and in one of the pits moved the sheeting in enough to somewhat diminish the required dimensions. Therefore in these pits the inside walings were placed and braced as soon as the excavation permitted.

After the 18-foot upper tier of sheeting was driven a horizontal frame of 9x12-inch timbers was made and braced to correspond with one of the tiers of inside walings, but had its outside dimensions 18 inches less than the inside dimensions of the waling tier in position. The braces were then removed from the waling tier and the new framework was set concentric with it in the same plane so as to leave a clearance of 9 inches between the timbers of the old and the new framework. This operation was repeated for each of the three interior waling frames which supported the faces of the 3x12-inch sheet piles. Then 9x12-inch splined sheet piles 18 feet long, with lower ends bevelled, were set in this 9-inch space between the frames resting on the bottom of the excavation. They were driven as required by a special 2,300-pound hammer sliding on the face of a light pair of leads, which moved around the pit on the timber track shown in the illustration, and was operated by a skeleton double-drum hoisting engine supplied with steam from the power plant.

As the excavation was continued the piles were driven so as to keep them just below the bottom of the pit. A follower was used which cleared the inner and outer timbers, except at the points opposite the transverse braces, where another full-size section of sheet piling was used instead of a follower, and remained permanently in position to transmit the pressure from the earth to the cross strut. By this means the sheeting was successfully carried down to the deep-lying rock under heavy outside pressure and was sustained at the bottom of the pit by 12x12-inch waling timbers 4 feet apart vertically. The pit was drained by two Cameron pumps, with 5-inch suction and 4-inch discharge pipes. The excavation was made in about two weeks. Four pedestals 8½ feet square at the base were also carried down to a depth of 35 feet under similar conditions by the same process. As each one of these pedestals contained only 100 yards of concrete, which was paid for at the regular unit prices, it was not probable that the contractor secured an undue profit for that portion of the work.

The end view of the storage-bins was taken from the cement end and shows the concrete mixer underneath, with the track on which the measuring cars were operated projecting from the tower in the foreground. The mixer was located near Pier 5, so as to be as close as practicable to the river portion of the bridge and convenient for a cement track. It was supported over a cut which carried the contractor's service track under the six lines of the Wheeling & Lake Erie Railroad and thus enabled his operations to be continuous, without any interruption from the train service. The tracks extended beyond the concrete plant to the dock and in the other direction connected with the track alongside the piers.

(To be continued.)



Mingo Bridge: Excavation and Sheeting for Pier Nine; Lowering Interior Bracing Frames for Sheeting at Pier Fifteen.

An Atmospheric Steam Surface Condenser built by Mr. A. Borsig, Tegel, near Berlin, for the municipal abattoir of Berlin, consists of 3,550 feet of brass tubes of 1¾ inches internal and 1⅞ inches external diameter. It is regarded as capable of dealing with 13,000 pounds of steam per hour in average atmospheric conditions at all seasons. The pump for the cooling water is 10 13/16x15¾ inches in size.

Standard Specifications for Cement.

At the convention of the American Society for Testing Materials held last week, the committee on standard specifications for cement presented a report embodying its recommendations for such requirements. The committee consists of Prof. George F. Swain, chairman; George S. Webster, vice-chairman; Richard L. Humphrey, secretary; Booth, Garrett & Blair, C. W. Boynton, Thos. J. Brady, Capt. Spencer Cosby, L. Henry Dumary, A. F. Gerstell, Edward M. Hagar, W. H. Harding, Lathbury & Spackman, Robert W. Lesley, F. H. Lewis, John B. Lober, Andreas Lundteigen, Charles F. McKenna, W. W. Maclay, Charles A. Matcham, Spencer B. Newberry, Prof. J. M. Porter, Prof. Joseph T. Richards, Clifford Richardson, L. C. Sabin, H. J. Seaman and S. S. Voorhees. Mr. Alfred Noble was a member of the committee until a few days before the convention, when he resigned. A glance at these names will show how well the leading purchasers, testing laboratories and manufacturers were represented on the committee. The specifications were not approved by four members of the committee and there was some opposition to them at the convention, as stated elsewhere in this issue, but they were finally ordered sent out to letter ballot for approval. They read as follows:

General Conditions.—All cement shall be inspected.

Cement may be inspected either at the place of manufacture or on the work.

In order to allow ample time for inspecting and testing, the cement should be stored in a suitable weather-tight building having the floor properly blocked or raised from the ground.

The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment.

Every facility shall be provided by the contractor and a period of at least twelve days allowed for the inspection and necessary tests.

Cement shall be delivered in suitable packages with the brand and name of manufacturer plainly marked thereon.

A bag of cement shall contain 94 pounds of cement net. Each barrel of Portland cement shall contain 4 bags, and each barrel of natural cement shall contain 3 bags of the above net weight.

Cement failing to meet the seven-day requirements may be held awaiting the results of the twenty-eight day tests before rejection.

All tests shall be made in accordance with the methods proposed by the Committee on Uniform Tests of Cement of the American Society of Civil Engineers, presented to the Society January 21, 1903, and amended January 20, 1904, with all subsequent amendments thereto.

The acceptance or rejection shall be based on the following requirements:

NATURAL CEMENT.

Definition.—This term shall be applied to the finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off the carbonic acid gas.

Specific Gravity.—The specific gravity of the cement thoroughly dried at 100 deg. C., shall be not less than 2.8.

Fineness.—It shall leave by weight a residue of not more than 10 per cent. on the No. 100, and 30 per cent. on the No. 200 sieve.

Time of Setting.—It shall develop initial set in not less than ten minutes, and hard set in not less than thirty minutes, nor more than three hours.

Tensile Strength.—The minimum requirements for tensile strength for briquettes one inch square in cross section shall be within the following limits, and shall show no retrogression in strength within the periods specified:

Neat Cement.

Age.	Strength Lbs.
24 hours in moist air	50—100
7 days (1 day in air, 6 days in water)	100—200
28 days (1 day in air, 27 days in water)	200—300
One part cement, three parts standard sand.	
7 days (1 day in air, 6 days in water)	25— 75
28 days (1 day in air, 27 days in water)	75—150

Constancy of Volume.—Pats of neat cement about three inches in diameter, one-half inch thick at center, tapering to a thin edge, shall be kept in moist air for a period of twenty-four hours.

(a) A pat is then kept in air at normal temperature.

(b) Another is kept in water maintained as near 70 deg. F. as practicable.

These pats are observed at intervals for at least 28 days, and, to satisfactorily pass the tests, should remain firm and hard and show no signs of distortion, checking, cracking or disintegrating.

PORTLAND CEMENT.

Definition.—This term is applied to the finely pulverized product resulting from the calcination to incipient fusion of an intimate mixture of properly proportioned argillaceous and calcareous materials, and to which no addition greater than 3 per cent. has been made subsequent to calcination.

Specific Gravity.—The specific gravity of the cement, thoroughly dried at 100 deg. C., shall be not less than 3.10.

Fineness.—It shall leave by weight a residue of not more than eight per cent. on the No. 100, and not more than twenty-five per cent. on the No. 200 sieve.

Time of Setting.—It shall develop initial set in not less than thirty minutes, but must develop hard set in not less than one hour, nor more than ten hours.

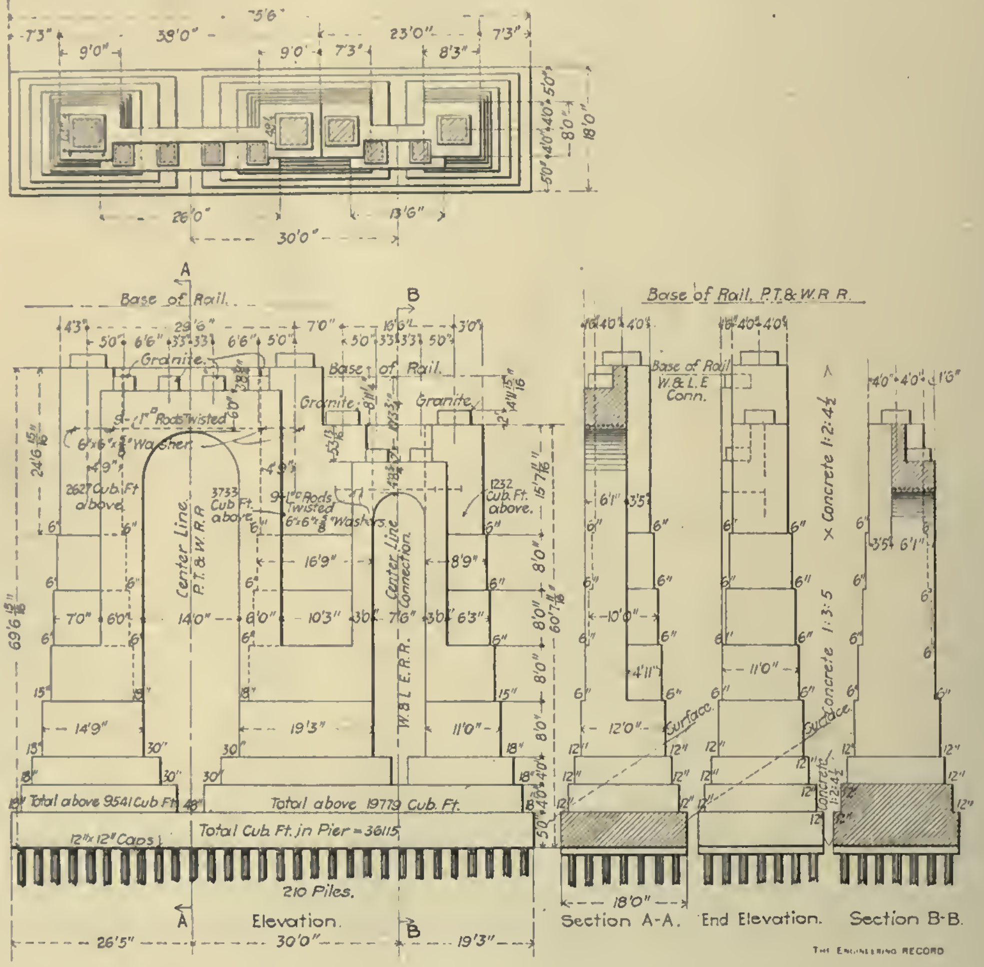
Tensile Strength.—The minimum requirements for tensile strength for briquettes one inch square in section shall be within the following limits, and shall show no retrogression in strength within the periods specified:

Neat Cement.

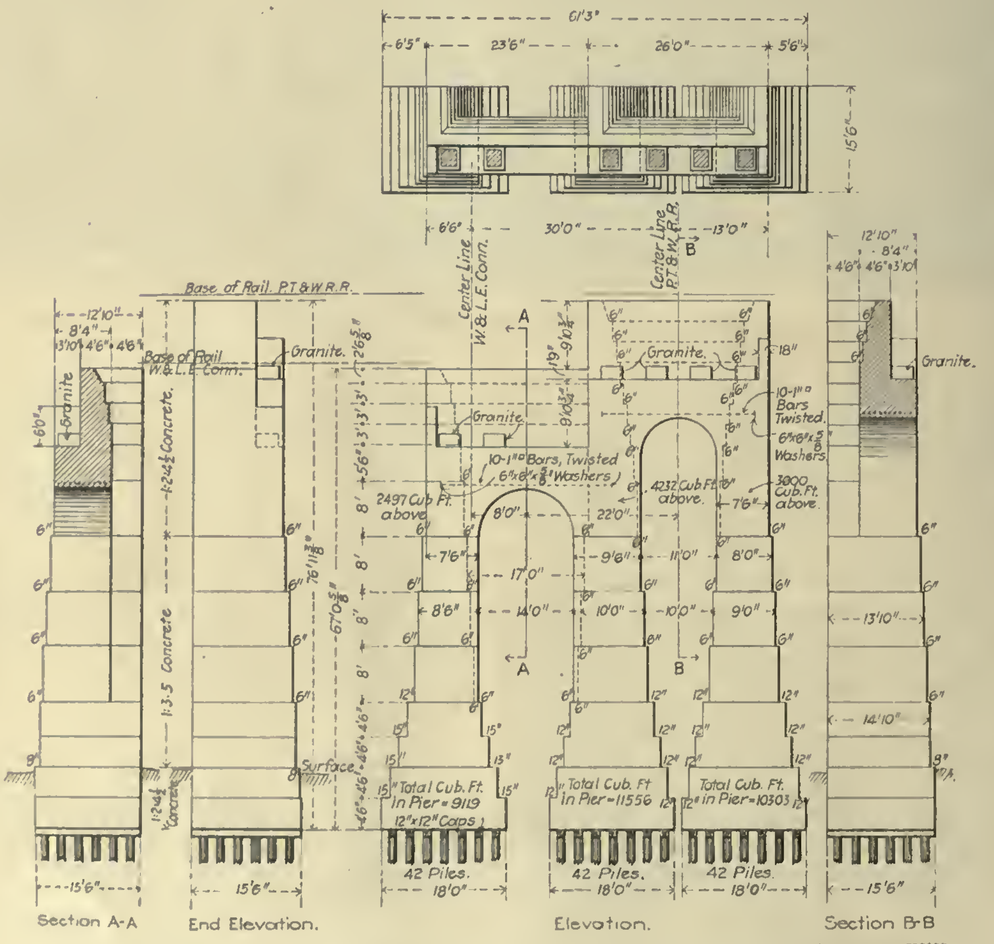
Age.	Strength Lbs.
24 hours in moist air	150—200
7 days (1 day in air, 6 days in water)	450—550
28 days (1 day in air, 27 days in water)	550—650
One part cement, three parts sand.	
7 days (1 day in moist air, 6 days in water)	150—200
28 days (1 day in moist air, 27 days in water)	200—300

Constancy of Volume.—Pats of neat cement about three inches in diameter, one-half inch thick at center, and tapering to a thin edge, shall be kept in moist air for a period of twenty-four hours.

(a) A pat is then kept in air at normal temperature and observed at intervals for at least 28 days.



Pier 9



Pier 10.

Mingo Bridge: Offset Shafts and Arch Tops of Monolithic Concrete Piers.

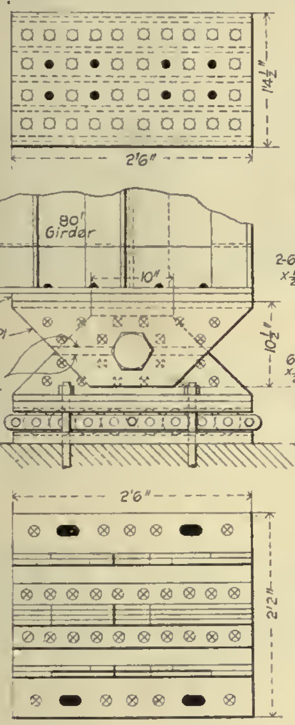
(b) Another pat is kept in water maintained as near 70 deg. F. as practicable, and observed at intervals for at least 28 days.

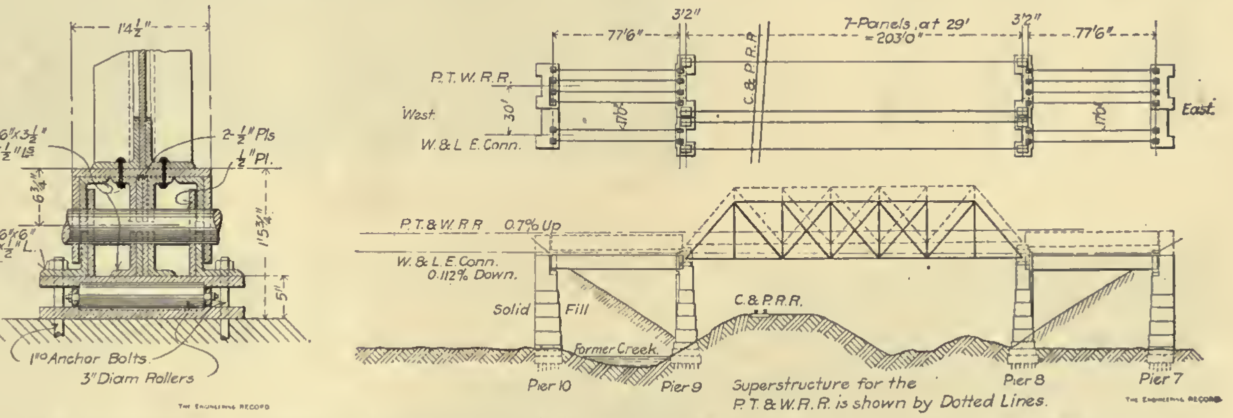
(c) A third pat is exposed in any convenient way in an atmosphere of steam, above boiling water, in a loosely closed vessel for five hours.

These pats, to satisfactorily pass the requirements, shall remain firm and hard and show no signs of distortion, checking, cracking or disintegration.

Sulphuric Acid and Magnesia.—The cement shall not contain more than 1.75 per cent. of anhydrous sulphuric acid (SO_3), nor more than 4 per cent. of magnesia (MgO).

A COAL STORE IN SOLID ROCK has been completed at Gibraltar for the British Government by Graham, Morton & Company, Leeds, Eng. It is hewn out of the rock so as to be bombproof, and, owing to the location of the operating engine and boiler houses under rock, the latter are maintained under an air pressure to secure ventilation. The bottom of the receiving hopper into which the coal is delivered by a mechanical conveying plant consists of a hinged door controlled by a lever and balance weight. When there is sufficient coal in the hopper to overcome the balance, the door automatically opens, immediately closing after the coal is discharged and so avoiding the escape of air.





Mingo Bridge: Truss and Plate-Girder Spans and Expansion Bearing for Overhead Crossing.

AN EARTH DAM 90 feet high above the bed of the stream is being built for the city of Tynemouth, England. The embankment across the valley will be 1,100 feet long and it will have two arms, which will run out to 1,500 feet. The foundation trench, which has been excavated for a length of 1,300 feet to an average depth of 30 feet below the ground surface, will be filled with concrete, and above the surface the dam is to have a puddled clay core. The width of the base of the dam is 600 feet. The reservoir will have a maximum depth of 80 feet and a capacity of about 850,000,000 gallons. According to the "Surveyor," in order to allow of the work being carried on it was necessary to divert the stream through a tunnel 15 feet in diameter and 650 feet long. This tunnel is lined with iron, and has a concrete and brick invert. When the reservoir is completed the tunnel will be used for the purpose of carrying off the overflow and the compensation water which must be allowed to flow through the stream.

The Woodsville Railroad and Highway Bridge.

The new Woodsville bridge carries a single track of the Boston & Maine Railroad and a highway across the Connecticut River between the villages of Woodsville, N. H., and Wells River, Vt. It crosses the channel at a narrow point with a single 239-foot span, and is interesting on account of its details, because it is the sixth structure which has been built at this point, and because it was the first single-span bridge over the Connecticut River. The first charter was granted in 1803 to the Wells River Bridge Company, which erected the first bridge on trestles in the year 1805. It was built by Mr. Avery Sanders for a contract price of $2,700, and was destroyed by a flood in 1807. It was replaced the same year with a similar structure, which stood for seven years and was washed out by a flood in 1812. Much of the timber was saved, but it was not rebuilt until 1820 or 1821, when it was reconstructed at a cost of $2,585.61, and endured until 1850, when it was again destroyed by a flood. The fourth bridge was built in 1851 with timber trusses and wooden piers, and was soon sold to the Boston, Concord & Montreal Railroad, which replaced it by a wooden bridge of the Burr truss type, which remained in service until it was removed in December, 1903, to make room for the present steel-truss bridge.

The fifth bridge was built with two decks and was intended for highway traffic on the lower deck and for railroad traffic on the upper deck, which was covered by a pitched wooden roof. It was operated for 50 years for railroad service and as a toll bridge, the major part of the stock being owned by the railroad company. Mr. Cyrus Latham was the engineer and Mr. Warren H. Smith was the contractor. The original cost was about $20,000, including the cost of land and approaches. It was built of selected, old-growth white pine, hauled to the site by six-horse teams from Whitefield, 32 miles away. It appears that the builders were not exempt from the troubles that attend similar work now. An item in the resident engineer's diary records that on November 30, 1852, seventy-five men from a rival railroad took possession of the work on the west side of the bridge, but were finally driven off about midnight and did not reappear, although two or three hundred workmen were collected to resist them the next day.

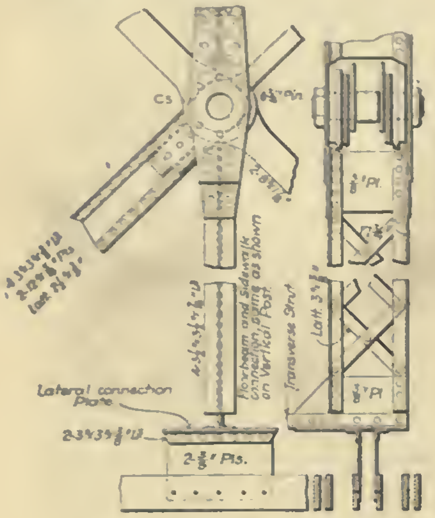
The span built in 1852 had two wooden Burr trusses about 238 feet long and 24 feet deep over all, and 19 feet 4 inches apart on centers. They supported a highway floor on the lower chord timbers and were covered by a shingle roof. Each chord was made with two pairs of horizontal timbers bolted together side by side without fillers between the two centerpieces. There was, however, clearance left between the center and outer pieces, which were framed to receive the 9x15-inch vertical members. In combination with the trusses there was a single wooden arch rib on each face of each truss. These ribs had a clear span of 231 feet 3 inches and a rise of 30 feet 9 inches for the intrados. The cross-section was 10 inches wide and 37 inches deep, and the ribs were built up of planks bolted together flatways.

In 1868 the bridge was repaired and strengthened by the addition of vertical rods to relieve the strain on the timber verticals and to tie the arches and trusses together more effectively. In 1886 the bridge was further reinforced by the addition of a single timber arch on the inside of each truss. These arches had a cross-section 12 inches wide and 69 inches deep, with a rise of about 28 feet 6 inches for the intrados. Vertical suspension rods through them had nut bearings at both ends and at the bottom carried horizontal transverse timbers, affording additional support to the lower chords of the trusses at two intermediate points of each panel. The addition of these arches reduced the clear width of the roadway to 12 feet 4 inches, and made it too dark and narrow for safety. When the bridge was removed in 1903 the timber was sound and showed no signs of decay, except at the ends of the arches.

Bridge No. 6 occupies the site of No. 5, but is seated on new granite abutments carried down to bedrock on the east side and having foundations on hard earth on the west side. It has a 239-foot 2-inch center-to-center pin-connected span and two overhead plate-girder approach spans, as shown in the general elevation, which is symmetrical about the center line, except that the girder span not shown is about 52 feet long. It is built to the standard specifications of the Boston & Maine Railroad, and carries a single track on the upper deck and a highway and one cantilever sidewalk about 9 feet above the lower chord level. The Pratt trusses have subdivided panels with vertical struts and suspenders to support the intermediate floorbeams. The top lateral system has X-braces of single and double 6x3½-inch and 5x3½-inch and 3½x3½-inch angles in every panel between floorbeams. The ends of the diagonals are field-riveted to horizontal plates which engage connection angles on the floorbeam webs, and have Z-shaped connections to the lower flanges of the top chords. The lower lateral system consists of single 3-inch X-brace angles field-riveted to horizontal plates, which are connected to the floorbeam webs and to the vertical posts. In both upper and lower lateral systems the vertical flanges of the angles are turned upward in one diagonal and downward in the other diagonal of the same panel, so that the two members clear each other and are field-riveted to horizontal connection plates at their intersection.

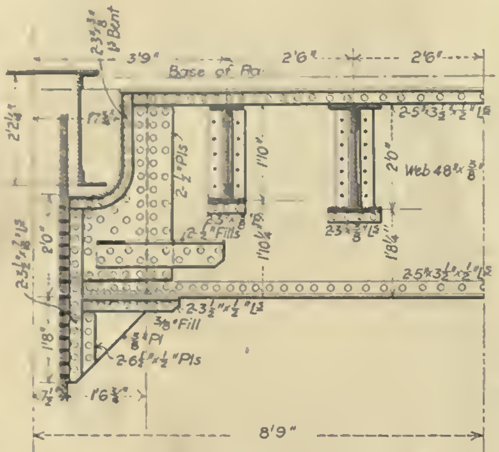
There are no sway-brace diagonals, but transverse rigidity is secured by solid-web knee-braces to the vertical posts at the lower flanges of the upper floorbeams.

The top chord is made with a center web, except in the two end panels. It is spliced about 2 feet from each main panel point and the joints are covered by top and bottom flange plates 33 inches long and by vertical web plates 6½ inches wide, all of which are field-riveted to both ends of the chords. At the ends of the span the chords are connected to the vertical posts with miter joints and ½-inch clearance. The main vertical posts are pin-connected to



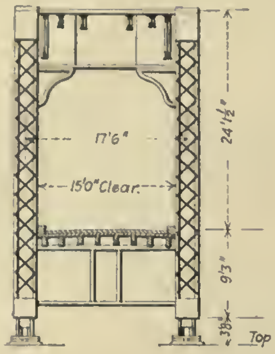
Foot of Sub-Vertical.

The Engineering Record

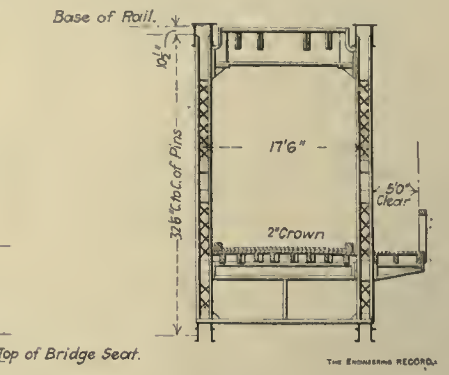


Upper Floorbeam at Main Panel Points.

The Engineering Record

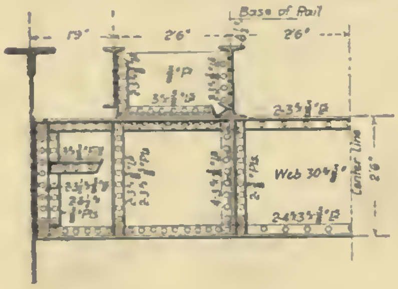


End Elevation, Truss Span.

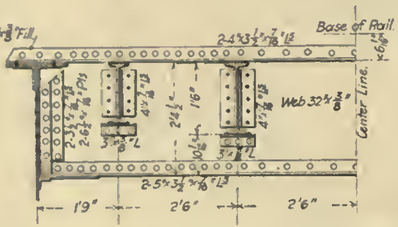


Cross-Section, Truss Span.

The Engineering Record



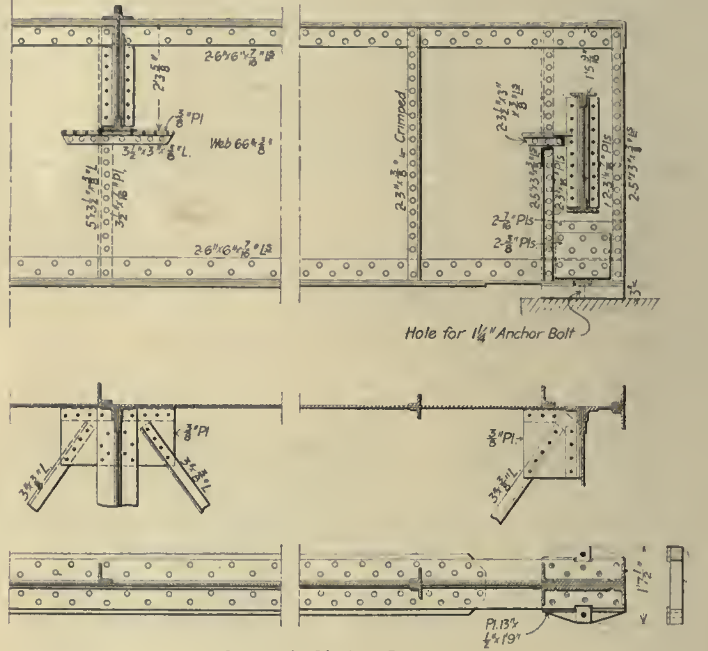
End Floorbeam



Intermediate Floorbeam

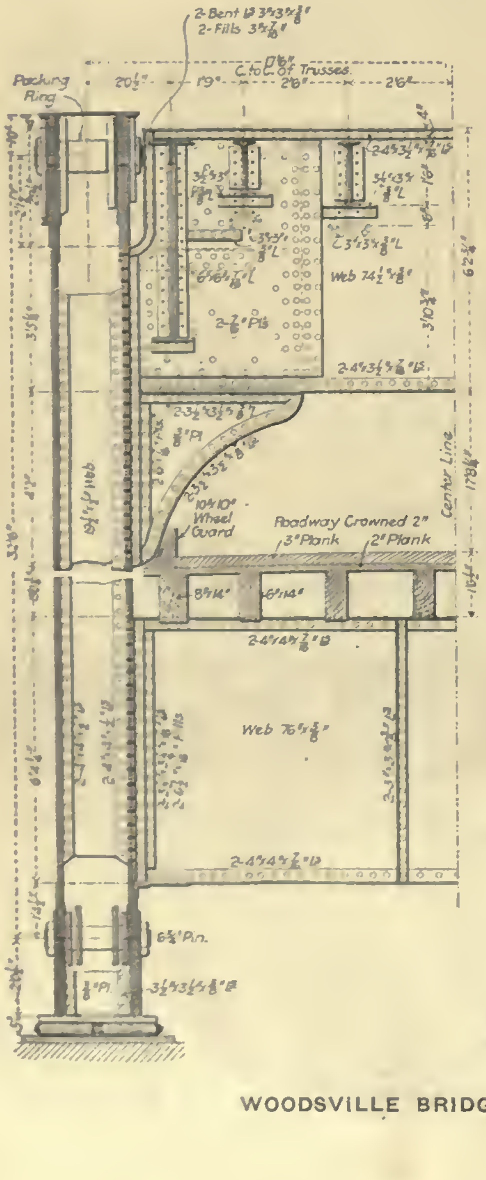
52-Foot Girder Span.

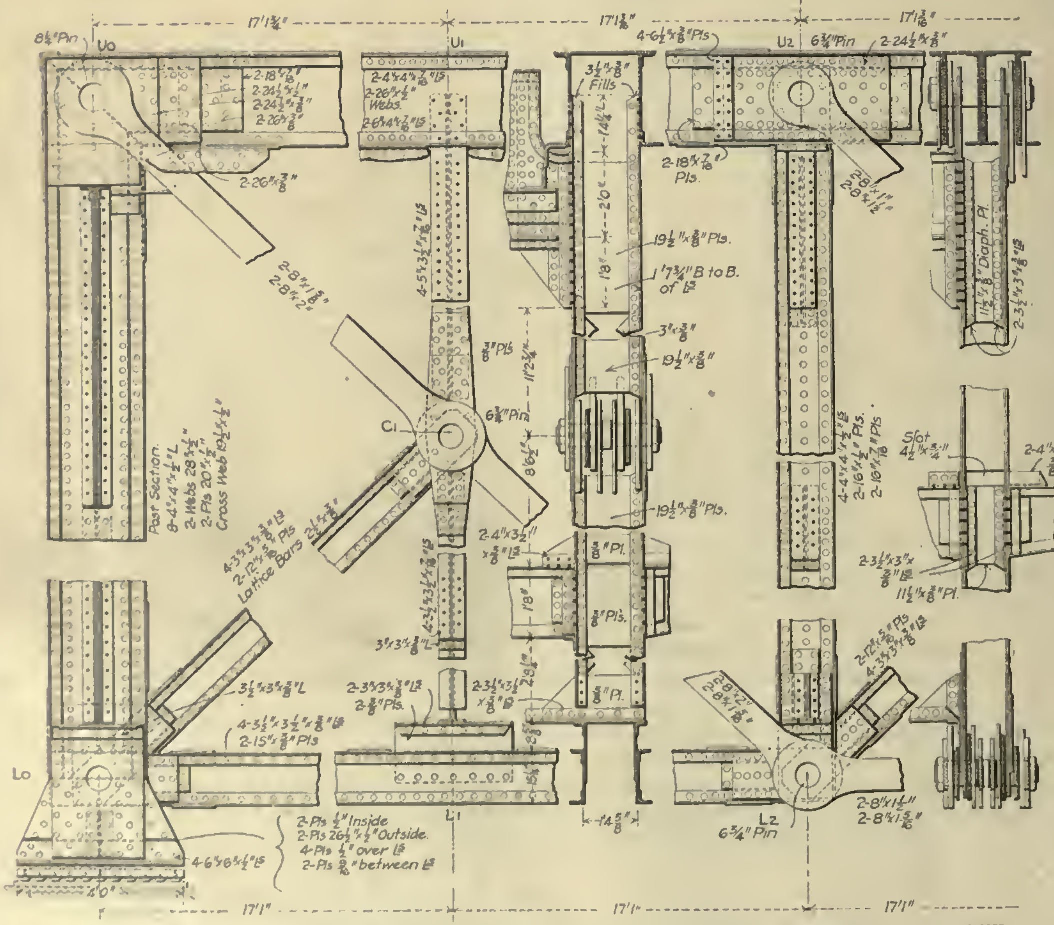
The Engineering Record



52-Foot Girder Span.

The Engineering Record



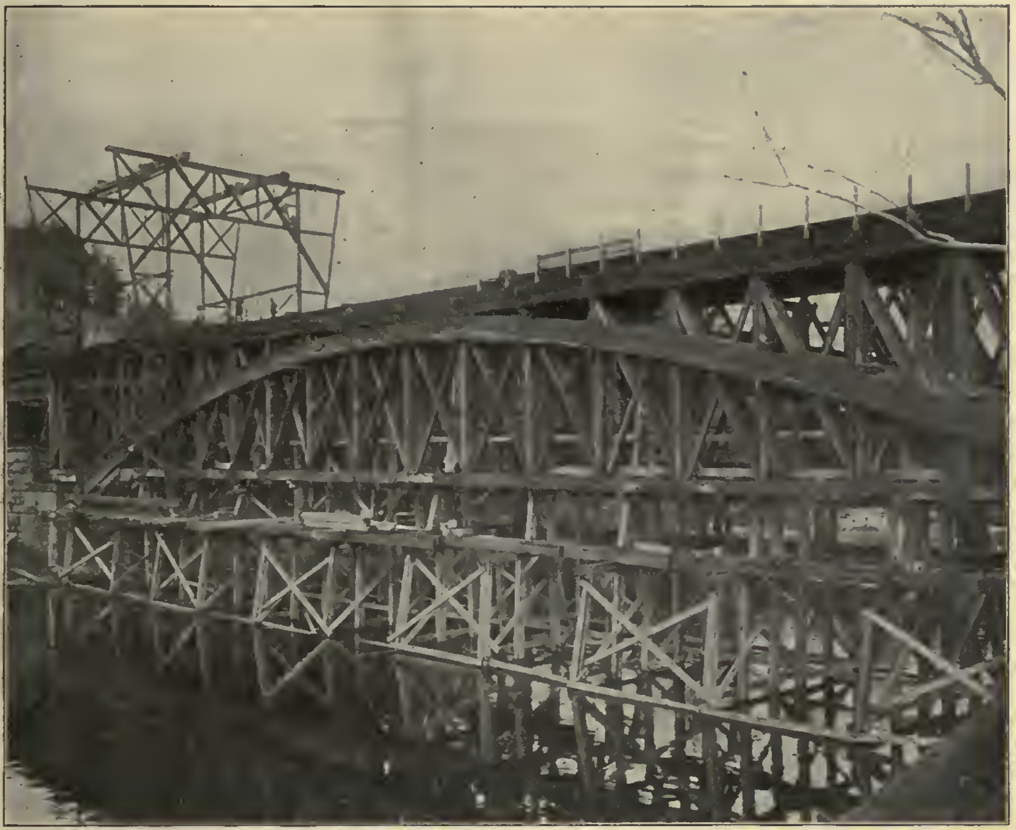


The Engineering Record

WOODSVILLE BRIDGE: DETAILS OF MAIN TRUSSES, FLOORBEAMS AND GIRDER SPAN.

both chords and the sub-verticals are field-riveted to the top chords.

The sub-verticals are continuous members, reaching across the full depth of the trusses and pin-connected to the diagonals at their intersections. The upper part of the member is made heavier than the lower part, because the load on the railroad floorbeam which it supports is much greater than that on the highway floorbeam which is supported by the lower part. Both ends have I-shaped cross-sections made with pairs of angles back to back, latticed together. At the upper end the angle flanges are field-riveted to the top chord webs. At the lower end there are horizontal flange angles field-riveted across the tops of the longitudinal horizontal flange angles, shop-riveted to gusset plates connected to the webs of the stiff end panels of bottom chords. The lower ends of the other sub-verticals are riveted to gussets, which are connected by a single line of rivets to the center pair of eye-bars of the bottom chord.

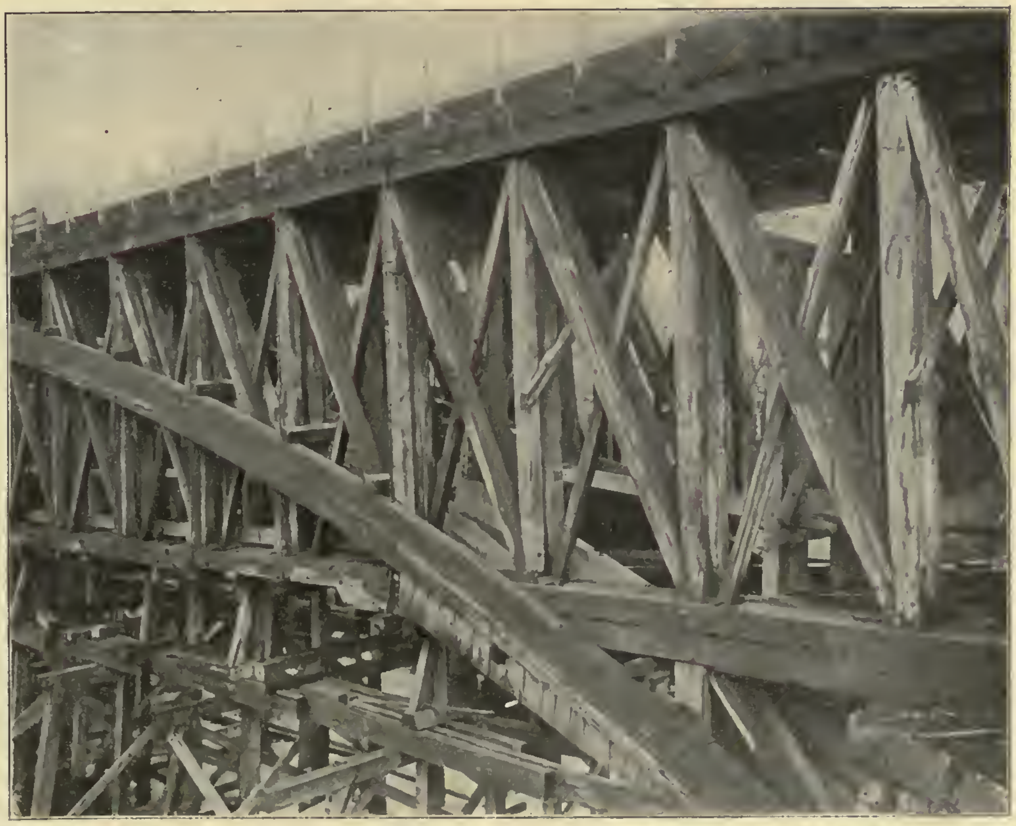


Woodsville Bridge: View of Old Span with Traveler and Falsework.

The intermediate top floorbeams are 48-inch plate-girders with short end sections of the web projecting beyond the lower flanges to afford sufficient length for connection to the vertical posts, as indicated in the detail at the main panel point. The connection at the sub-panel point is similar, except that the field rivets to the sub-vertical are shorter than those to the main vertical. The web splice is made with double cover-plates, which extend to the end of the floorbeam and reinforce it at the point of maximum shear. The upper ends of the floorbeam webs are notched to clear the chord pins and are stiffened by neatly curved flange angles.

The highway floorbeams are 20-inch plate-girders, which are web-connected to the vertical and sub-vertical posts, with their flanges about 8 feet above the center line of the bottom chord. They carry wooden longitudinal joists, which are dapped over the top flanges, so as to give the required crown to the wooden floor. Transverse angle struts connecting the bottom chords at panel points are supported in the center by vertical suspension angles from the middles of the floorbeams.

The 5-foot sidewalk, which is carried on one side of the bridge, is supported by solid-web cantilever brackets field-riveted to the vertical posts and sub-verticals. The upper flanges of these brackets are spliced to those of the floorbeams by horizontal transverse plates in vertical planes, which engage pairs of connection angles field-riveted to the floorbeam and cantilever flanges. At the cantilever end, these angles are shop-riveted to the splice plate, but at the other end all of their rivets are field-driven. Both vertical posts and sub-verticals are stiffened by transverse diaphragms at the floorbeam connection. The outer edge of the sidewalk is protected by a wooden fence with vertical posts bolted to short vertical angles projecting above the upper flanges of the cantilever brackets, and stayed by bolts through the outer line of longitudinal joists.



Details of Wooden Arch and Truss after Nearly Fifty Years' Service.

The end floorbeams for both the upper and lower roadways are similar to the intermediate floorbeams of the respective systems, except that they are made very much deeper, so as to act as transverse girders supporting the river ends of the longitudinal girders in the approach span. The upper floorbeams also serve as portals and their ends are connected to deep kneebrace brackets. The two lines of main railroad stringers have a 24x7/16-inch web and pairs of 6x6x½-inch flange angles. They are connected to the floorbeams by fourteen ⅞-inch rivets through the vertical flange angles at each end. The outside stringers are made with a 22x5/16-inch web and 3½x3½x⅜-inch flange angles, and have ten rivets in each floorbeam connection. None of the stringers have vertical web-stiffener angles, and all of them are, for convenience of erection, seated on horizontal bracket angles.

The end lower chord pins have half-hole bearings in the webs of both the vertical posts and shoes, between which there is ½ inch clearance. The inside pin plates of the vertical posts and the outside pin plates of the shoes project to form jaw-plates and have full holes which lock the members together. The shoe webs are connected by a transverse diaphragm, and are extended to a length of 4 feet at their connection to the 1-inch base plate 2 feet 10½ inches wide, which is seated at the expansion end on a nest of eleven 4-inch rollers. The rollers are supported on a cast-iron pedestal 13 inches high, which is exactly similar to that shown for the fixed end bearing, except in its height, which is made less to allow for the thickness of the roller bed, and that it has a longitudinal rib to engage the groove in the rollers, while the fixed end pedestals have a transverse groove to engage the projecting strip which is riveted across the base plate of the shoe, and serves to center the pedestal during erection. Both pedestals have their upper surfaces planed and are secured to the masonry by four 1-inch anchor bolts.

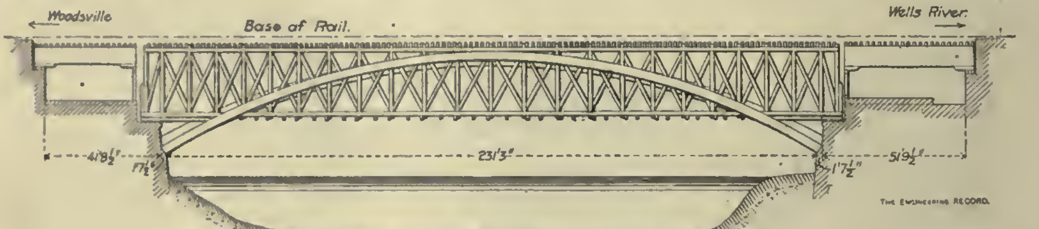
The approach span, which is shown in the general elevation, corresponds to the one at the opposite end of the bridge, except in the dimensions and materials for the girders. The 41½-foot span has a 56-inch web and 6x6x⅝-inch flange angles with a single 14-inch cover-plate on each flange. The 52-foot span has a 66-inch web plate and 6x6x7/16-inch flange angles, with two 15-inch cover-plates on both flanges. At the river end of the span the girders are web-connected to the end floorbeams of the channel span. At the shore end they are seated on bed-plates bolted to the abutment masonry. At this end there is a ½-inch sole-plate countersunk-riveted to the lower flange with a 4½x1-inch notch in the center of each longitudinal edge to clear the guide lugs on the cast bed-plates and allow for temperature movements.

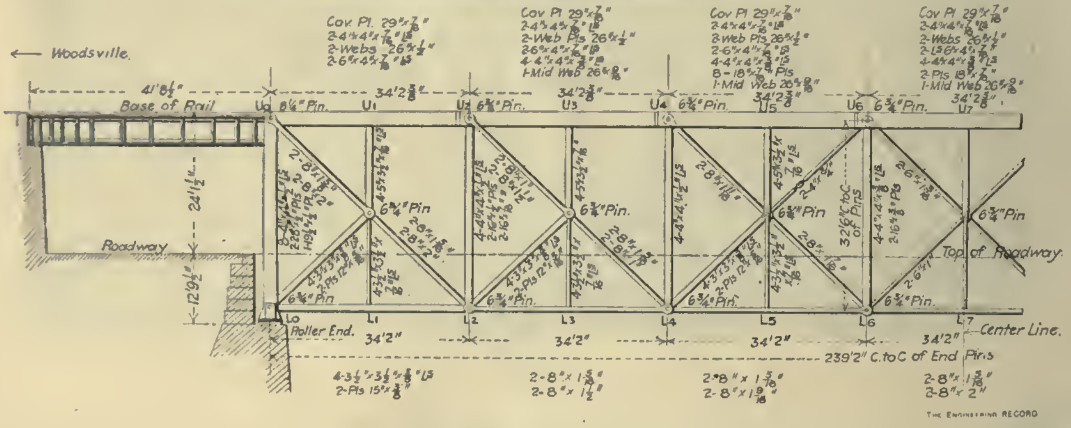
In both spans the girders are spaced 14 feet apart on centers and are divided into 10-foot 2½-inch main panels by the 32-inch floorbeams, which are web-connected to them. The shore-end floorbeams are set lower than the intermediate floorbeams, so as to support the main stringers directly on their top flanges. The intermediate floorbeams are web-connected to both main and side stringers, and have the upper corners of their webs cut to clear the top flanges of the main girders, to which they are field-riveted through the vertical end connection flanges. The top flange angles are reversed so that their horizontal legs are down and engage the cover-plates of the top flanges of the main girders, to which they are field-riveted. The main and side stringers are respectively 18-inch 60-pound and 15-inch 42-pound I-beams corresponding to those in the channel span. Their top flanges are flush with the top flange angles of the main girders, so that the thickness of the track ties carries the rails clear of the top flanges of the floorbeams. The ends of the intermediate floorbeams are seated on, and field-riveted to, horizontal angles which are shop-riveted to the main girder webs and afford connection for the horizontal gusset plates, which are also field-riveted to the bottom flanges of the floorbeams and receive the ends of the 3x3-inch X-brace lateral angles. At the shore end of the span these lateral angles have horizontal connection plates riveted to the webs of both floorbeams and main girders.

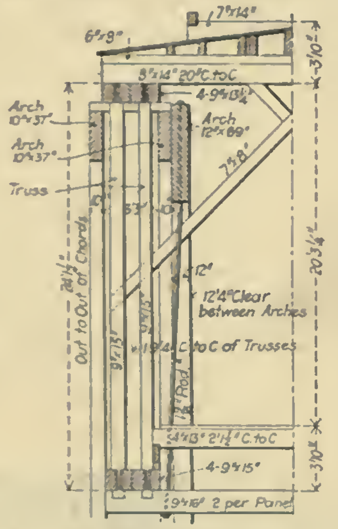
The track ties are covered with 2-inch longitudinal planks laid with tight joints to form a roof over the roadway and protect it from dripping oil, water, etc. A gas-pipe hand rail is carried along one side of the upper deck and provides a safe foot walk on the top chord of the channel span (which is flush with the top of the 2-inch plank mentioned above), and the projecting ties of the approach spans, for the yardmen while attending to the large amount of shifting which is done over the bridge. The vertical posts for this hand rail are 4x3-inch angles with one flange riveted to horizontal angle clips field-riveted to the top and bottom flanges of the top chord. In the girder spans the angle posts have a single horizontal flange angle at the foot, which is bolted to an extended cross-tie, the extremity of which receives a kneebrace angle riveted to the top of the fence post.

The railroad track is 45 feet above water level, and the depth of the water is from 22 to 40 feet. A frame-trestle falsework was built, on which the old bridge was supported during removal, as shown by the accompanying half-tone. The old structure was taken down by an ordinary timber traveler, which moved on a single rail outside of each truss, and was afterward used in the ordinary manner for the erection of the steelwork.

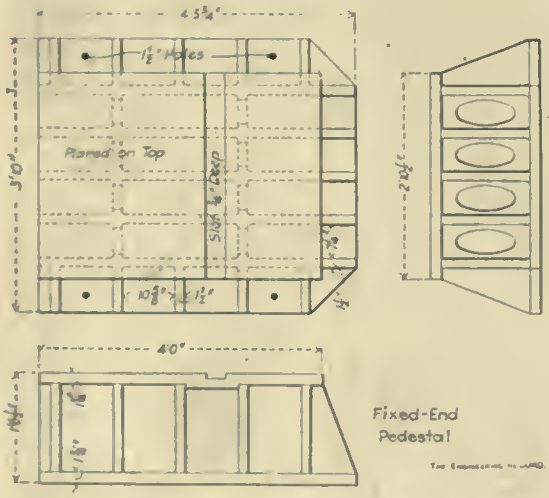
The bridge was designed and its construction directed by the Engineering Department of the Boston & Maine Railroad, Mr. H. Bissell, chief engineer, and Mr. J. P. Snow, bridge engineer. Mr. John W. Storrs, assistant engineer, was in charge of erection and inspection. The American Bridge Company was the contractor for the superstructure, and Messrs. Ellis & Buswell, of Woburn, Mass., were the contractors for the substructure.



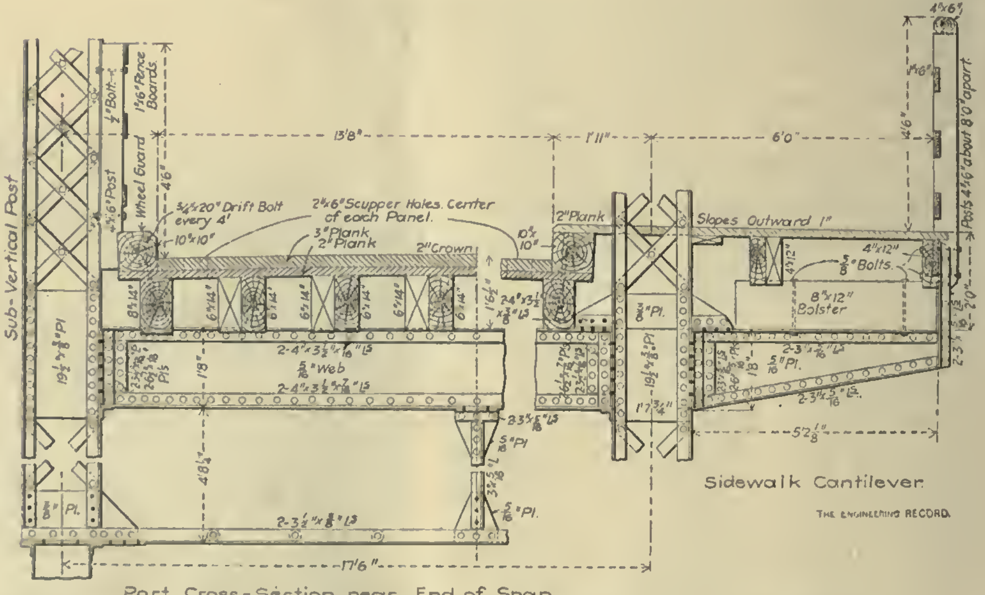




Half Cross-Section of Main Span. Old Bridge.



Fixed-End Pedestal



Port Cross-Section near End of Span.

Woodsville Bridge: General Elevation of Old and New Bridges and Details of Floor Construction and Truss Pedestal.

The International Exhibition at Liege, 1905, has allotted some 300,000 square feet of space to the department of engines, boilers, gas-producers and railway rolling stock. Of this 199,507 square feet has been apportioned to Belgium, 45,531 to Germany, 40,580 to France, 6,996 to Great Britain and 5,650 to the United States. The total area is said to be 9 per cent. more than that devoted to the corresponding sections in the Düsseldorf Exhibition of 1902. Exhibitors are to be charged $1.10 per square foot for rental.

The Quittacas Pumping Station and Other Features of the New Bedford Water Works.

New Bedford is a manufacturing city with a population of about 72,000, situated in the extreme southeasterly part of Massachusetts, on Buzzards Bay. The construction of a waterworks system was commenced in 1866 and completed in 1869. Water was introduced November 26, 1869. The source of this supply was a storage reservoir artificially formed by constructing a dam across the valley of the Acushnet River, at a point seven miles north of the center of the city. The area of the watershed tributary to this reservoir is 3,300 acres; the area of the water surface of the reservoir is 300 acres, and the capacity of the reservoir is 400,000,000 gallons. The water flows by gravity from this reservoir through a 3x4 foot oval brick conduit 5⅝ miles, to a receiving reservoir of 3,000,000 gallons capacity, in the city. A pumping plant, known as the Purchase Street pumping station, is near this receiving reservoir, and from this point the water was pumped to the Mt. Pleasant distributing reservoir, which has a capacity of 15,000,000 gallons, and is at an elevation of 154 feet above tide water. From this last named reservoir the water was distributed by gravity throughout the city previous to July 10, 1899. The capacity of the storage reservoir was augmented by a connection with Little Quittacas Pond, made in 1886. This connection was discontinued in 1899, when Little Quittacas Pond was made a part of the new system, then established to meet the urgent need for a better water supply.

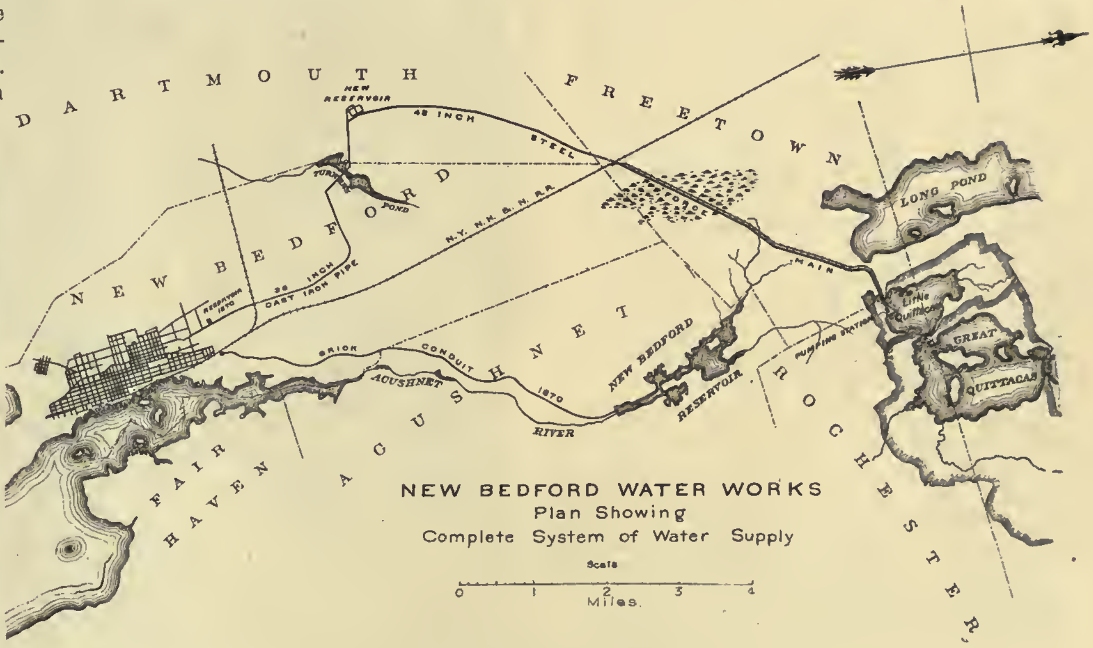
Gatehouse, High Hill Reservoir.

There were so many defects in the old system that after a long study as to the feasibility of patching it up, it was decided to begin anew. The new supply was obtained by the development of the watersheds of Little and Great Quittacas ponds, eleven miles north of the center of the city. Besides these ponds the new works include a pumping station of 20,000,000 gallons daily capacity on the shore of Little Quittacas Pond, a 48-inch steel force-main 8¼ miles long, leading to High Hill distributing reservoir, which has a capacity of 67,000,000 gallons, and a 36-inch cast-iron distribution main, leading to the city, 3⅗ miles in length. Both old and new systems of supply are shown on the accompanying map, which also indicates their locations with respect to the city. Incidentally it may be stated that the old system above described, was totally abandoned with the introduction of the new supply in 1899. It is, however, held in readiness for a quick start at the Purchase Street pumping station in case of emergency, as for example, a break in the single line of pipe leading from the new distributing reservoir to the city.

Little Quittacas watershed has an area of 1.4 square mile and that of Great Quittacas is 11.4 square miles, making a combined area of 12.8 square miles for the gathering ground of the new supply. The supply appears now to be ample for at least 10,000,000 to 12,000,000 gallons per day, through the dryest season. Whenever the increase in the demand causes a shortage, the storage can be increased by raising the level of the ponds at least two feet.

The two ponds have an available storage capacity of 4,050,000,000 gallons above the invert of the conduit conveying water to the new pumping station, and the water is of satisfactory quality, although subject at times to some of the failings as to taste and odor which afflict, in various degrees, all surface water supplies. For 1903 the average daily consumption of the city was 6,946,000 gallons, or 96 gallons per capita, all of which had to be pumped, since the water surface of the ponds is not high enough to furnish a suitable pressure even in the low areas of the city. Some meters are used, 19.7 per cent. of the services being metered.

No available satisfactory site for a new distributing reservoir was to be found nearer than High Hill, about five miles from the center of the city, and eight miles from the site selected for the new pumping station at Little Quittacas Pond. On the top of this hill a reservoir of two basins, formed partly by excavation and partly by embankment, having a capacity of 67,000,000 gallons, was built, so that its water surface, when full, would be 166 feet above the level of Little Quittacas Pond, and afford a pressure on the distribution pipe system ranging from 93 pounds along the water front, to about 25 pounds on the hilltop. This reservoir is lined with concrete 6 inches deep on the horizontal portions, and 9 inches thick on the inside slopes. The embankment has proved to be an exceedingly sound, tight embankment. The new distributing reservoir's being located 62 feet higher than the former distribution level, forever takes care of the high-service supply, which was a very important item.



NEW BEDFORD WATER WORKS
Plan Showing
Complete System of Water Supply

The locations chosen for the distributing reservoir and the pumping station necessitated a long force main. It has a length of 8¼ miles, is 48 inches in diameter, and was made of 5/16-inch steel plates riveted. It is coated with asphalt applied at a temperature of 300 degrees Fahrenheit, this part of the work being very carefully inspected, and the pipe safely protected from abrasion during transportation and laying. After five years of use, the pipe line was thoroughly examined inside, and at some points on the outside, and the coating was found in almost perfect condition; it is believed to be in excellent condition now, after the expiration of nearly seven years. To aid in the construction of this pipe line and the pumping station, a branch railroad about 4¾ miles long was laid along the line from the tracks of the New Bedford division of the New York, New Haven & Hartford Railroad, crossed by the pipe, and since that time this spur track has been maintained for the purpose of conveying coal and other supplies to the pumping station. The new supply main from High Hill reservoir to the city, is 36 inches in diameter and 3⅗ miles long; it passes the Mount Pleasant distributing reservoir, constructed in 1869, and is connected to it by a pipe in which there is a check valve, ordinarily held shut by the pressure in the new main, because the new reservoir is 62 feet higher than the old. There is a 36-inch by-pass around High Hill reservoir connecting the force main with the new supply main.

The new pumping station is attractively situated and surrounded by neatly kept grounds. Its architectural style and general appearance are well shown by an accompanying view, and one of the drawings shows its arrangement in plan, with the important dimensions of the various rooms. The station really consists of three connected buildings, the engine house, the boiler house and the coal shed, having exterior walls of brick, faced with native granite, and steeply pitched roofs, with steel trusses and 2-inch sheathing covered with black slate. In the engine room are two 10,000,000 gallon pumping engines, the steam for which is generated in two circular fire-box boilers, while in the boiler house there is room for a third boiler. The coal shed has a capacity for 1,000 tons. The chimney is of brick, 143 feet high above the ground, and 136 feet above the bottom of the flue entrance from the boiler, with a flue 5 feet in diameter; its construction is indicated by an accompanying drawing. The exterior face bricks are speckled gray, harmonizing with the granite.

In the angle between the engine house and the boiler house there is a two-story portion of the station, providing on the first floor, a machine shop for light repair work, and in the upper story, a room for the Water Board, an engineer's office and a bathroom. The floor of the machine shop is 4½ feet above that of the basement beneath the engine room, while the floors of the offices are 7 feet above the main floor of the engine room. At the middle of the southwest side of the engine house a 12x17-foot conservatory was built, and is kept filled with flowers and plants.

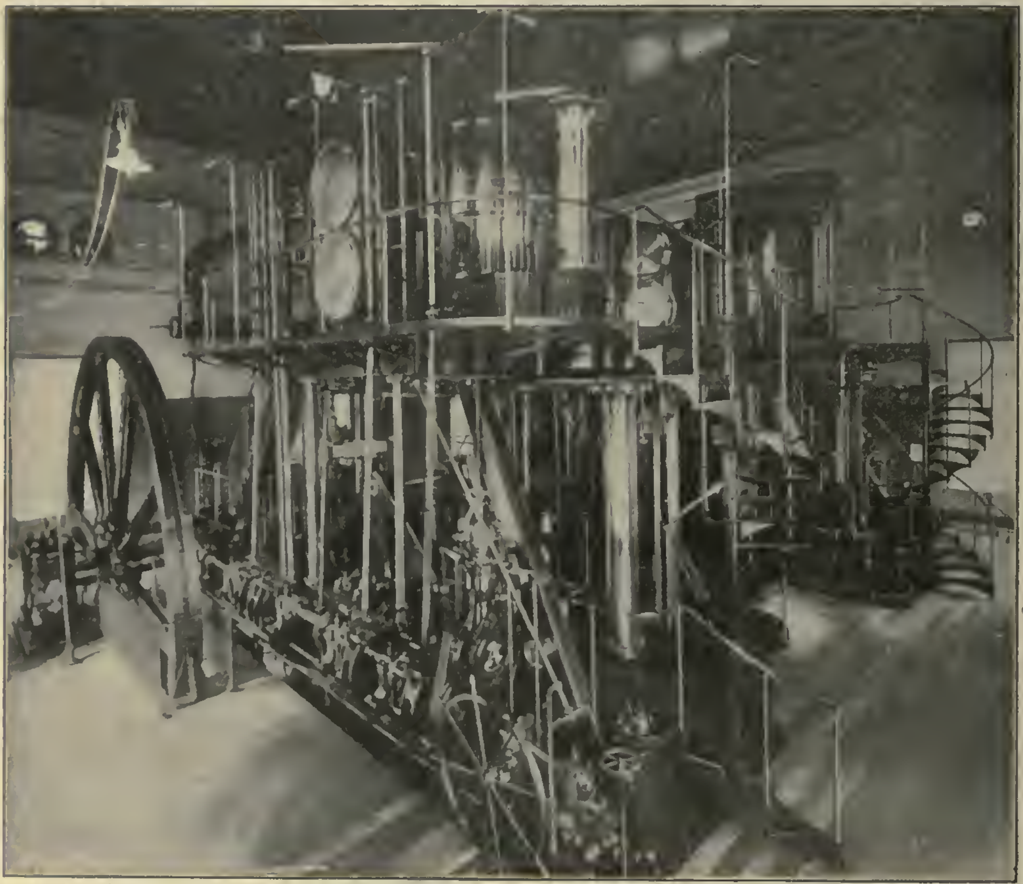
The floors of the boiler house and coal shed are at the same level, being 5 feet above the engine room basement floor, and 4 feet below the main engine room floor. Hence coal can be wheeled directly from the shed to the front of the boilers, which are fired by hand. As indicated by the plan, the relative positions of the coal shed and the boiler room are such that there is a straight path from the coal pile to the furnaces. On the way the coal car passes over the platform of a Fairbank's scale in a weighing room which forms a vestibule between the boiler room and the coal shed, with two sliding doors. In one corner of this 14x9-foot weighing room is a flight of stairs leading up to the loft. The weighing room partition is continued across the coal shed, forming a 14x25-foot store room for general storage, opposite the weighing room.

Coal is brought into the shed in coal cars on an elevated track, carried at the level of the eaves on a steel trestle, and is dumped on to the concrete floor. For taking the coal to the boilers a hand car, built from drawings made by the superintendent of the water works, is used. No track is required for this car. Pocahontas and George's Creek Cumberland coal is used for the most part, and costs on the average about $5.75 per gross ton delivered in the shed.

The two boilers are of a circular fire-box type, of special design. One was built by the I. P. Morris Company, of Philadelphia, and the other by the Atlantic Works, of East Boston, Mass. Each boiler is 31 feet 7¾ inches long and 9 feet in diameter; each has 152 3-inch tubes, and a heating surface of 2,031 square feet in area. The regular steam pressure is 185 pounds per square inch. The water supply for the boilers is taken from the force main, and passes through a Gleaner feed-water heater, in which the temperature of the feed-water is raised to about 150 degrees Fahrenheit previous to passing through the feed pumps, the heat being furnished by the exhaust steam from the feed and air pumps and the lighting engine, and from the drips from the throttle, separator and high pressure steam chest. The boilers are connected to a 6-inch header, from which a 10-inch steam main 75 feet long leads directly into the engine room. A 6-inch connection supplies each engine through a 5-inch inlet nozzle. An accompanying view shows one of these boilers on the skids, as it was being put into the station.

The two engines, designated as A and B, are of the well-known Leavitt compound beam-and-flywheel type, each operating two differential plunger pumps, and are shown in the interior view of the engine room. These engines were built by the Dickson Manufacturing Company, of Scranton, Pa., and are duplicates, being arranged as rights and lefts, but so geared that the cam shaft turns in the same direction on both engines. The steam cylinders are vertical and inverted, the pistons of the high and low-pressure cylinders being connected to opposite ends of the beam. The steam cylinders are 16⅜ and 36¼ inches in diameter; the differential pump plungers each have diameters of 13.7 and 19⅜ inches. The strokes of both engine and pump are 90 inches. The flywheels are 25 feet in diameter. The pedestals for the main beam-pin and the main pedestals for the crank-shaft are formed in the engine bed-plate, and are in the same horizontal plane. There is a separate outboard pedestal for the crank-shaft journal beyond the flywheel.

Each engine bed-plate is supported on four massive cast-iron columns resting on heavy masonry piers at the ends of the pump pit. The cylinders rest upon a cast-iron entablature carried on twelve columns, four of which are of cast-iron, arranged in pairs, the two columns of each pair being connected together to form the guides for one crosshead, four of which are diagonal cast-iron struts, and the remaining four of which are polished steel. There is a gallery all around each engine at the base of the cylinders, also one at the top of the bed-plate, and platforms for access to the indicators and other parts. There is a spiral stairway at the low-pressure end of each engine, and a straight stairway at the high-pressure end. The galleries of the two engines are connected by a bridge.


Interior of Engine Room, Quittacas Pumping Station, New Bedford.

Steam distribution is effected by gridiron valves operated by cams on a horizontal shaft in the same horizontal plane as the crank-shaft, and driven by the latter through miter gears. The exhaust from the top of the high-pressure cylinder enters a tubular reheater having steam of boiler pressure inside the tubes. Thence it passes to the upper inlet valve chest of the low-pressure cylinder. Similarly the exhaust from the bottom of the high-pressure cylinder passes through another heater on its way to the bottom inlet valve chest of the low-pressure cylinder. The main exhaust pipe is 12 inches in diameter. The cylinders are thoroughly jacketed all over, on heads and barrels, with steam at boiler pressure. All heated surfaces are thoroughly protected from radiation by magnesia coverings. The cylinders, side pipes and reheaters, with their connecting pipes and nozzles, are covered with a neat lagging of iron and black walnut. An independent jet condenser with single-acting horizontal air pumps, built by the George F. Blake Manufacturing Company, is connected with each engine. The drips from all the jackets are returned to the boiler by gravity, while the drips from the working side of the receivers and the low-pressure steam chest are wasted. The steam used by the air pump passes through all the jackets in succession. The boiler feed pump and the lighting engine are supplied from the main steam pipe.

The pumps are located beneath the engine bed-plate, so that the two plungers are in line with the two steam piston rods and connected to the steel crossheads. The high-pressure piston with its connected pump plunger makes its upward stroke at the same time that the low-pressure piston and its plunger are making their downward stroke, and vice versa. The two pumps connected with each engine are in a pit between the two large brick masonry piers supporting the ends of the engine bed-plate, and rest upon granite capstones on concrete foundations.

Each pump consists, as usual, of three principal sections, the lower, or suction chamber, a middle chamber containing the suction valves, and the upper chamber, forming an air vessel and containing the delivery valves. The 30-inch suction main enters the lower chamber of the pump worked by the low-pressure piston, and the water passes thence to the lower chamber of the high-pressure pump. Connected with the latter are two large suction air vessels, and the upper part of each lower chamber is so constructed as to form additional suction air vessels. The pump worked by the low-pressure piston discharges into the delivery chamber of the pump worked by the high-pressure piston, from which the water enters the force main. The plungers of each pump work through two stuffing boxes. The upper plunger passes through an outside stuffing box, and the lower plunger through a stuffing box at the upper valve deck, provided with a long sleeve.

The normal speed of each engine is 32 revolutions per minute, and at this speed each actually delivers over the weir, at High Hill reservoir, very nearly 10,230,000 gallons in twenty-four hours. The theoretical plunger displacement is 229.74 gallons per revolution, or 10,586,880 gallons in twenty-four hours. As the result of weir measurements the actual delivery is assumed at 222 gallons per revolution. This quantity corresponds to an allowance of 3.37 per cent.

for slip of the pumps, and leakage from the pipe line.

A hand traveling crane of 61 feet 10 inches span, and ten tons capacity, built by William Sellers & Company, of Philadelphia, was installed in the engine room as early as feasible, and used in the erection of the pumps and engines.

From the lower chamber of each low-pressure pump a suction main leads through the foundation masonry, beneath the engine into a pump well 43 feet 11 inches x 10 feet, 13 feet deep. This well has a concrete bottom 2 feet 9 inches thick, and brick and stone masonry walls 3½ feet thick at the top and 4½ feet thick at the bottom, the brickwork being laid in Portland cement mortar. Water is brought into this well from the adjacent pond through a brick conduit 451 feet long, having a horseshoe-shaped cross-section 5 feet wide and 5 feet high.

Engine House and Coal Shed of the Quittacas Pumping Station.

The average static head on the pumps is about 167 feet, and the dynamic head, when the engines are running, is nearly 188 feet. During the year 1903, the average duty of engine A was 125,217,470, and of engine B 132,270,870 foot-pounds per 100 pounds of total coal burned. This duty is based on the total coal used in the building for all purposes, including that for banking fires, starting, heating, shop engine by day, and electric light engine by night, with no deductions for ashes, moisture or anything else. Engine A was run 102 days during the winter, and engine B 212 days in the spring, summer and fall. With coal at $5.14 per ton of 2,000 pounds, the cost per million gallons of water pumped into the reservoir was $6.20, and the cost per million gallons raised one foot high was 3.30 cents. The station is operated about 19 hours per day, usually, with a force of seven men.

The various rooms and the machinery are illuminated by means of incandescent electric lights, the current for which is generated by a 100-light Edison dynamo driven by an Ideal engine, installed in the machine shop.

A complete 24-hour test was made on April 9 and 10, 1903, of engine B and the boiler built by the I. P. Morris Company. It was conducted by Messrs. S. R. Bartlett and P. J. Kearney, of the graduating class of the Massachusetts Institute of Technology, and the work was done under the general supervision of Professor Edward F. Miller of the Institute. The results of this test were embodied in a graduating thesis, and are included in the annual report of the superintendent of the waterworks, which has just been published.

The following arrangements were made for the test: The pipe ordinarily conveying the feed water to the heater was disconnected and led to a weighing tank in the boiler room. This tank discharged into another provided with a hook gauge so that the water level could be brought to its original height as often as desired. An auxiliary pump taking its steam from an auxiliary boiler was used to put the water from the tank into the heater. The regular feed pump supplied the boiler as usual. The water taken from the heater to operate the damper regulator was discharged into a barrel and weighed. The steam used by the air pump was determined in a preliminary run of two hours by condensing it alone in the heater and weighing. During the test, the exhaust from both the air and the feed pumps was passed through the heater and weighed, thus determining the steam used by the feed pumps, assuming the exhaust from the air pump to be constant. The lighting engine was supplied with steam from an auxiliary boiler, and the exhaust wasted.

One of the Boilers for the Quittacas Pumping Station.

The drips from the throttle, separator and the high-pressure steam chest, which ordinarily passed through the heater, were collected in a barrel and weighed. The drips from all the jackets, ordinarily returned to the boiler by gravity, were collected during the test in a closed steel reservoir about 15 inches in diameter and 5 feet tall, thoroughly lagged. On the side of this tank was a long gauge glass and a scale, previously graduated, giving the capacity of the reservoir at any level to 1/100 of a cubic foot. The pressure in the tank quickly emptied it when the discharge valve was opened. The heat lost by wasting these drips during the test, was determined, and an allowance made in calculating the amount of coal used had they been returned to the boiler. The drips from the low-pressure steam chest and the working side of the reheaters were collected in a barrel on scales.

A throttling calorimeter with a ¼-inch steam orifice was attached to the steam pipe just before the throttle. A record was kept of the time during which the calorimeter was in use, and the amount of steam used by it was calculated by Napier's formula.

The height of water in the suction well was read by means of a float and a graduated brass rod. The delivery pressure was measured by an open leg mercury column graduated in pounds per square inch, connected to the air chamber of the pump.

Samples of flue gas were taken in flue just over the boiler used. A sample of coal was taken from each lot weighed, and kept in the coal pocket until the end of the test, when this pile was thoroughly mixed and quartered, and a sample taken. This was analyzed and the heat of combustion determined by the chemical department of the institute.

A preliminary run was made on April 9 to determine the amount of water pumped over the weir per revolution, and the leakage in the 8-mile force main.

A running start and stop were made, care being exercised to have the condition of the fire and the levels of the water in the boiler and in the jacket-drip tank the same at the end as at the beginning. Cards from both ends of the steam cylinders and from the central chambers of the pumps, together with readings of pressures, temperatures, revolutions, etc., were taken at the stroke of a gong every fifteen minutes. At the end of each hour the coal was weighed back and the level in the feed water tank brought back to the hook gauge. There were nine observers. The steam gauges were tested with sealed weights before being used, and the thermometers had been previously calibrated. The steam used by the jackets was calculated from the amount caught in 20 hours in the reservoir. The principal results of these boiler and engine trials are given in tabular form herewith:

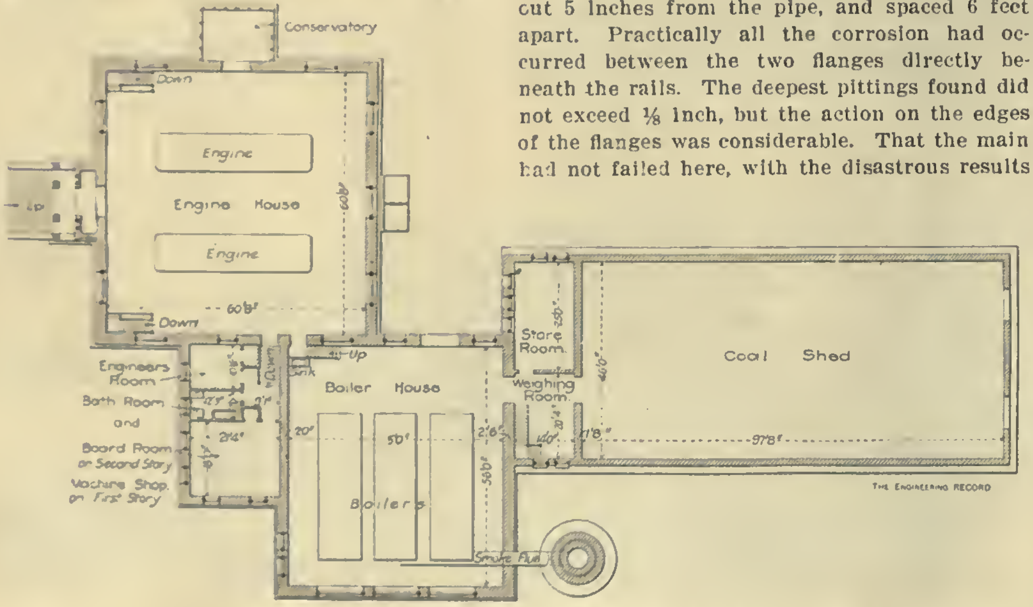
Boiler Test Results.

Quality of steam at throttle	0.985
Total feed water put into boilers (24 hours). lbs.	114,808
B. T. U. put into same	123,640,000
Total returns from jackets, lbs.	15,397
B. T. U. put into same	13,083,000
Total coal burned, lbs.	12,331
B. T. U. taken up by water per lb. coal burned	10,027
Excess coal burned during test because of not returning jacket drips, lbs.	458
Equivalent evaporation per lb. of coal from and at 212 deg. F., lbs.	10.38
Equivalent evaporation from and at 212 deg. F. per lb. dry combustible, lbs.	11.73
Coal per sq. ft. of grate per hour, lbs.	12.23
Max. assumed possible error of test, per cent.	2.73
Air per lb. coal from analysis of flue gases, lbs.	24.5
Air per lb. coal Formula $12\,C + 36\left(H - \frac{O}{8}\right)$ lbs.	10.6

Excess air supplied, per cent	131
Heat carried off by flue gases, per cent	14
Heat lost by radiation, per cent	16.8
Thermal efficiency of boiler plant, per cent	69.2
Boiler H.-P. developed (A. S. M. E. rating)	154.69

Engine Test Results.

	H. E.	C. E.	
Total revolutions in 24 hours			46,101
Revolutions per minute			32.01
Total H.-P. of H steam cylinder	75.55	75.60	151.15
Total H.-P. of L steam cylinder	98.44	92.05	190.49
Total			341.64
Total H.-P. of pump opposite H cylinder			162.8
Total H.-P. of pump opposite L cylinder			162.2
Total			325.0
Steam through cylinders in 24 hours, lbs.			88,585
Total steam from jackets of cylinders and reheaters, lbs.			21,793
Total steam from jackets of cylinders and reheaters not counting the steam drawn from jackets by air pump, lbs.			15,397
Total lbs. of steam for engines and jackets, counting steam used by air pump, lbs.			110,378
Total lbs. of steam for engines and jackets, not counting steam used by air pump, lbs.			103,982
Lbs. steam, counting air pump steam, per horse-power for steam cylinders per hour, lbs.			13.46
Lbs. steam, not counting air pump steam, per horse-power for steam cylinders per hour, lbs.			12.68
Steam required by plant for 24 hours, excepting steam used by jackets and returned, lbs.			98,393
B. T. U. required for the above			105,960,000
Temperature of jacket returns entering boiler, deg. F.			363.4
Total B. T. U. required by plant in 24 hours			119,043,000
Coal required for 24 hours, lbs.			11,873
Cubic feet of water pumped in 24 hours			1,375,810
Weight of 1 cu. ft. of water at 53 deg. F., lbs.			62.4
Capacity of pump in gallons per 24 hours at speed of 32.01 revolutions per minute (calculated from weir), gals.			10,292,000
Displacement of pump plungers in cu. ft. in 24 hours			1,415,800
Resistance overcome expressed in feet of water, ft.			185.15
Foot-lbs. of work done in 24 hours			15,895,000,000
Duty (foot-lbs. of water work done for 100 lbs. coal)			133,880,000
Duty (foot-lbs. of water work done per 100 lbs. dry coal)			139,900,000
Duty (foot-lbs. of water work done per 1,000,000 B. T. U.)			150,010,000
Duty (foot-lbs. of water work done per 100 lbs. coal from plunger displacement)			137,770,000
Coal per steam horse-power per hour, lbs.			1.343
Coal per horse-power of actual work done, lbs.			1.479
Slip, per cent			2.82
B. T. U. per horse-power per minute			223.9
Thermal efficiency of engine, per cent			18.95
Efficiency of a Carnot engine working between 181.0 lbs. gauge and 26.88 in. vacuum, per cent.			31.31
Per cent. efficiency of Carnot engine			60.52
Number of expansions			25.5



Test Data.

Kind of coal	George's Creek
Total grate area, sq. ft.	42
Total heating surface (tubes, 1,740 sq. ft.; front head, 13 sq. ft.; back head, 22 sq. ft.), sq. ft.	2,031
Lbs. of coal fired in 24 hours	12,364
Mixture from grate, lbs.	911
Good coal in mixture, lbs.	33
Total lbs. of water weighed in barrels in boiler room	120,925
Total lbs. water used for damper regulator	6,117
Average temperature of room, deg. F.	70.8
Average temperature of outside air, deg. F.	51
Average temperature of flue, deg. F.	425
Average temperature of feed water at weighing barrels, deg. F.	53.7
Average temperature of feed water after passing through heater (at boiler), deg. F.	140
Average pressure at throttle gauge, lbs.	181.0
Average draught pressure (inches of water)	0.674
Barometer (inches of mercury eq. 30.12)	14.79
Pressure at starting test, lbs.	183.0
Pressure at stopping test, lbs.	182.5
Chemical analysis of coal:	
H_2O	4.3
S + O + N	5.4
C	79.9
H	3.5
Ash	6.9
Heat of combustion of coal, B. T. U. per lb.	14,517
Flue gas analysis:	
CO_2	7.18
CO	0.17
O_2	12.34
N_2	80.31
Weight of drip from L. P. jacket (24 hours), lbs.	704
Weight of drip from separator and H. P. steam chest, lbs.	269
Steam used by feed pump and air pump, lbs.	9,539
Steam used by calorimeter, lbs.	1,018
Average temperature of engine room, deg F.	82
Average temperature of exhaust steam, deg. F.	121.2
Average temperature of condensed steam leaving heater, deg. F.	69.0
Average temperature of upper receiver, deg. F.	347.9
Average temperature of lower receiver, deg. F.	267.4
Vacuum in condenser (inches of mercury)	26.88
Pressure in upper receiver (gauge)	20.0
Pressure in lower receiver (gauge)	23.7
Discharge pressure in lbs. per sq. in.	76.09
Feet of water to 1 lb. pressure	2.308

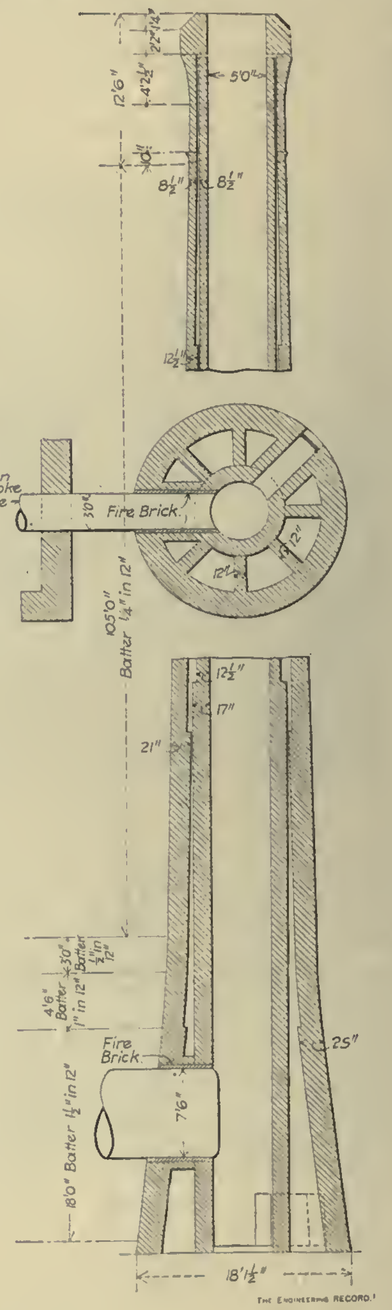
Steam cards: High—M. E. P., H. E. 48.66, C. E. 51.70; low—H. E. 13.11, C. E. 12.41. Average per cent. cut-off, 20.2; 18.2.

Water cards: M. E. P., high, 75.9; low, 75.6.

Mr. R. C. P. Coggeshall has been superintendent of the New Bedford waterworks for twenty-three years, and the works above described were constructed under his general supervision. Messrs. George S. Rice and George E. Evans, of Boston, were the designing and consulting engineers, and had immediate charge of the work. The pumping engines and the boilers were designed by Dr. E. D. Leavitt, of Cambridgeport, Mass. Mr. Charles D. Austin, of Boston, was the architect for the pumping station.

Electrolysis of the water mains in various parts of the city has been suspected for some time, and so Mr. A. A. Kundson, of New York, was engaged last summer to make an electrical survey and present a report. The most serious damage by electrolytic action was discovered on the steel force main where it crosses beneath the track of the Old Colony Street Railroad Company. At this point the pipe is reinforced by three riveted flanges ⅞-inch thick, standing out 5 inches from the pipe, and spaced 6 feet apart. Practically all the corrosion had occurred between the two flanges directly beneath the rails. The deepest pittings found did not exceed ⅛ inch, but the action on the edges of the flanges was considerable. That the main had not failed here, with the disastrous results which would inevitably have followed, is attributed to two reasons: 1st. The presence of the flanges, most of the current when leaving, passing out from their upper edges to the rails. 2d. The main is not continuously positive to the rails. There are frequent reversals, and the positive readings, although reaching at times as high as 25 volts, are of short duration. To remedy this dangerous condition the railway company has carefully rebonded its tracks, and has strung an overhead return-current cable, with frequent connections to the rails, for a considerable distance either side of the threatened point. Evidences of electrolytic action were found in several places on the distribution system, but no serious cases. However, several lengths of 6-inch cast-iron ball-and-socket-joint pipe, which had been taken up from a river crossing, were found so badly softened by electrolysis near their spigot ends that nails could be easily driven into the metal. These pipes had to be condemned and new pipes substituted. The pittings and furrows were from ⅛ to ⅜ inch deep.

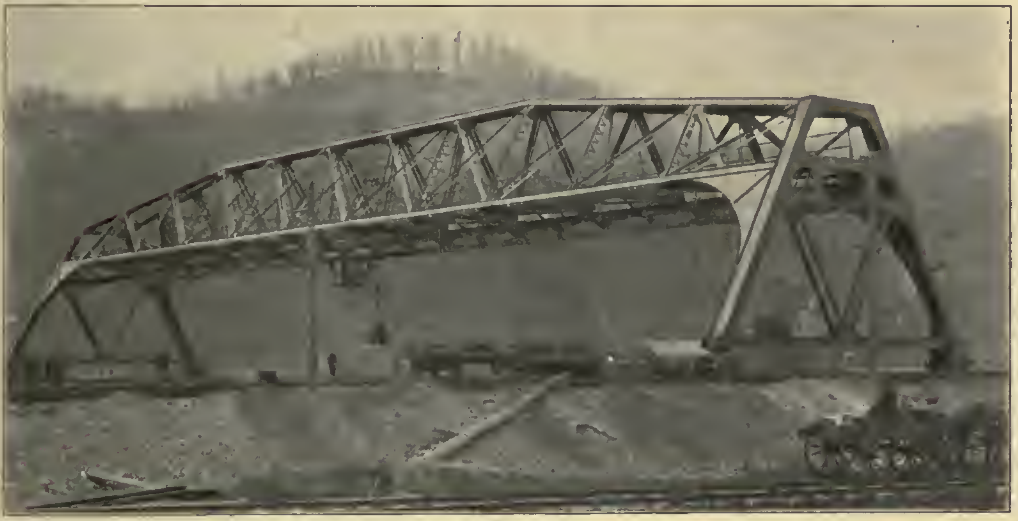
Headquarters for the maintenance force were established during the latter part of 1903 on a lot of land about 115x225 feet, on which were erected several new buildings, from plans by the superintendent. Across the rear end of the lot an 81x24 foot shed, with granolithic floor, accommodates carriages, wagons and tool houses, and has storage room on the second floor. Along one side of the lot is a second shed, 172x20 feet, with granolithic floor, for the storage of special castings and other supplies; it is provided with a conveying apparatus travelling on an overhead track and making it possible for one man to load or unload any of the castings. On the opposite side of the yard is a large space devoted to the storage of cast-iron pipes of various sizes. In the center of the yard is a two-story 160x32-foot brick shop building, with a paved driveway all around it. A portion of the building, 37 feet long, at the end farthest from the street, is a stable, and the remainder of the building contains offices, a blacksmith shop, a general workshop, a meter testing and repair room, and store rooms. Teams can be driven through the general workshop from one side of the building to the other. This new establishment is a great aid to the department in the conduct of its regular duties.



Plan of Quittacas Pumping Station, New Bedford, and Details of Chimney.

The New Structural and Car Shops of the Cambria Steel Company, Johnstown, Pa.—II.

Installation and Operation of Shops.—All shapes used in the structural shop are sheared to length in a pair of special hydraulic turret shears built by Messrs. R. D. Wood & Company, Philadelphia, Pa. These machines are located on the lines of the roller-table runs and cut the shapes in transit from the receiving end to the storage skids, thus avoiding rehandling. Their operation produces a neat square end, and as these tools can make about one cut per minute on average shapes, they are considered economical and satisfactory and have largely displaced cold saws for this work. The shear blade has a concave cutting edge arranged to engage the web of the shape a short distance each side of the center simultaneously and to shear it progressively with a minimum effort. It is directly connected to the vertical plunger, which is operated at either of three pressures, according to the sectional area to be sheared. The pressures are 900, 1,350 and 1,800 pounds per square inch, and are derived from the standard 450 pound hydraulic pressure by means of three-stage intensifiers, as shown in the engraving at the right of the shears. The same shear blade is used for several shapes and the corresponding dies are set in a large turret mounted on a horizontal shaft, which enables it to be very quickly revolved and change the die from one size to another without trouble or delay. Two turrets are required, one for beams and another for channels. Five upper blades are required to shear all beams from 3-inch to 24-inch. The machine is operated by one man besides the two helpers that set the piece to gauge, and the roller man who operates the delivery table.



Cambria Steel Works: Two-Hundred-Foot Gantry Crane in Shipping Yard.

The ordered lengths of all shapes are stored on skids in the yard east of the structural shops, where plates also are sheared to length, trimmed and stored. This distributing yard is commanded by five lines of overhead traveling cranes on transverse runways, which collect the material as required for different orders and load it on narrow-gauge cars running into the shop on longitudinal tracks. The shop is arranged for the south side to be used chiefly on beam work, and the north side for columns, girders and trusses. The progress of the materials through the shop is essentially continuous in a longitudinal direction with transverse offsets to special machines.

The location of the machine tools and their names and sizes are indicated by reference letters in the floor plan, which is given on page 803, which correspond to the same letters in the reference table at the bottom of this page.

Besides these tools, there are installed in the west end of the shop seven portable pneumatic riveting machines, two of which were made by Pedrick & Ayres, and have 30 and 42-inch throat clearance. The others are Allen machines and have throat clearances of 34, 36 and 40 inches. There are also distributed through the shops twenty-nine Yale & Towne differential chain hoists mounted on overhead longitudinal and transverse trolleys arranged to suit the work handled at the different machine tools. These include three 10-ton hoists, seven 5-ton hoists and nineteen 2-ton hoists. The heavy ones are principally used at the stationary riveting machines, and the lighter ones are used for the punches and shears, or travel on the transverse roof trusses.

Ample provision is made for storing around each machine the stock to be used in it, and great care is taken always to keep a good supply of material ready for a machine and to take it away promptly when finished. By this system the amount of material stored at each machine indicates at a glance whether proper provision is made for maintaining the work at full capacity, and stoppages or congestions are very obvious.

Materials are unloaded from the narrow-gauge track either by the 6-ton girder cranes that run in the lower chord panels of the north side roof trusses, as indicated by the dotted lines or by the 1, 3 and 6-ton pneumatic hoists which travel on the lower chords of the roof trusses. Plates and shapes are handled through the shears, punches and straightening rolls on roller tables, and are moved back and forth to the longitudinal tracks on permanent transverse skids. Single beams and light assembled members are suspended from overhead runways and are carried through stationary riveting machines; girders and other heavy members are seated on stationary skids and riveted up by movable yoke machines or by pneumatic hammers. Finished members are delivered from the west end of the shop by the longitudinal tracks, which are commanded by the 200-foot 10-ton gantry crane. This machine moves them transversely, piles them for storage and loads them on cars for shipment at any point in the yard.

The Yard Gantry.—This gantry is interesting for its unusual dimensions and special features of design. It consists of two main riveted Pratt girders framed together at an angle of 60 degrees and supported on two end bents having a pair of inclined posts in the vertical transverse plane of each bent and a four-wheel truck at the foot of each post, which travels on the 3½-foot gauge track of T-rails laid on special double-web longitudinal girders, which distribute the heavy loads on long transverse ties resting on the surface of the ground. The top chords of the main trusses are riveted close together with transverse diaphragms, and the bottom chords 20 feet apart are connected by a system of horizontal trussing, from which the runway girders for the trolley hoists are suspended.

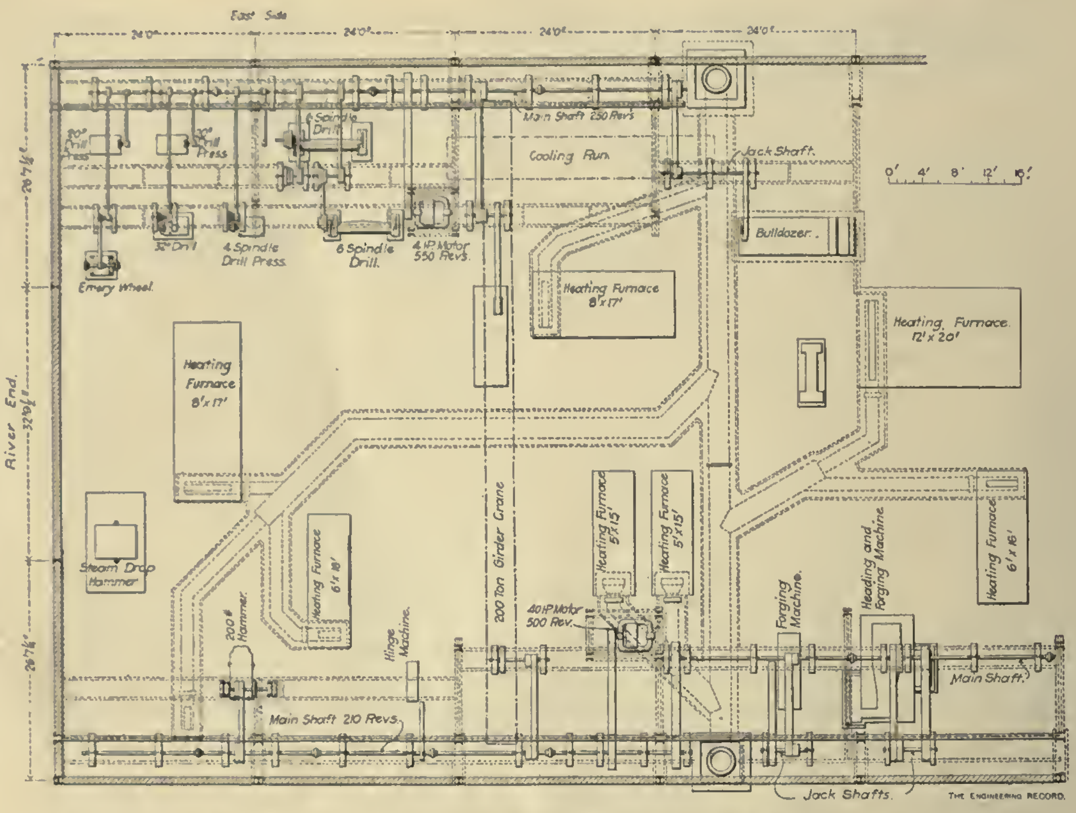
The top and bottom chords are made with pairs of 12-inch channels, the former having a cover plate on the upper flanges, the latter being latticed on both sides. The web members are made with pairs or double pairs of angles, and the inclined columns in the end bents are made with four 3x3-inch angles, two 24x¼-inch web-plates, and one 18x¼-inch cover-plate, and are connected to the transverse members by ¼-inch gusset plates with rounded corners. The floorbeams are made with pairs of 9-inch channels, and the stringers are 15-inch plate-girders with pairs of 4x3-inch flange angles. They are suspended from the top chords at panel points by inclined members consisting of single 3x2½-inch angles.

MACHINERY, MOTORS AND TOOLS IN THE STRUCTURAL SHOP.

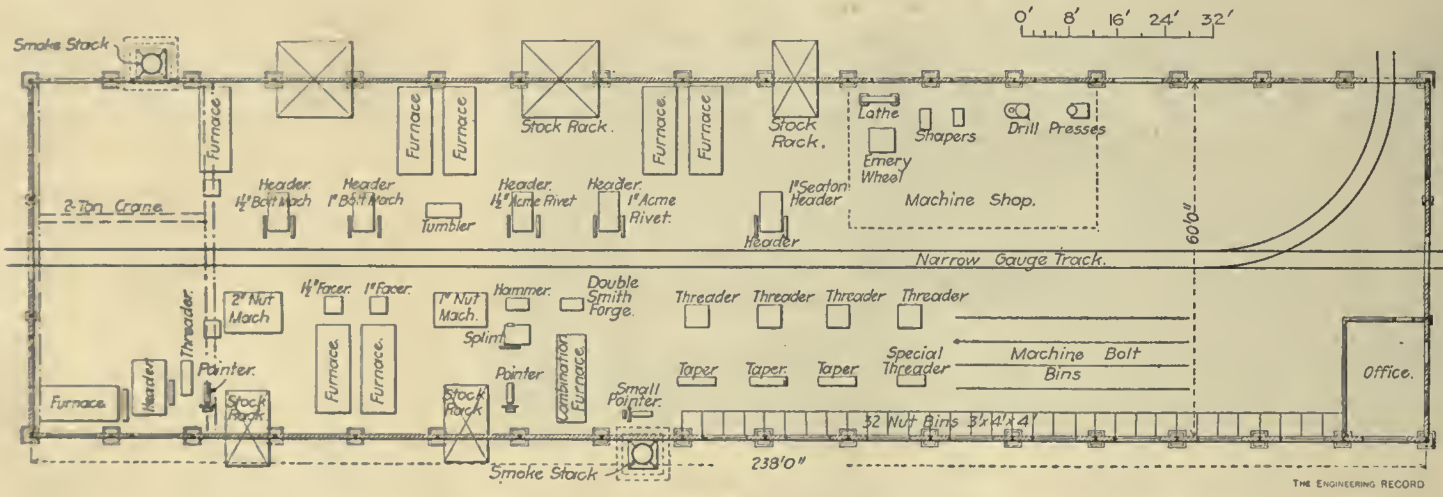
				Motors.		
Mark.	Size.	Name of machine.	Capacity.	H.P.	R.P.M.	Make.
A.	No. 4	Hilles & Jones double angle shear	8x8x1-in. angle	15	775	Crocker-Wheeler
B.	No. C. 12-in. throat	Hilles & Jones lattice bar punch	Punch. 2½-in. hole in 1½-in. metal, shear, 8x1½-in. flat	10	750	Westinghouse
C.	No. 1 18-in. throat	Long & Allstatter single punch	Punch, 1½-in. hole in 1-in. metal; shear, 8x1-in. flat	10	850	Westinghouse
D.	No. 4	Newton cold saw	....	10	750	Westinghouse
E.	No. 6	Hilles & Jones coping m'chine	24-in. I-beams	10	750	Westinghouse
F.	No. 5	Hilles & Jones beam punch	Two 1 1/16-in. holes in 1-in. metal	10	800	Crocker-Wheeler
G.	No. 5	Hilles & Jones beam punch	....	10	800	Crocker-Wheeler
H.	No. 993	Bement & Miles rotary planer	....	15	650	Westinghouse
I.	No. 44	Bement & Miles rotary planer	....	15	650	Westinghouse
J.	No. 5	Bement & Miles radial drill	4¼ ft.	5	800	Crocker-Wheeler
K.	....	Bement & Miles radial drill	3½ ft.			
L.	....	Emery grinder	....	5	800	Crocker-Wheeler
M.	....	Albra bull riveter	48-in. throat	..	...	....
N.	....	Pedrick & Ayer bull riveter	60-in. throat	..	...	....
O.	36-in. arm	Prentice Bros. wall drill	3½-in. spindle	10	750	Westinghouse
P.	78-in. arm	Pond radial drill	4½ ft.	15	...	Westinghouse
Q.	78-in. arm	Pond radial drill	4½ ft.			
R.	78-in. arm	Pond radial drill	4½ ft.			
S.	78-in. arm	Pond radial drill	4½ ft.			
T.	No. 7 48-in. throat	Bement & Miles punch	1¼-in. hole in 1-in. metal	10	750	Westinghouse
U.	No. 7 48-in. throat	Bement & Miles punch	1¼-in. hole in 1-in. metal	10	750	Westinghouse
V.	No. G	Long & Allstatter mult. punch and spacing table	....	..	...	....
W.	14-in.	Craig & Ridgeway Sons air hoists	6 tons	..	...	....
X.	10-in.	Craig & Ridgeway Sons air hoists	3 tons	..	...	....
Y.	6-in.	Craig & Ridgeway Sons air hoists	1 ton	..	...	....
Z.	No. 3	Hilles & Jones plate straightening roll	6 ft. 2 in. between heads	15	775	Crocker-Wheeler
AA	No. 6	Hilles & Jones gate shear	60x1-in. plate	15	775	Crocker-Wheeler

The runway girders have a clearance of 21 feet 2½ inches above the surface of the ground, and the trucks are 43 feet 9¾ inches apart in each bent, which affords a wheel-base wide enough to maintain the position of the gantry square with the tracks. Each truck has four 24-inch double flange steel-tired wheels keyed to 5-inch axles running in bronze bearings 7 inches long. They support a framework of riveted I-beams and carry in the center a steel socket with a nearly hemispherical bearing for a 6-inch hardened steel ball, which fits closely in the cast-steel bearing bolted to the base-plate of the inclined post. The lower bearing for the ball is slightly elongated transversely, so as to allow a little motion for temperature expansions and contractions in the 200-foot main trusses.

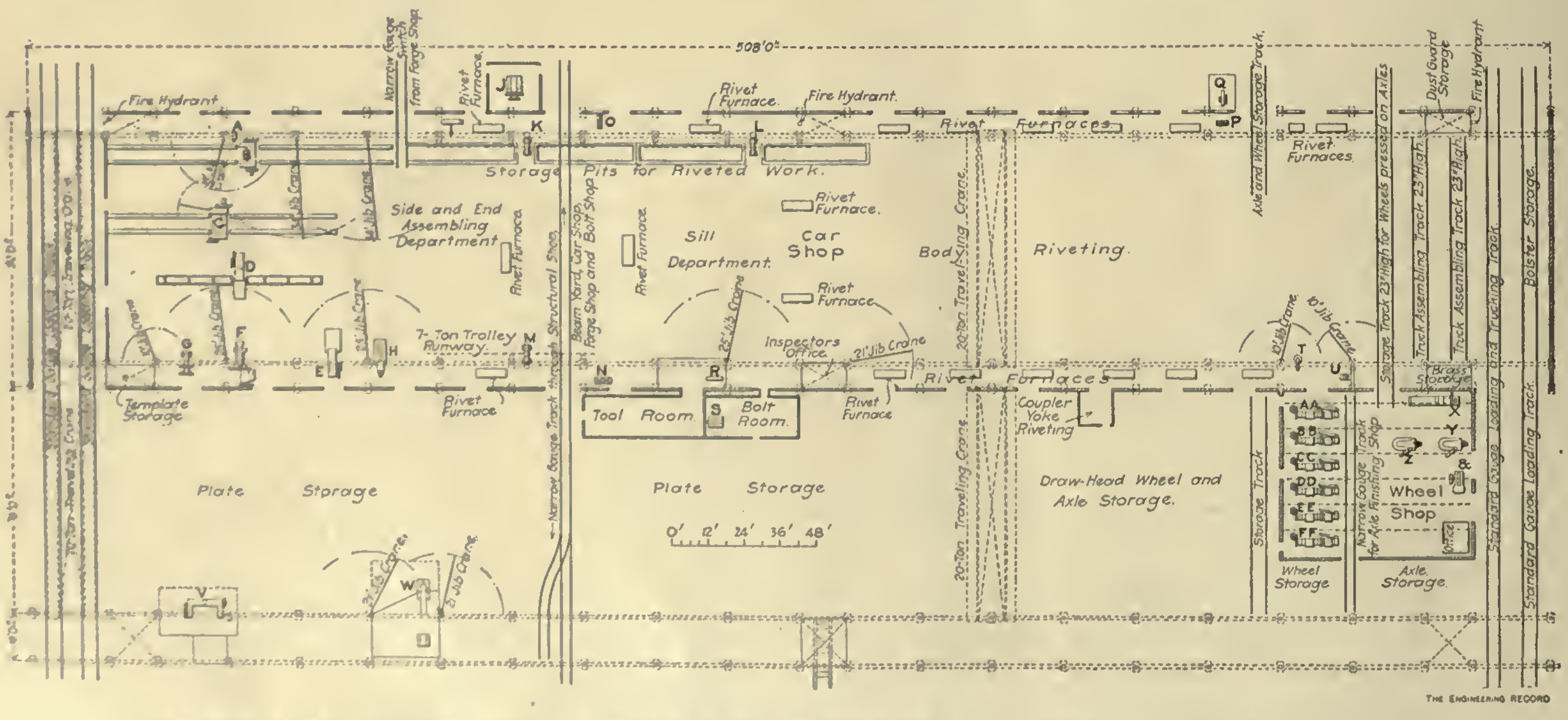
Each truck is provided with two snow-ploughs, which are easily detachable. One axle of one truck on each end is miter-geared to a horizontal driving shaft supported in universal bearing blocks on the main trusses, so as to provide for the locomotive movement of the gantry. This is operated by a 50-horse-power electric motor in the center of the bridge. The hoist trolley has a cast-iron winding drum with right and left-hand chain grooves milled out of the solid metal. It is provided with a suspended operator's cage glazed on all sides, and is furnished with two 25-horse-power electric motors for traversing and hoisting, respectively. The different speeds are 200 feet per minute



Forge Shop Plan, Showing Location of Principal Floor Tools and Overhead Shafts.



Plan of Furnaces and Tools in Bolt Shop.



CAMBRIA STEEL WORKS: TOOL LOCATION PLAN OF CAR SHOP AND WHEEL AND AXLE SHOP.

for the gantry, 400 feet for the trolley, and 20 feet for the hoist, with full load. The ends of the gantry are made so that the trolley could readily be moved from this gantry to a similar one brought in line with it on an adjacent track, if double service should be provided and the yard extended to a width of 400 feet, as was at first proposed.

The gantry is proportioned for a trolley load of 20,000 pounds with 5,000 pounds excess allowed for impact. The estimated weight of the trolley is 23,000 pounds, making a total of 48,000 pounds on a 9-foot wheel base. The dead load of the gantry was assumed to be 8,000 pounds at each lower chord panel point of each truss. Wind pressure was assumed at 20 pounds concentrated at each panel point of the bottom chord. The maximum unit strains from live loads in tension is 12,000 pounds per square inch of net section. The gantry was designed and manufactured by the Wellman-Seaver Engineering Company, Cleveland, Ohio.

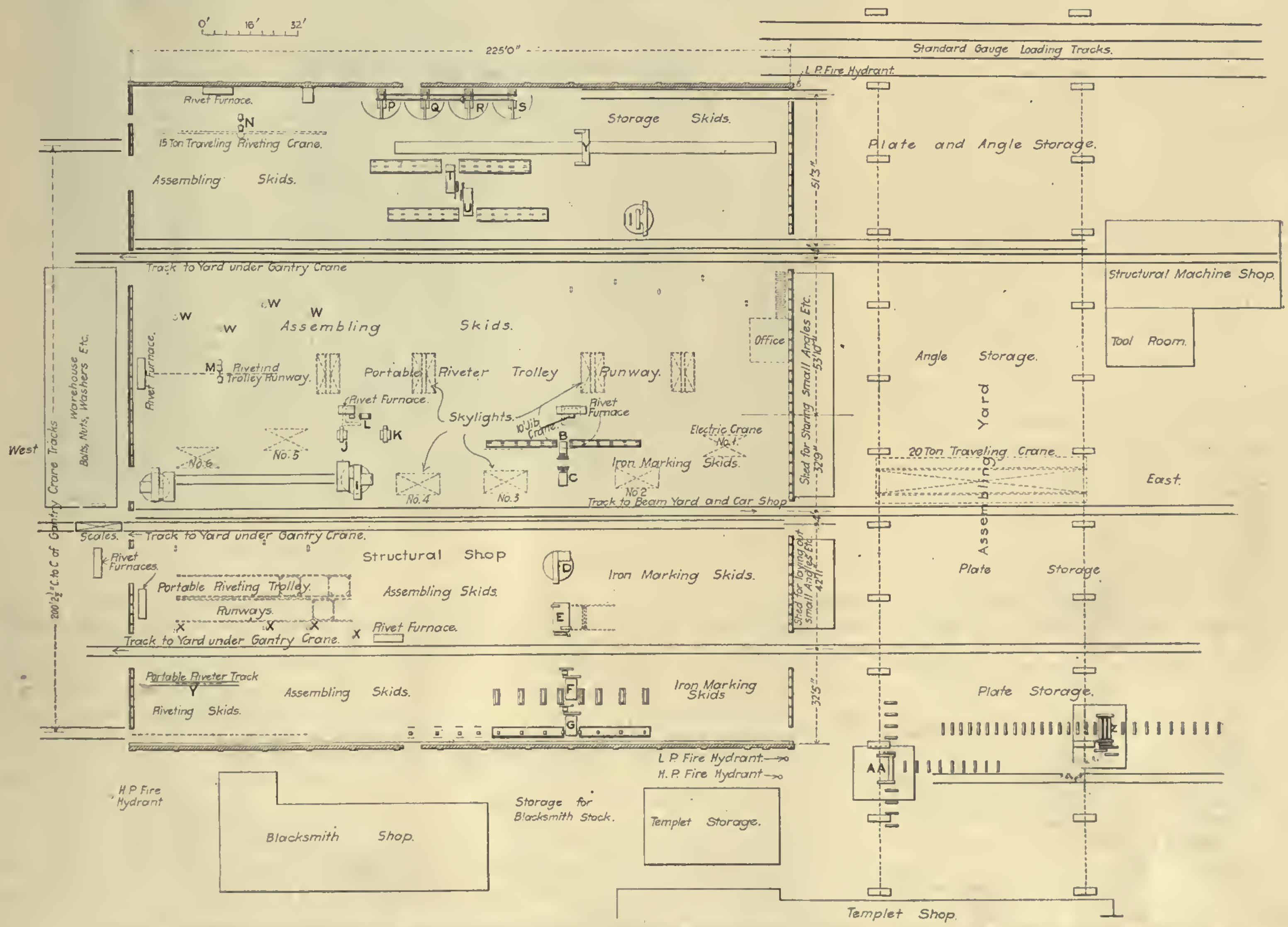
Bolt and Rivet Shop.—This shop is 238 feet long and 60 feet wide inside; its main framework consists of eighteen transverse bents 14 feet apart. The columns are 9-inch I-beams, with their webs transverse to the 9-inch brick walls, in which they are solidly imbedded. The riveted Fink roof trusses are made with pairs of angles back to back, and are seated on the column caps and knee-braced to the columns. They support 6-inch I-beam purlins about 5 feet apart, which are covered with matched sheathing, the roof covering being tar paper and slate. One 2-ton hand crane of 23-foot span runs transversely across one end of the building.

For moving materials this shop is served by the small hand crane already mentioned and by a center longitudinal narrow-gauge track running from end to end, as shown in the floor plan. A number of coke furnaces 15 feet long and 5 feet wide are arranged near the walls on both sides for heating the rivet rods, which are kept in racks that allow them to project through the side walls of the building, and thus cause less obstruction in the interior. Adjacent to the furnaces are the different heading and upsetting and facing machines, and beyond them are a series of turning and tapping machines to cut the threads on the bolts and nuts. Another machine, which is not shown in the plan, has been installed for cold rolling the threads on the bolts. All the machines in this shop are arranged in three groups and belted to a single line shaft. This shaft is made in three sections, coupled together, and each driven by

MACHINERY, MOTORS, BLOWERS AND RIVETERS IN CAR SHOP.

Mark.	Size.	Name of machine.	Capacity.	Strokes or revs.	—Motors.— H.P.	—Motors.— Revs.
A.	No. 1	Barnes vertical drill	20-in. swing †	..	..	...
B.*	No. 6	Hilles & Jones mult. punch, 62 in. long	Twelve 15/16-in. holes through ¼-in. metal.	..	15	650
C.*	No. 6 10-in. throat	Cleveland mult. punch, 90 in. long	Twelve 15/16-in. holes through ½-in. metal	18	20	600
D.	No. 7 48-in. throat	Bement-Miles punch No. 507	1¼-in. hole, 1-in. metal.	28½	10	750
E.	No. 7 48-in. throat	Bement-Miles punch No. 506	1¼-in. hole, 1-in. metal.	28½	10	750
F.	No. 6 48-in. throat	Hilles & Jones single punch	2-in. hole, 1¼-in. metal.	..	15	650
G.	No. A 12-in. throat	Long & Allstatter single punch	2-in. hole, 1⅛-in. metal.	..	7½	850
H.	....	Baush radial drill	5 ft. arm	..	10	750
I.	No. 8	Sturtevant blower	18¾-in. diam. discharge	..	20	...
J.	10-in. throat	Old single punch	....	21	10	750
K.	No. 288	Pedrick & Ayer riveter	5-ft. throat	..	..	...
L.	No. 287	Pedrick & Ayer riveter	5-ft. throat	..	..	...
M.	No. 241	Pedrick & Ayer riveter	4-ft. throat	..	..	...
N.	No. 1	Champion emery wheel grinder	....	..	10	750
O.	No. 1	Champion emery wheel grinder	....	..	10	750
P.	....	Safety emery wheel grinder	....	..	10	750
Q.	....	National alligator shear 1 in. round	....	..	10	750
R.	No. 6	Sturtevant blower	14⅝-in. diam. discharge	..	15	650
S.	....	Acme double bolt cutter	1¼-in. bolt	..	5	950
T.	....	Aurora upright drill	....	..	10	750
U.	....	Prentice wall drill	36 in. from wall	..	10	750
V.	No. 5 24-in. throat	Hilles & Jones gate shear	⅝-in. plate 78 in. long	..	15	650
W.	No. F 81	Hydraulic flanger	4½-in.x5-ft.x90-ton	..	..	...
X.	....	Niles' hydraulic press	48-in. wheel	..	40	550
Y.	....	Pond wheel borer	42-in. wheel			
Z.	....	Pond wheel borer	42-in. wheel			
&	No. 5	Bridgeport safety emery wheel grinder	....			
AA.	No. 5	Bement-Miles double axle lathe	11 in. diameter			
BB.	No. 5	Bement-Miles double axle lathe	11 in. diameter			
CC.	No. 5	Bement-Miles double axle lathe	11 in. diameter			
DD.	No. 5	Bement-Miles double axle lathe	11 in. diameter			
EE.	No. 5	Bement-Miles double axle lathe	11 in. diameter			
FF.	No. 5	Bement-Miles double axle lathe	11 in. diameter			
1	No. 1	Caskey pneumatic punch	....	..	..	...
4	No. 2	Caskey pneumatic punch	....	..	..	...

*Hard spacing tables with punches B & C. †Run from No. 6 H. & J. multiple punch.



CAMBRIA STEEL WORKS: FLOOR PLAN OF STRUCTURAL SHOP, SHOWING LOCATION OF TOOLS AND MACHINES.

an independent 20-horse-power open type Westinghouse motor. The shop is also used for light forging and the smith fires and furnaces have down-take flues carried under the floor to a steel stack at one end. A 35x42-foot room is enclosed by a wooden partition on one side of the building, and is used for a machine shop and tool room. Ventilation is secured through steel louvres which occupy the clere-story sides of the monitor.

Car Shop.—This shop is of very simple construction, as already described, and contains punches, drills, riveting machines, presses, lathes and emery wheels with which the car frames and plates are fitted. They are arranged as shown on the floor plan, on which they are indicated by reference letters corresponding with the accompanying table.

All these machines are driven by independent Westinghouse motors with the exception of the double bolt cutter, which is operated by a Crocker-Wheeler motor. The movable installation comprises two Pedrick & Ayer riveters with 24-inch stroke, three Allen riveters with 10-inch stroke, one 10-ton, two 3-ton, and eighteen 2-ton Yale & Towne chain hoists and two Harrington 2-ton chain hoists. The Morgan traveling crane has two 35-horse-power motors on the hoist and two 2-horse-power traversing motors on the trolley. The Sellers crane has two 50-horse-power motors on the hoist and two 6-horse-power traversing motors on the trolley. The annex at one end of the shop is devoted entirely to wheel and axle work and is lighted by sawtooth skylights and windows in the side walls. The lathes are driven in sets of three by motors supported from the lower chords of the roof trusses and belted to jack shafts driving the different tools.

Forge Shop.—Parallel and adjacent to the car shop is an 86x120-foot building of similar construction, which is also built to enclose a runway for a 76-foot-span yard crane, and is used for bending, flanging and other heavy forge work. Longitudinal rows of interior columns about 19 feet high and 9 to 15 feet from the side-wall columns, support overhead platforms and girders for the electric power installation on each side of the building. These are separate and essentially duplicate systems, each with a 40-horse-power Westinghouse motor driven at about 455 to 550 revolutions, and belted to jack shafts at the eaves level, from which the tools on the main floor are driven. These tools are located, as indicated by the floor plan, as close as convenient to the side walls, leaving a center area, about 50 feet wide in the clear, unobstructed for handling the plates and other materials at the furnaces and on the working tables. The furnaces are connected by a system of underground flues to a transverse flue connected with the base of a steel stack 30 inches in diameter and 90 feet high on each side of the building.

An Absorption Dynamometer of a new and simple type was described recently by M. Ch. Renard in a communication to the Paris Academie des Sciences. A graduated rod mounted on a sleeve at its center carries on opposite sides two flat plates of aluminum, so attached that they can be slid along the rod to different positions. The apparatus is essentially an air brake. With the plates in any fixed position it has been shown by trial that the torque is proportional to the specific weight of the air and to the square of the angular speed. The instrument is calibrated once for all, according to "Engineering," and may then be used to determine the power of any motor by simply mounting the dynamometer on the motor shaft and noting the speed of revolution maintained.

Tests for Detecting Brittle Steel.

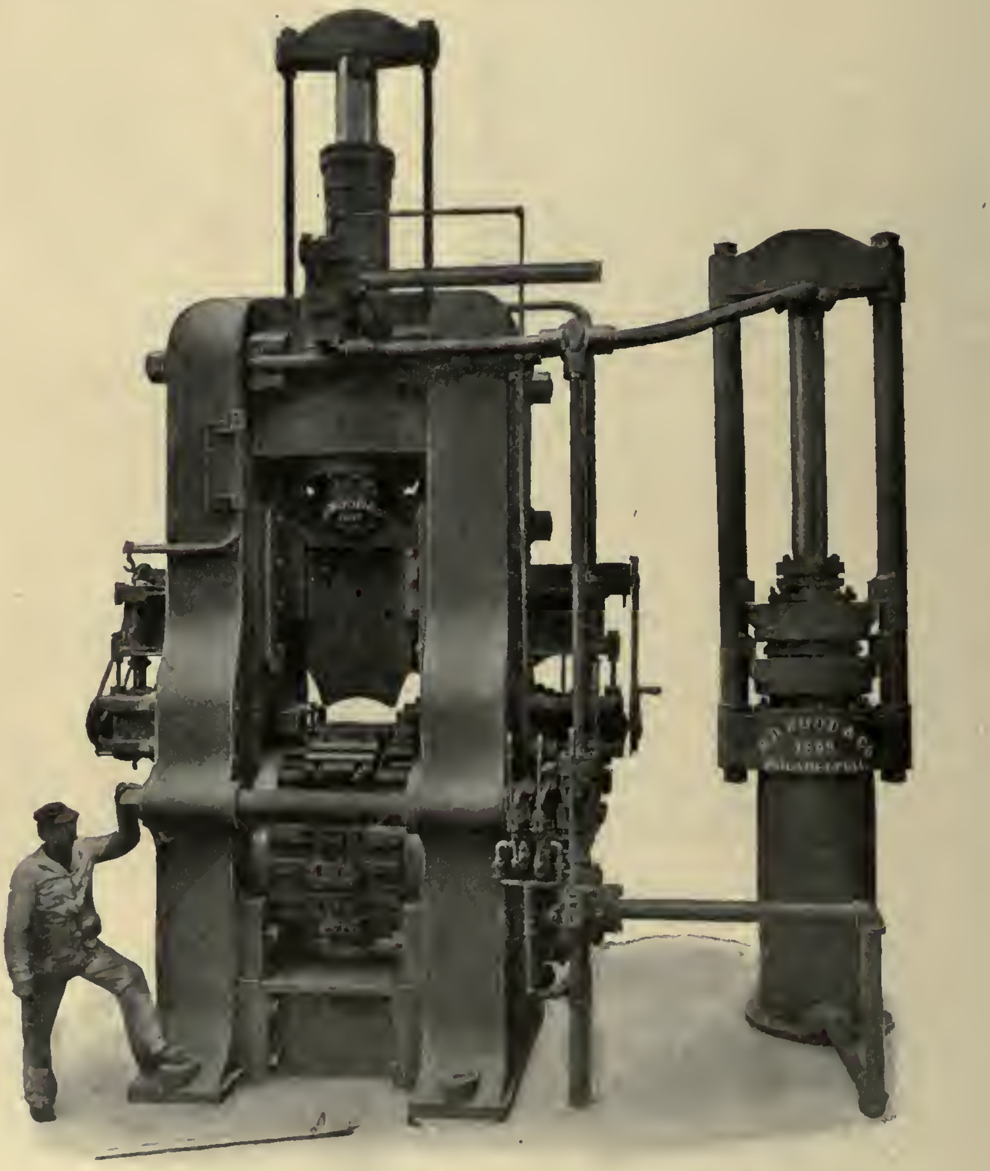
A paper read before the American Society for Testing Materials, by Mr. Wm. R. Webster.

All engineers aim to avoid the use of brittle steel in their structures. They have, very properly, specified such chemical limits as will eliminate this trouble in steel from segregation. This course has been followed in this country for years and does not need further comment.

Most of the steel now made will meet all the requirements of the specifications in general use, with a large margin to spare. This has given a false sense of security and too many chances are being taken. In some cases the cold bending tests have been omitted on boiler steel and the material accepted on the results of tension tests alone. Hundreds of boilers are made every year under these conditions. Every now and then a plate fails in shop work and samples taken from such plates will generally not bend flat cold, or anywhere near it. We have no means of learning how many other brittle plates, which do not fail in shop work, are put in boilers. The failures generally occur in thick material, and in most cases, the ordinary cold bending test as called for in our specifications would have detected the brittleness.

There are other cases where axles, rails, etc., are put in service without any physical tests whatever being made. This is directly contrary to the specifications adopted by this Society and the opinions expressed in the discussions at our meetings.

Some think that heat always has a softening effect on steel, as in annealing, and that the hotter the steel is finished in rolling or forging, the softer it will be. On the contrary, under such conditions, heat has a hardening effect and is one cause of brittle steel. The laboratory experiments on the effect of heat have been confirmed by the results obtained from large masses of steel. Steel finished too hot in rolling or forging will have a large grain and will fail under the ordinary cold bending and drop tests. The engineer cannot ignore this any more than he can ignore the effect of chemical composition. Under these conditions is it not proper and just that he demand of the maker some assurance that his steel is finished at the proper temperature and not at any old temperature? It is, of course, preferable to prevent, if possible, steel being made brittle, than to take the chances of its being detected after it has been made brittle.



Cambria Steel Works: Turret Shears for Cutting Large Shapes in Yard.

This Society took a decided step in the right direction in specifying that cold bends shall be made on each heat of steel in the condition it leaves the rolls. This has been more clearly defined by the Committee on Iron and Steel Structures of the American Railway Engineering and Maintenance of Way Association, in their specifications, as follows: "Full-size material for eye-bars and other material 1 inch thick and over, tested as rolled, shall bend cold 180 degrees around a pin the diameter of which is equal to twice the thickness of the bar without fracture on outside of bend." This requirement has been put in general use and necessitates the bars being finished in rolling at a lower temperature, and large eye-bars are now made which meet the requirements of full-size test very much better than formerly.

All of our present specifications make concessions in the requirements for the heavy material, and it is a question if we have not gone too far in that direction, as it assumes that such heavy material will, of necessity, be finished at a much higher temperature than the lighter material. It also does not induce the maker to improve his methods. The necessary improvement in the present methods which would be required to finish the heavy material at the proper temperature would decrease output and increase cost of such heavy material. Is the consumer willing to pay more for a better material? If so, the maker would, no doubt, meet him half way.

It will not be necessary to adopt any of the more elaborate tests which have been suggested to detect brittle steel, if the finishing temperature is properly controlled and wide cold bends made of full thickness of material rolled. But in the case of forgings, castings, and other very heavy material, annealing will have to be more generally introduced.

Some Details of an Electric Railway Power Station at Canton, Ohio.

A number of power-station details of interest from the standpoint of design are the subject of the accompanying illustrations. They show various systems of piping in the power station serving the Canton-Akron electric railway, which is an interurban line of some 54 miles total length of track. It extends from Akron to Navarre, Ohio, passing through Canton and Massillon, in both of which places local systems are operated. The total distance from Akron to Navarre, by direction of the railway, is 34 miles.

Engine Room of the Canton-Akron Railway Plant.

The plant is located in Canton on a branch of the Tuscarawas River. It is a brick building of the usual arrangement, in that the boiler and engine rooms are side by side. Both rooms are of the same size, 46 feet wide and 128 feet long. At the center the engine room has an extension or bay 36x48 feet for the sub-station equipment and the switchboard. In a corresponding position to this, immediately outside of the boiler room, is an extensive coal storage. The engine room is the loftiest portion of the plant, accommodating a traveling crane, which is of 30,000 pounds capacity, built by the Whiting Foundry Equipment Company; and its roof is of the ridge form, with matched lumber, tar paper and slate, supported on steel trusses.

There are at present installed in the boiler room six 300-horse-power Aultman & Taylor boilers, set, as usual, in pairs, with space for a fourth battery. Each boiler has 144 tubes 4 inches in diameter, arranged 16 wide and 9 high, and two 42-inch steam drums. They are designed to generate steam at 160 pounds. They are equipped with the Jones' underfeed stoker and burn half slack and half run-of-the-mine coal. Owing to the proximity of the mines, the run-of-the-mine coal costs $1.70 per ton delivered and the slack coal $1.20. The coal storage is a covered bin 14x78 feet in plan and 18 feet in average height. It is capable of holding twelve carloads. Coal is dumped directly into it from a railroad siding 6 feet above the floor level of the bin, there being four broad chutes through the outside wall of the bin into which side-dump cars can deliver. In the partition wall between the storage and the firing space there are four openings from the bin and these are closed with counterbalanced lifting doors. The openings are approximately 3 feet wide and 6½ feet high, with an arched top. The door is reinforced with angles and is suspended from two cables, each passing over a small sheave above and carrying a counterweight at the other end.

The products of combustion are carried off through a horizontal smoke duct above the floor between the rear of the boilers and the main partition wall of the station and pass into a 200-foot Custodis radical brick stack. A mechanical-draft plant is installed, comprising a 6-foot Buffalo fan, driven by a 3x10-inch Sturtevant engine, with an induction motor as a reserve source of power.

The high-pressure piping is standard wrought iron, the fittings and flanges extra heavy, of the Crane manufacture. The general scheme of piping between boilers and engines is shown in one of the illustrations. Each of the supply pipes from a boiler takes the usual upward bend and connects into the top of the header. It is fitted with two valves which are close together near the header, leaving a single length of piping from the boiler nozzle to the valves, with a bend at the upper end on a radius of 3½ feet. The valves nearer the boilers are Chapman gate valves, while those marked A are Crane automatic stop and check valves, to prevent a reverse flow of steam to any boiler from the remainder of the plant in the event of any disablement to that boiler.

The header is in two sections, one for two batteries and the other for the third battery and the one which, it is stated, is shortly to be added. Neither section has any valve, but the two are joined by an offset of the full size of the headers, with the gate valve in the offset. The offset is, of course, employed to allow for expansion, and contains six changes of direction, having six right angle elbows. The header is drained at five points. The drainage taps are made in the bottom of the tees, three of them immediately below the entrance of the steam from three boilers and the other two in the bottom of the tees from which the header expansion offset connection is made, the taps being spaced at approximately equal intervals.

The connections from the header to the engines are likewise taken from the top of the main, with gate valves near the header, and pass through openings in the partition wall into the engine room. In the case of the smaller engines each terminates in a zig-zag separator mounted immediately above the safety stop valve on the engine; in the case of the larger engine the height of the stop valve made it advisable to place the separator in the horizontal portion of the supply pipe before its curved descent to the engine. If, for the purposes of brief analysis, all engines are assumed working at the same time and taking steam at one-quarter cut-off, it will be found that 410 cubic feet of steam are passed per minute through each of the 7-inch pipes and 690 cubic feet per minute through the 9-inch pipes, corresponding to a velocity of 1,500 feet per minute in the first case and of 1,600 feet in the second. With steam at 150 pounds pressure, this corresponds to 33,300 pounds of steam per hour or little more than 1,000 boiler horse-power required for the main generating units.

Another of the illustrations shows the exhaust connections from the generating apparatus. It will be noted that the exhaust connection from each engine contains a corrugated copper expansion joint. The piping is carried in the basement under the engine room floor and runs toward the center to the condensing equipment, which comprises two Blake simplex twin vertical jet condensers with air pumps, 12x28x18 inches in size. At the condensers the exhaust piping is cross-connected as shown. There are two relief atmospheric exhaust lines toward each end of the system, each of these 18 inches in diameter and carried above the boiler house roof into a Lyman exhaust head. A short distance above the engine room floor each riser is provided with a Blake automatic relief valve with outside dashpot. The elbow at the bottom of the riser is a special one for seating on a Crane floor stand with flanged top. The piping throughout is cast iron.

Adjoining the condensers is a hot well 6 feet deep. A wire screen strainer is arranged to slide between a pair of angle bars in this well in such a manner as to filter the water before it leaves the well. The cage formed by the strainer is packed with excelsior and the strainer may be readily removed for cleaning.

As originally designed, the Blake condensers took water from the river and discharged into the hot well. It was intended to use the hot well water for boiler feed, and hot-water pumps were installed, as shown, for delivering the hot water to the feed-water heater. These pumps are provided with the suction from the intake water, however, so that either hot or cold water can be sent to the feed-water heater, as desired. Lately a deep well has been driven in the boiler room and feed water is delivered from this to a Cochrane heater supplied with steam from the auxiliaries. In addition to the condenser installation shown, a 2,100-horse-power Bulkley barometric condenser has been installed. This has been found large enough to take care of the entire station, so that the Blake condensers are not used except in case of an emergency. It takes water from a well outside of the building, 10x20 feet in size, the water flowing into it by gravity from the stream. The condensing water is discharged into the hot well and passes through an overflow back into the creek.

The boiler feed apparatus is located in the boiler room at the center of the firing space against the outside wall. There is a duplicate installation of pumps of the Smith-Vaile duplex Admiralty pattern, 10x12x6 inches in size. They handle hot water, drawing from the open heater and delivering through a Ross feed-water filter for removing oil. The economy of space resulting from the position and connections of the filter are indicated in the drawings of the feed-water equipment. The heater is a No. 9 Cochrane, built by the Harrison Safety Boiler Works. As already mentioned, the feed water is obtained from a deep well and the water is heated to about 200 degrees. For a time city water was used, and is still accessible, or, if necessary, feed water can be taken from the hot well, as described.

The generating equipment comprises two Allis-Reynolds Corliss cross-compound condensing engines 20 and 38x42 inches in cylinder dimensions, and one engine of the same type with cylinders 26 and 52x48 inches. The smaller engines are rated at 700 horse-power, although they have developed 1,200, while the larger is rated at 1,500 horse-power and has developed 2,000. In the larger engine both exhaust and steam valves are double ported. This engine drives an 800-kilowatt three-phase 25-cycle revolving-field General Electric generator running at 94 revolutions per minute and delivering current at 13,200 volts. The smaller engines are direct-connected to 400-kilowatt generators of the same type. Their speed of rotation is 107 revolutions per minute.

Another of the illustrations is a diagram of the piping connections for an automatic oiling system which has been installed. In the basement there are two tanks of the size indicated, one above the other. The oil is fed from the upper tank into the lower and forced by air pressure supplied from a 10x10-inch Westinghouse air compressor to the engine oil cups, which are designed for either pressure or gravity feed. After passing through the bearings the oil is returned by gravity to receiving tanks in the basement and is then forced by pressure through two Turner oil filters on the engine-room floor.

The electrical output of the station is controlled from a switchboard placed across the center of the switchboard bay. It is made up of blue Vermont marble panels, of which the main generator panels have power factor indicators, recording wattmeters and engine-governor controlling switches, in addition to other regulating apparatus.

The station was built by the L. E. Myers Company, of Chicago which company was contracting engineer for the entire road. As a result of the use of stokers and cheap coal, together with efficient condensing apparatus, the cost of current is said to have been brought down to 0.54 cent per kilowatt hour. The average for several months has been 0.6 cent, not including interest, taxes and depreciation. Messrs. Pierce, Richardson & Neiler, of Chicago, were the consulting and designing engineers. Mr. E. J. Rauch is general superintendent and purchasing agent of the Canton-Akron Railway Company, and Mr. J. B. Anderson is chief engineer.

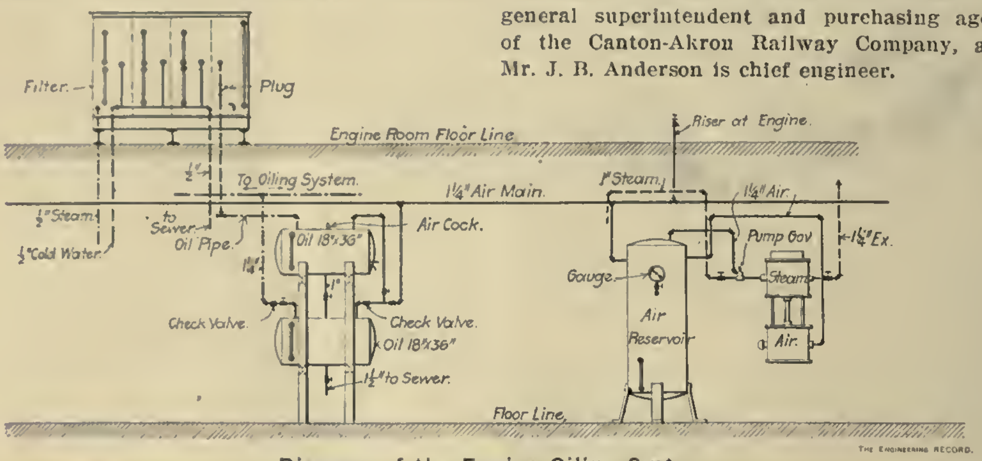
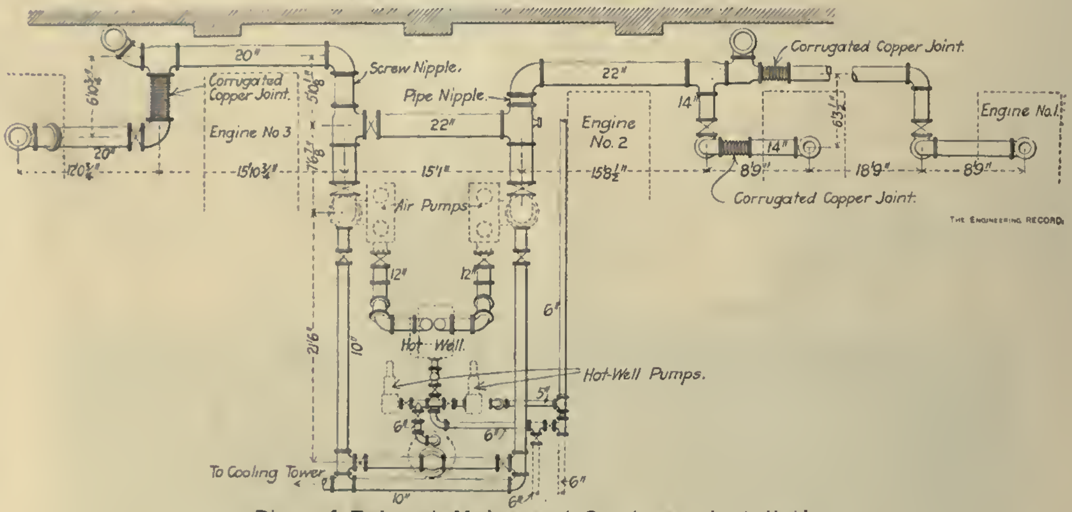
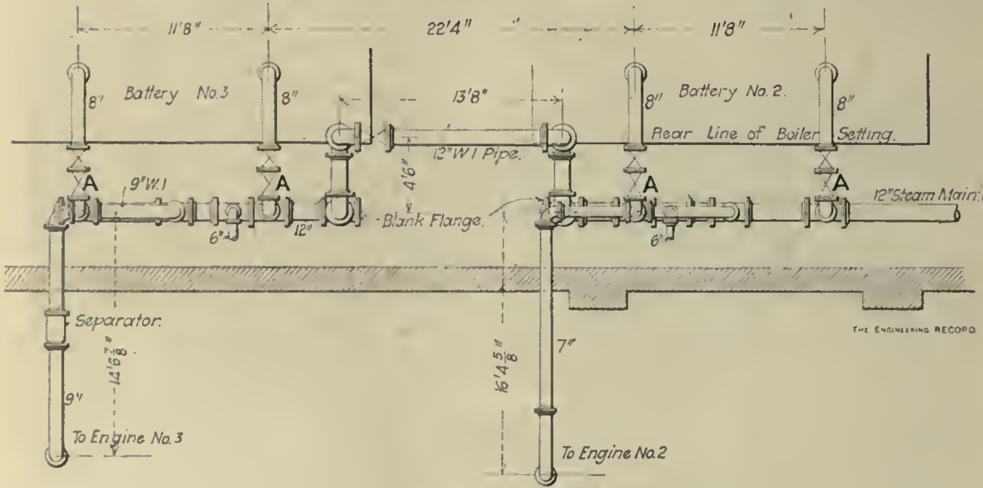


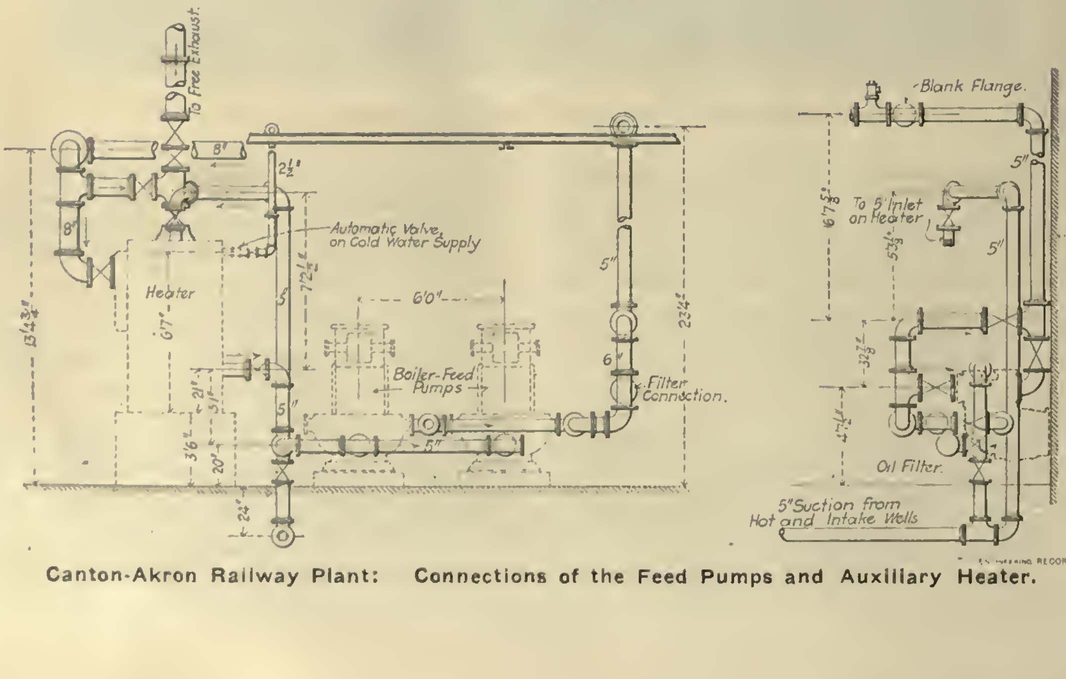
Diagram of the Engine Oiling System.



Plan of Exhaust Mains and Condenser Installation.



Part Plan of the High-Pressure Steam Piping.



Canton-Akron Railway Plant: Connections of the Feed Pumps and Auxiliary Heater.

Lowering the Chicago Tunnels.

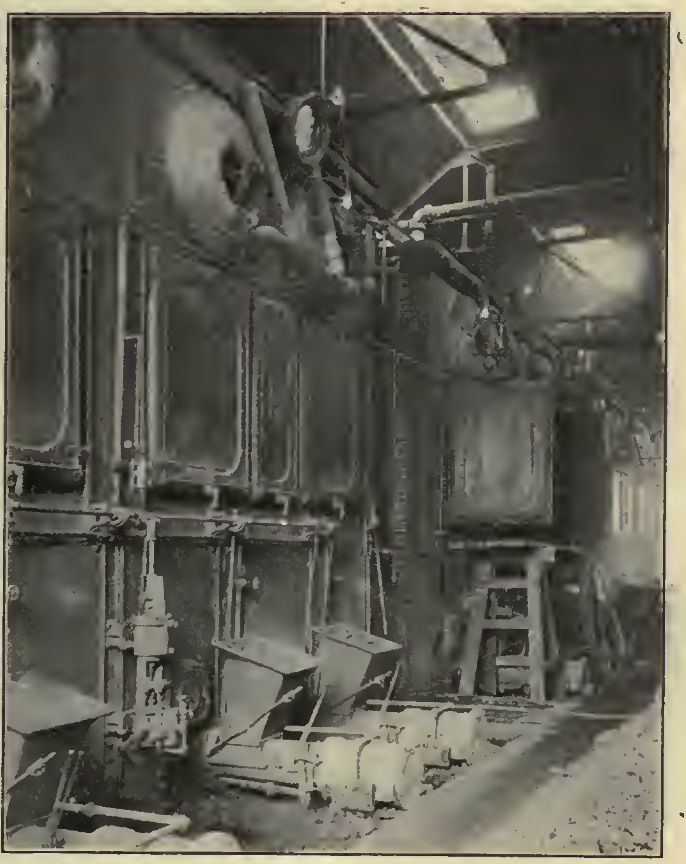
Extracts from a report by Col. O. H. Ernst, Corps of Engineers, U. S. A.

There is no controversy over the assertion that the tunnels as now constructed are obstructions to navigation and should be altered without unnecessary delay, but there are very serious legal and economic difficulties in the way, and it is therefore desirable that a statement should here be made of the gravity of the injury which they have inflicted and are daily inflicting upon the lake traffic of Chicago.

Statistics of the tons of goods entering and leaving the Chicago and Calumet rivers since 1889 show that while the gain in the Calumet River has been very great, it has barely been sufficient to counterbalance the loss in the Chicago River. The trade of the two combined was only a trifle more in 1902 than in 1889, and this in face of the fact that there was an enormous increase in the general trade of the Great Lakes during that period, and also in face of the fact that the growth of Chicago in population and wealth was very great. The trade of the Chicago River decreased over 3,000,000 tons, or more than one-third, between 1889 and 1902. The influences which cause a shifting or growth of trade are numerous and complicated, and it is possible that there are influences at work here which do not now appear, but it seems to me evident that the trade of the Chicago River was bound to decline when the stream ceased to have the capacity necessary to accommodate the large modern freight carriers. Obstructions in the river, such as encroaching docks, center-pier bridges and tunnels, become more and more serious as the size of vessels increases. They have now reached the stage where the largest and most economical freight carriers cannot use the Chicago River at all except near its mouth. Such vessels draw about 20 feet. The depth of water over the tunnels is about 17 feet in two cases, and about 18 feet in the third, which limits safe navigation to a draft of about 16 feet. Large vessels may, with difficulty, get by the other obstructions just mentioned, but they cannot get over the tunnels.

The Chicago River, in addition to its duty as a navigable stream, has to perform the functions of a discharging channel to carry the large volume of water required to dilute the sewage now being discharged into the Des Plaines and Illinois rivers through the new drainage channel. Its area of cross-section must be made large enough to accommodate the required volume without creating velocities which will be detrimental to navigation. The plans upon which the trustees of the Sanitary District are working contemplate the ultimate discharge through the drainage canal of 10,000 cubic feet per second, of which 8,000 cubic feet are to pass through the part of the river where these tunnels are located. The trustees are now at work enlarging the river to fit it for this new duty. They have replaced many of the center-pier bridges with bascule bridges, and expect to replace all. They have widened and deepened the river in many places, but they have no present intention of attacking the tunnels. The depth which they have adopted is 26 feet for a width of 100 feet in the middle of the stream, decreasing to a depth of 16 feet at the dock line. This gives an area of cross-section of about 4,700 square feet. At the bridges, however, it is reduced to about 4,000 square feet. As vessels will not be moored at the bridges, the whole of this cross-section is available for flow and should be able to discharge 8,000 cubic feet per second at a low velocity. In reconstructing the tunnels there must be provided an equal area of cross-section over them; that is, 4,700 square feet where there is no bridge and 4,000 square feet where, as at Washington Street, there is a bridge.

At present the amount of water which the trustees are allowed to pass through the river is limited by the Secretary of War to about 4,100 cubic feet per second, so that for the present a less area of cross-section is permissible.



Canton-Akron Railway Boiler Plant and Stoker Equipment.

At La Salle Street the river is 278 feet wide, and there is a channel 17 feet deep for a width of 62 feet over the tunnel near the middle of the river. The area of cross-section available for flow is 4,193 square feet. A depth of 22 feet will accommodate the deepest-draft vessels now navigating the lake, and at this place it will furnish the area of cross-section required to discharge 8,000 cubic feet per second at a low velocity. There can be no certainty, however, that the draft of vessels navigating the lakes will not be increased in the future.

At Washington Street the river is only 150 feet wide, and of this width 35 feet at the middle of the river is occupied by the pier of a drawbridge, leaving two passageways, one 58 and the other 57 feet wide. In each of these there is a depth of 17 feet, but the width for that depth is not great enough for a vessel to pass, and practically the depth is not more than 16 to 16½ feet. The area of cross-section available for flow is 1,911 square feet, which is barely sufficient to pass the 4,100 cubic feet per second now authorized by the Secretary of War. The work of enlargement by the trustees of the sanitary district just above the tunnel is completed and just below it is well advanced. The sudden change from a cross-section of 4,700 square feet to one of 1,911 square feet causes a change of velocity which adds to the difficulty of steering, a difficulty which is increased by the break in the shore line.

At the Van Buren Street tunnel the river is 184 feet wide, and there is a channel 17 feet deep for a width of 92 feet near the middle of the river, with a maximum depth of 18 feet at the center. A vessel drawing 17½ feet can, with care and good luck, be passed over this tunnel when the level of Lake Michigan is not unusually low. The area of cross-section available for flow is 3,128 square feet. Under the plans of the trustees of the Sanitary District the width of the river here is to be made 200 feet.

The average number of cars passing through the tunnels daily is now about 2,007 at La Salle Street, 2,000 at Washington Street, and 540 at Van Buren Street. If separate electric cars were used instead of the trains, there would be a car passing every thirteen seconds for La Salle Street, every eleven seconds for Washington Street, and every thirty seconds for Van Buren Street during the crowded hours, and at rather greater intervals at other hours. To turn these cars over the bridges will, of course, make trouble. In addition to this traffic, the La Salle Street tunnel carries a 36-inch water pipe, constituting an important link in the city water supply; and both the La Salle Street and Washington Street tunnels carry a large number of wires for electric lighting, telephone and telegraph services. There are probably a hundred or more cables in each of these tunnels.

The tunnels differ from each other in construction and admit or different treatment in the methods of alteration. At Van Buren Street the greater part of the work can be done without suspending the cable-car traffic, but that will involve retaining the present roof until the end of the work. With that method no immediate relief to navigation would be given. At La Salle and Washington streets the river section must be removed and reconstructed almost entirely, and the tunnels would be disabled at the start. In those cases there is no good reason why the first work should not be directed so as to relieve navigation soon after it is begun.

A reasonable time to allow for reconstructing the tunnels at a lower level will be from eighteen months to two years after the work is begun. It should cover two winter seasons, when navigation is suspended. In the meantime relief to navigation and increased discharging capacity can be furnished within two months after the work is begun in the case of the worst two tunnels.

My opinion is that the city of Chicago should be required to alter the La Salle Street tunnel so that there shall be a depth of water over it of at least 26 feet for a length of 160 feet near the middle of the river, the work to be completed on or before March 15, 1907, and to be so begun and conducted that on and after April 1, 1905, there shall be a navigable channel over the tunnel not less than 22 feet deep.

Furthermore, the city of Chicago should be required to alter the Washington Street tunnel so that no portion of it between the abutments of the proposed new bridge shall come within 26 feet of the water surface, the work to be completed on or before March 15, 1907, and to be so begun and conducted that on and after April 1, 1905, there shall be a navigable channel over the tunnel at least 22 feet deep.

The receivers of the Chicago Union Traction

Company should be required to alter the tunnel near Van Buren Street so that there shall be a depth of water over it of at least 26 feet for a length of 160 feet near the middle of the river, the work to be completed on or before April 15, 1906.

Remodeled Studebaker Power Plant at South Bend, Indiana.

The problem of rearranging and enlarging the system of power generation and distribution is quite formidable in a manufacturing plant which has been long established and which has been added to from time to time to meet the demands of the moment as cheaply as possible, regardless to a greater or less degree of any consistent general plan. The establishment of Studebaker Bros.' Manufacturing Company at South Bend, Ind., was started in 1852, and has been gradually developed and extended until it now covers something over 100 acres. There are two distinct manufacturing departments, one for wagons and one for carriages. In general each of these departments consists of wood-working, forging, assembling and painting shops and storage for finished goods. There are also extensive lumber storage yards and drying kilns, where stock is prepared for both departments. Steam power was generated at two boiler plants about 500 feet apart, and was piped to engines at three different points. These engines turned heavy shafts running through the buildings and carrying many wide pulleys with slow-speed belts.

The carriage department power plant contained four Babcock & Wilcox boilers, a simple 30x60-inch Lane & Bodley Corliss non-condensing engine and also some small high-speed engines, belt connected to lighting dynamos and an electric-welding generator. The exhaust from the engines was used for heating the carriage department and the boiler feed water. The boilers at this plant were in reasonably good shape, but the draft conditions were bad because of an underground flue 150 feet long, which had been constructed at some time in the past in order to make use of the stack of the drying kilns. The boiler house and the engine house are separated only by a roadway and are quite centrally located with respect to the entire plant.

The power plant of the wagon department contained five Babcock & Wilcox boilers, ranging in size from 120 to 240 horse-power. Some of them were in good condition, but others were considered unsafe for the pressures suitable for modern power installations. These boilers supplied steam to two 24x40-inch Brown-Corliss non-condensing engines, located in an adjacent room, to one 17x42-inch engine of the same make and type some distance from this power house and to a 1,500-pound steam hammer in the blacksmith shop. The two engines in this power house were belted directly to shafts in the wood-working department, where the larger portion of the power is used. The smaller engine was belted directly to the shafting in the forge shops and paint shops. The exhaust steam was used for heating these departments and the office building and a large quantity was constantly required in the dry kilns.

While the transmission system in the carriage department was quite complicated and formed a large percentage of the total load on the engine, the engine there was comparatively new and of such design and size as to satisfactorily carry it load. Owing also to the demand for the exhaust steam from it during the greater portion of the time, it was not imperative that this department should receive attention. In the wagon department, however, the engines were working continuously to their ultimate capacity with the steam pressure allowable in the boilers supplying them. Moreover, the demands of the business and consideration of economy indicated that the time had come when some different arrangement for generating and distributing power must be adopted.

In considering the problem, Mr. George M. Brill, of Chicago, as consulting engineer, in cooperation with Mr. W. F. Evans, master mechanic, and Mr. H. D. Johnson, manager of the manufacturing department of the Studebaker Bros.' Manufacturing Company, had to take into account several positive conditions. Dry kilns are in use which require steam on three hundred and sixty-five days in the year. The steam consumption is further increased in the winter time by the heating requirements of the shops. The shavings and scrap from the wood-working departments are sufficient to generate steam equivalent to 600 boiler horse-power. The wood waste must be delivered to the fire-room by fans and must be supplemented by coal to generate the 900 horse-power required. The possibility of erecting in the near future a new building to house the wagon department—the present quarters then to be used for storage—and also the absolute necessity of continuous operation of the plant during any and all changes forbade a radical rearrangement of the machinery to effect a considerable improvement in its economy.

Several plans were considered, one contemplating gas engines in connection with a plant under discussion for furnishing fuel gas to many of the forges. Another plan contemplating driving the main lines of shafting in the wagon department direct with a compound condensing engine, the existing boiler plant being remodeled somewhat. The shafting was to be divided into several lengths connected by friction clutches. Uncertainty about the location of extensive additions to the buildings prevented the adoption of the first plan, and the second plan was regarded as having nothing beyond its lower first cost in its favor when compared with the electrical drive which was adopted.

The final decision was to centralize all power generating apparatus at one point, with the plant of the carriage department as a nucleus. Such of the Babcock & Wilcox boilers from the wagon department as were suitable for a working pressure of 125 pounds, three in number, were reset in an addition to the carriage department boiler house, and all seven of the boilers were equipped with mechanical stokers; a new stack was also built. In the piping, provision was made for furnishing steam to an additional unit and also for the installation in the future of additional heating lines of either exhaust steam or hot water. The 30x60-inch Lane & Bodley engine was left to operate the carriage department as formerly, and it was also arranged to drive the generators for lighting and for the electric welding machine.

In the space previously occupied by these small generators was installed a direct-connected engine and generator with some margin of capacity over the present demands of the wagon department. The engine is a 22 and 44x42-inch Reynolds' cross-compound Corliss, condensing engine and it is direct connected to a three-phase General Electric 480-volt generator having a capacity of 500 kilowatts at 100 revolutions per minute. The exciter, a 30-kilowatt, 125-volt, General Electric machine, belt-driven from the 18-foot flywheel of the engine, supplies the field coils of the alternator and also of three synchronous motors installed in the works.

Motor-Driven Planer at the Studebaker Works, South Bend, Ind.

A vacuum of 26 inches is maintained by an Allis-Chalmers jet condenser and a Reynolds' patent 32x12-inch air pump, which discharges into a hot well. This well, from which the boiler feed water is taken, overflows into a 1,000,000-gallon reservoir formerly used in connection with the fire system. The reservoir was a factor in solving the problem, presenting an advantage in arranging the condensing system. Over one end of this reservoir, using its walls as foundations, was erected a Barnard-Wheeler cooling tower, a view of which is given in the illustrations. The condenser is located in the basement at such a level that the cooling water gravitates to it from the reservoir. When the water is not sufficiently cooled in the reservoir for use in the condenser, it is circulated over the cooling tower by a 6-inch Lawrence centrifugal pump driven by an 8x12-inch vertical engine, the suction of the pump being connected to the hot well and the discharge carried to the top of the tower. This arrangement provides a flexible system of water circulation. A Cochrane oil separating system has also been installed to keep the water clean.

The switchboard has six panels; one exciter, one generator, and four feeders. It is designed for extension and for the parallel operation of two generators when the installation of the second unit becomes desirable. Only three feeders are now in use. These feeder panels are equipped with polyphase recording wattmeters and automatic oil switches. As the requirements for close regulation are not as exacting as usual, no special electric regulating devices were considered necessary. The three power feeders lead from the switchboard on poles to three points outside the manufacturing building, thence through the walls to the distributing panels, which consist of marble slabs enclosed in asbestos lined boxes with all the wiring on the back except the fuse terminals and fuses. Induction motors each driving a group of machines by means of counter shafting, were installed and so arranged as to make the three feeder lines carry about 300 horse-power each.

Cooling Tower at the Studebaker Works, South Bend, Ind.

To determine the motor requirements in the wagon department, especially in the wood-working plant, tests were made on different groups of machines by operating different sections of the shafting independently. A 50-horse-power direct-current motor, mounted on a truck and arranged to be firmly blocked when driving the shafting, was put in position and connected to the different sections of shafting at noon or at night to avoid interference with the working of the plant. This half-day run on each section gave opportunity for getting the maximum, minimum and average running conditions, and as a result a considerable rearrangement of the manufacturing operations and speeding up of much machinery has been effected. It has been found practical to drive several planers by direct-connected motors with rigid couplings, and one of these units is shown in an accompanying engraving.

There are also in operation three synchronous 40-horse-power motors, one on each of the three power feeders. Each one of these motors drives an exhaust fan for collecting shavings by means of a short belt, thus avoiding the use of clutches. The motors are started with the field open, and a damper in the suction pipe of the fan is closed to allow the motor to be brought to speed practically without load. This arrangement has been found to work with entire satisfaction, and a high power factor, about 0.88, is obtained by the use of the synchronous motors. The three feeder circuits are of approximately equal capacity and carry a total rated motor capacity of 915½ horse-power, which is 168 per cent. of the 500-kilowatt rated capacity of the generator.

The plant has worked smoothly and without any interference during the changes, nor have any shut-downs occurred since the new equipment was put in operation. The single central plant is found to utilize the waste wood fuel better and requires a less amount of coal to make up the total quantity required than under the former conditions.

Some Attempts to Limit the Personal Equation in Cement Testing.

Abstract of a paper presented to the American Society for Testing Materials, by Mr. W. A. Aiken.

At the convention of the Society held two years ago, the writer outlined in a general way the work inaugurated at the cement testing laboratory of the New York Rapid Transit Railroad Commissioners. In mentioning the efforts to minimize as far as possible the baneful influence of the "personal equation" of the tester, reference was made to some special experiments just then commenced which it was hoped would lead up to some interesting results. It is the data collated from those experiments which have now crystallized into a regular part of the work, although so far only for comparison, which are the subject of the present paper. For two years the laboratory has been regularly making up every tenth lot of cement submitted for use on the work, under what the writer calls the "dry" process of briquette making, in addition to the usual method practiced in laboratories generally. After much experimenting and numberless trials, the method now rigidly followed was adopted.

The gang moulds are filled with dry cement in three layers, the lower two being tamped by three blows of a wooden mallet and a tamping iron exactly fitting the moulds, the top layer being simply put into place, pressed in and smoothed off with a small trowel, after the moulds have been filled. Three blows of the mallet were adopted because repeated experiments demonstrated that this number gave results, when the briquettes were broken, approximating the strength desired in what was considered the most acceptable cement at the 7-day period; fewer blows not giving such satisfactory results in every way, more blows developing abnormal strength at that period as well as at later stages.

After the briquettes are finished, as far as filling the moulds is concerned, the whole is put into storage tanks and there left to take up as much water as required. At the expiration of 24 hours, all the briquettes are ready to be taken from the moulds, when those for the first period are immediately broken and the others stored in tanks. By careful weighing of a great many sets of briquettes it has been ascertained that 22 per cent. of water by weight is taken up during the first immersion. This is just 1 per cent. more than is generally used in ordinary practice in this laboratory, though therein when tempering the aim is to obtain the same paste consistency always, irrespective of the percentage of gauge water. While this does occasionally vary, from 20½ to 22 per cent., working as the writer does with the output of one company's mills, this variation occurs so seldom that it may be ignored in calling the average gauge water 21 per cent.

The variation in weight of individual briquettes (the average results always being obtained from ten breaks) as well as the variation in tensile strength of these ten briquettes is markedly less than with the ordinary briquettes. The pronounced feature of the Rapid Transit specifications, viz.: the percentage of gain in strength between 7 days and 28 days, which requirement to a greater or less extent is finding its way into other specifications, is readily met in practically every instance under this "dry" method of manipulation, and while this is not applicable to sand mortar tests and does not approximate actual field conditions, even to the extent of briquettes ordinarily made, still as cement is not practically used neat and laboratory results are only for comparison at best, any method giving such regular results should claim attention.

Here follow some comparative results, the figures given for each period, being averages of 300 briquettes representing over 50,000 barrels of cement, irrespective of its acceptance or rejection:

Ordinary Wet Briquettes.

7 days.	28 days.	3 months.	6 months.	1 year.
711 lbs.	791 lbs.	779 lbs.	774 lbs.	821 lbs.

Gain 11.1%, 7 days to 28 days.

Dry Method Briquettes.

7 days.	28 days.	3 months.	6 months.	1 year.
739 lbs.	888 lbs.	903 lbs.	863 lbs.	871 lbs.

Gain 20.1%, 7 days to 28 days.

Of the lots of above total, which were accepted as approximating the gain requirement, the marked showing was as follows:

Ordinary Wet Briquettes.

7 days.	28 days.	3 months.	6 months.	1 year.
705 lbs.	797 lbs.	788 lbs.	779 lbs.	863 lbs.

Gain 13.0%, 7 days to 28 days.

Dry Method Briquettes.

7 days.	28 days.	3 months.	6 months.	1 year.
710 lbs.	887 lbs.	912 lbs.	878 lbs.	897 lbs.

Gain 24.9%, 7 days to 28 days.

Of the lots of first total rejected for marked failure to comply with the 15 per cent. increase requirement, the results are as follows:

Ordinary Wet Briquettes.

7 days.	28 days.	3 months.	6 months.	1 year.
764 lbs.	809 lbs.	785 lbs.	804 lbs.	695 lbs.

Gain 5.9%, 7 days to 28 days.

Dry Method Briquettes.

7 days.	28 days.	3 months.	6 months.	1 year.
816 lbs.	937 lbs.	903 lbs.	880 lbs.	792 lbs.

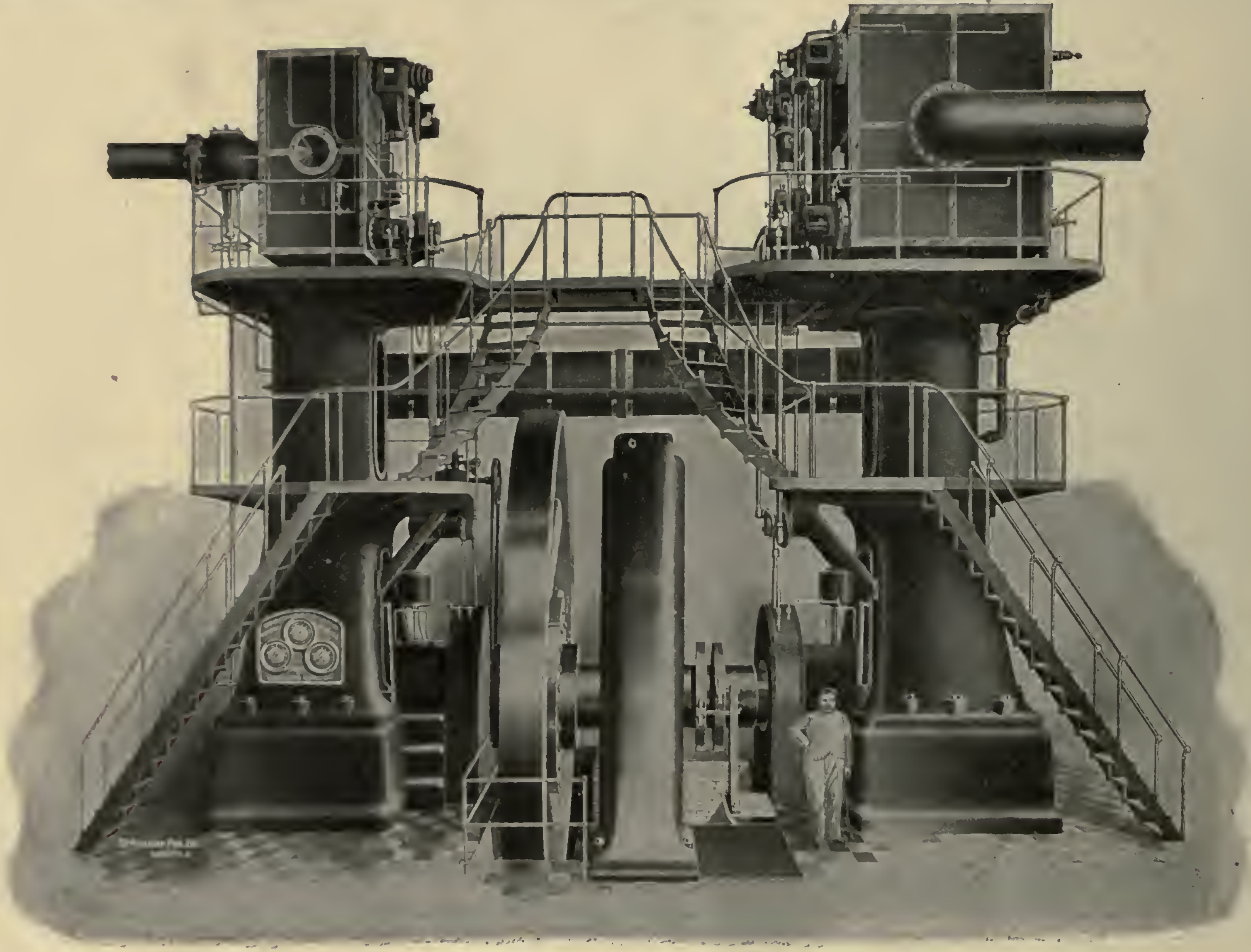
Gain 14.3%, 7 days to 28 days.

The last results would have assured the acceptance of all the rejected cement, if the failure to show proper increase had been the only reason for adverse action.

Examination will show that in every instance the "dry" method briquettes show the greater strength at every period, and while the above are averages, the uniformity of results in individual lots, as referred to before, is very marked. In most instances the lowest dry break is as good as the best wet break. These results are very surprising and are incontrovertible evidence that the manipulation of the cement by the tester surely works detrimentally as far as obtaining most regular laboratory results.

A New Vertical Cross-Compound Engine.

The Hamilton Corliss engine, which has long held a conspicuous place in the field of the horizontal steam engine, is now to be regularly made in the vertical form. One of 2,500 horse-power has already been built, for exhibition at the Louisiana Purchase Exposition, direct-connected to a 1,500-kilowatt alternator manufactured by the National Electric Company, of Milwaukee, and the Hooven, Owens, Rentschler Company, of Hamilton, Ohio, the makers, have designed a line ranging in cylinder dimensions from 16 and 32x36 inches to 48 and 96x60 inches, adapted for all medium speeds, for any desired steam pressure and for belt or direct connection. The valves, which are double ported, on both the steam and exhaust sides, are located in the barrels to avoid the inconvenience of having to disconnect the valve gear when the heads are removed, but they are arranged so as to keep the amount of the clearance at the same value it would be if they were placed in the heads. The exhaust valves, for example, are brought partly within the cylinder walls, although they do not enter the space swept by the piston while the piston is allowed to pass the ports. Separate eccentrics are employed for the steam and exhaust valves, driving them direct without wrist plates; and the governor, which is of the fly-ball type, has control over both cylinders. The exhaust chambers are separated from the cylinder walls by an air space.



Front View of the Twenty-Five-Hundred-Horse-Power Hamilton-Corliss Vertical Compound Engine.

The 2,500-horse-power engine at St. Louis has the following dimensions: High-pressure cylinder, 34 inches in diameter; low-pressure cylinder, 68 inches; stroke, 54 inches; speed, 83 revolutions per minute; main bearings, 25 inches in diameter and 42 inches long; shaft in wheel and generator, 30 inches in diameter; crank pin, 11 inches in diameter and 11 inches long; wheel, 22 feet in diameter and 120,000 pounds in weight.

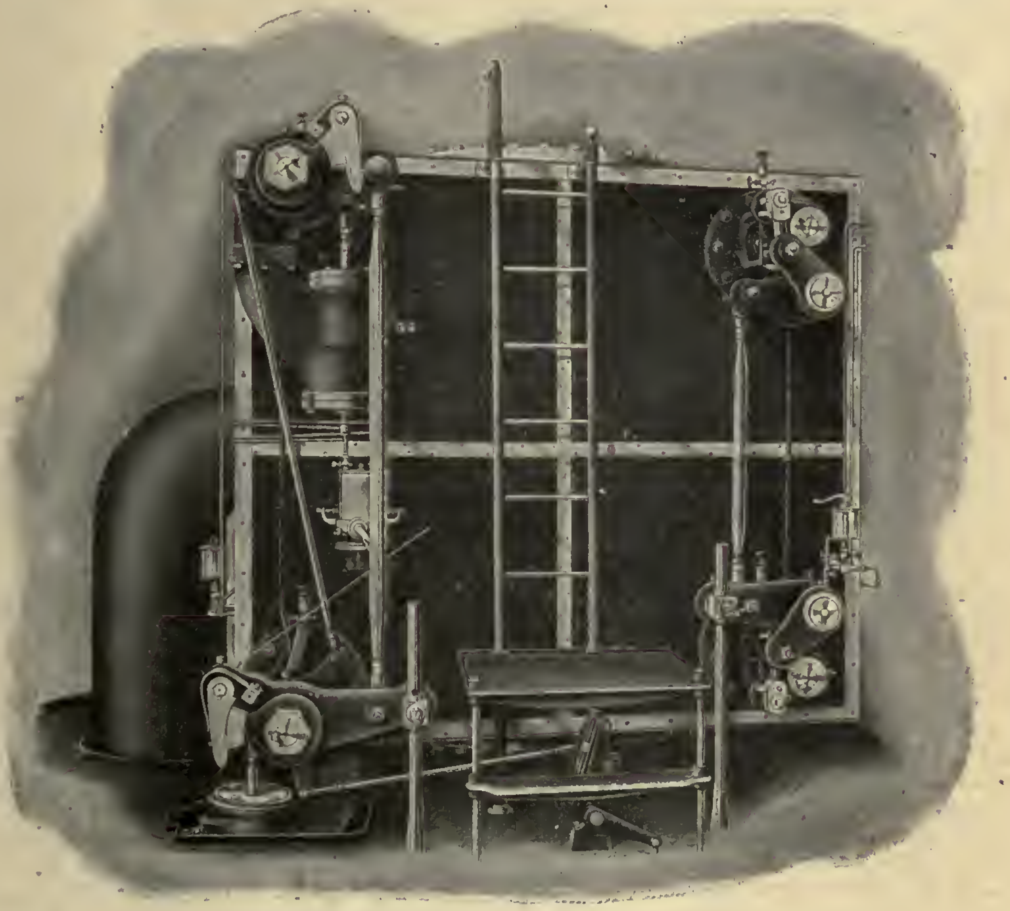
The cylinders are made of close-grain charcoal iron, as hard as practical to machine them. Besides the air space separation of the exhaust chambers from the cylinder walls, there is a 2-inch space between the cylinder walls and lagging. The lagging is finished with sheet steel with bright polished angle steel. The arrangement of the exhaust valves has already been mentioned. The design of the steam side aims to place the ports so that the incoming steam strikes the piston squarely on the end, preventing any side shock and pounding. The valves are cored to make them as light as possible.

The bedplate is of the box section, strongly webbed. It is cast in one piece and is carried around the crank at full height, forming a deep crank pit to retain oil. The base has easy lines and well rounded corners, as indicated in the accompanying engraving. The main bearing portion is bored and faced to receive the bottom box, which is of the shell type and arranged so that it can be removed by raising the shaft sufficiently to remove the weight from the box. The box is arranged for water circulation. The A-frame is cast in two pieces, strongly webbed, and is planed and fitted together and bolted with reamed fitting turned steel bolts. Its lower portion is of the box, or rectangular section, which gradually changes to a circular section as it reaches the top, giving pleasing but strong lines. The openings on the sides are designed to receive oil shields which entirely close this part of the engine. The guide barrel is circular in form slightly flattened on the sides where the openings come, which are also designed for oil shields and doors. This portion of the frame is also strongly webbed. The guides are separated from the walls of the barrel by an air space and are bored from a common center. The barrel is faced at both ends at the same setting to secure perfect alignment.

The pistons are cored for lightness. They have a follower ring and one sectional ring, which is pressed out by spiral springs held in place by T-headed brass bolts. The pistons are forced on a taper and locked with a jamb nut and keeper. The cross-head is of steel, with cast-iron slippers, lined with phosphor babbitt, peined in, bored and scraped to fit. Each slipper has a wedge adjustment which is entirely independent, so that the position of the slipper is not changed by its movement. The slippers are fastened to the cross-head by several steel bolts, relieving the wedge bolts of any extra stress, and they are arranged so that they can be easily removed. The effort in the design has been to secure a construction such that it is impossible for them to get adrift. The piston rods are fastened to cross-heads by thread, jamb nut and keeper. The connecting rod is of the solid end pattern and is five and one-half cranks long, with wedge adjustment at each end, so arranged that in taking them up the length of the rod and clearance spaces remain constant. The boxes are of bronze, babbitted, peined, bored and scraped to fit.

The wheel is made in eight segments, a section of the rim and one arm to each segment. The segments are bolted to the hub with turned steel bolts, the holes being reamed for a driving fit. The rim is clamped together with steel arrowhead links, shrunk in place. The hub is in two separate disks forced upon the shaft.

The driving of the valve-gear is obtained, as stated, through separate eccentrics for both the steam and the exhaust valves. The desired motion is secured by the use of levers and links on each bonnet. The dash pots are hung from the bonnets and are close to the cylinder, making a compact and self-contained arrangement. Both the steam and exhaust cam rods have unhooking devices and the gear can be worked by hand to facilitate starting and warming up. The valves are double ported, as stated, and have a very short travel. The releasing gear hooks and latch block trip plates have eight reversible wearing edges. The links have bronze connections with key adjustments.



The Valve Gear of the Low-Pressure Cylinder.

The governor is of the high-speed, center-weighted, fly-ball type, with motor and micrometer attachment for changing speed from the switchboard to regulate for throwing in parallel. It is placed on the first gallery platform, and is easily accessible. The range of cut-off is from zero to three-fourths stroke. The intermediate rocker arm supports for eccentric rods are of the box section, strongly bolted to the guide barrel, and are reinforced by braces from the A frame.

The main bearings are lubricated by a continuous stream of oil, furnished by an oil pump driven from the eccentric. The oil is pumped from a tank, located beneath the floor, to two receivers, which are located over each main bearing cap. From there it flows by gravity to all parts of the journal. The eccentrics, cross-head slippers, cross-head and crank pins are oiled from a gravity feed system by multiple sight-feed tanks located on the upper part of the engine. The cross-head slippers have wipers on the bottom end, which dip into reservoirs at the bottom end of stroke, insuring desired lubrication of the guides. All the valve gears, rocker arms, etc., are lubricated by grease cups. The eccentrics are entirely enclosed to prevent oil from creeping along the shaft and coming in contact with the wheel and generator.

A Proposed Test for Detecting Brittleness in Structural Steel.

A paper read before the American Society for Testing Materials, by Mr. J. P. Snow.

It is felt by many users of structural steel that mill inspectors should give more attention than is now usual to the detection of brittleness in our bridge material. Brittleness may be due to improper heat treatment or to segregated carbon or phosphorus. These defects may occur in material rolled from part of the slabs derived from a given ingot, while material rolled from the same melt or even from other slabs of the same ingot may be exceptionally good. If the ordinary tensile and bending tests of the heat from which the material in question is derived should be taken from those parts where objectionable segregation had not occurred and which had received proper heat treatment, the results would not expose the brittle features of the part supposed to be bad.

The desideratum is a practicable method of testing, which will furnish the inspector a means of detecting brittleness in any piece that comes from the rolls that he suspects may be objectionable. The object of this paper is to suggest a scheme which seems to me to answer this requirement.

Prime essentials of a test of this sort, are simplicity and quickness of accomplishment. Mill men say, with reason, that they cannot hold stock until machine finished samples can be prepared and elaborate tests made. I am informed that much of the material now being used is many miles from the mill, on its way to the fabrication shop, before the testing machine work is done on the specimens that are supposed to determine whether the material is to be accepted or rejected.

Determining the temperature of the metal after or before the last pass through the rolls is neither efficient, precise nor conclusive. Delaying the piece before the last pass until the right temperature is reached, refines only the outer skin of the material. It is not the function of buyers to tell the manufacturer how he shall produce his steel or at what temperature he shall roll it, but rather to ascertain if the product which he offers is suitable for their uses. This can be best accomplished by testing the finished product in a direct way.

The scheme herein proposed is in substance a nicked bending test on crop ends of plates and shapes as they are trimmed at the rolling mill for shipment.

A nicked bend is proposed because the object is not so much to see if the specimen will bend without fracture, as to open up the grain of the steel, to see whether it is fine and silky or coarse and crystalline.

It is proposed to take a generously wide piece of crop end so that the effect of the shear at the edges will not affect the result. It is deemed unfair to the manufacturer to depend upon narrow sheared specimens for this scheme of bending, because the injurious effect of the shear should not be assessed against the quality of the steel. Punched specimens are ruled out for the same reason. If narrow specimens with milled edges or punched specimens with reamed holes are used, the vital element of quickness of accomplishment is lost; for, while the specimens are awaiting their turn at the finishing machine the plate or shape from which they are cut is loaded for shipment or covered up in a pile of other stock. The scheme proposed will tell its story, if desired, before the rolling heat has left the piece. It can be executed and a decision reached almost as quickly as the surface inspection of a plate can be made.

In detail the scheme is to shear from the crop end a piece say 12 inches wide and nick it about 3 inches from one edge, preferably across the direction of the rolling, with a tool made for that particular thickness; clamp it in a vise and bend the free end over by power. Both the vise and bending roller are to be actuated by hydraulic power, which is always available in a rolling mill. The nick is proposed to be made with a tool like a blacksmith's flatter having a raised bead on its face.

Nicked bending tests by impact have been recommended in the past by many investigators. In 1892 Le Chatelier advocated such tests before the French Committee on Methods of Testing and since that time work on these lines has been done by Barba, Considère, Le Blant, Aucher, Fremont, Osmond and Charpy in Europe and by S. Bent Russell and others in this country. All these experimenters sought to determine the resilience of the material by impact tests, thinking to replace the ordinary tensile tests by these determinations. But as shown in Johnson's "Materials of Construction," impact testing is surrounded by so many uncertainties that it has never been found commercially practicable for structural materials. Evidently the constant effort has been to make the test prove too much. In the scheme herein advocated the object is not a complete physical test of the material but simply an examination of the grain, as shown in the fracture, to ascertain if the material is brittle from any cause.

To insure a fracture in ductile material, the deformation must be localized by a nick. The form of the nick, its depth and shape must be determined by experiment but for a beginning it is suggested that a depth of one-eighth the specimen be tried, the bead with which the nick is made to have the form of the Whitworth screw thread. Investigation may show that a single size of nick may be used for different thicknesses but it is probable that each thickness should have its particular size. The nicking die may be struck by hand hammers or a light quick-acting steam hammer may be provided for the purpose.

As to the method of producing the deformation, it is possible that the distinctive difference between material that is good enough to be accepted and that which ought to be rejected cannot be brought out by making the bend with a press. It may be necessary to use impact, as was done by Fremont in a series of experiments described by him at the Budapest meeting of the European Railway Congress.

These experiments show that a ductile steel may be broken short off by a blow of sufficient velocity. We know that ordinary structural steel when nicked and bent will invariably break unless it is exceptionally ductile and in very narrow specimens; hence, it seems that a press bend on a wide specimen will certainly produce a break and show up the grain. A press bend, if effective, is preferable to a blow on account of its more certain action and because it does not need adjustment for different thicknesses as would be needed if the bending was done by a blow.

It is believed that a test of this kind will expose coarse grain in steel, due to improper heat treatment, segregation, bad chemistry or any defect that tends to brittleness. The engineer may, under present specifications, demand certain chemical and physical qualities when buying steel. He may not be justified in prescribing the exact ratios of the many "ites" or the precise "eutectic values" of the various compounds that enter into the material which the manufacturer gives him for steel, but he may reasonably demand simple tests like that advocated here to satisfy himself that the material is free from brittleness.

In the past when puddled iron was the usual srtuctural material, engineers depended largely upon bending tests to ascertain the quality of the output of the mills. Mr. C. C. Schneider has told me that he cared little for the tensile strength, elongation and other physical features of wrought iron as determined by the testing machine, but that he set great value on cold bending tests of scrap ends. Sir Benjamin Baker, when engaged upon the Forth bridge, stated that he placed more reliance upon bending tests of mild steel than upon testing machine determinations. With the steel of the present day we must test for ultimate strength to secure a grade that can safely undergo the ordinary shop manipulations and examine the chemistry to secure uniform composition, but have we not too much lost sight of the valuable old time feature of bending? The ordinary plain bending will not always show us the grain of the steel. In fact the width of the specimen and the radius of the bend are so selected in our usual specification that ordinarily good material will bend without fracture. Its ability to do this is the gage for acceptance. To this end the sheared edges are planed, which defeats the very purpose of the test desired, on account of the time involved in the operation. Moreover, we bend but one specimen for each melt, which assuredly does not attempt to control the rolling heat.

It is true that the proposed test may involve closer attendance of the inspector at the mill than our usual commercial testing requires, and it may be impossible to define the lines by which an inspector shall be governed in rejecting material, as sharply as can be done under our present system, but the inspector's attendance can be arranged for and the results reached by Fremont give us a clew to what may prove to be a proper criterion for acceptance.

In the illustrations accompanying Fremont's paper it will be seen that when a specimen of non-ductile material is bent, a hardened ellipse tends to form on the compression side which acts as a heel around which the fibers on the tension side have to stretch. If the specimen is nicked, this stretch is localized and confined to the fibers at the bottom of the nick and breaking is sure to occur. If the material is somewhat ductile and the specimen narrow, the compressed metal flows outward. This flowing out assists compression and tends to decrease the stretch required on the tension side by removing the heel farther from the tension face, and hence helps toward a gradual break instead of a short one. This consideration explains the well-known fact that wide specimens will not bend so successfully as narrow ones.

If, in the proposed nicked bend, the specimen should break around Fremont's "ellipse of enlargement," instead of square across; or if it did not break clear through, we could safely conclude that the material was not brittle. If the break was square across and the fracture silky or but partly granular, we could assume that the heat treatment was good and segregation not excessive; but if the fracture showed crystalline facets or appeared dull and cokey it would be ground for rejection. After sufficient careful experimenting I am sure that workable limits can be fixed upon for the guidance of inspectors. It is possible that thick and thin material cannot be brought to follow the same law, but rules can be established for varying thicknesses. Material that is known to be good and that which is known to be bad, both from overheating and segregation, can be experimented upon and safe extremes established.

Metallurgical literature is filled at present with complaints of poor structure in rails and to some extent in other steels. This complaint is not quite so common in regard to structural steel, for the reason, probably, that it is usually in thin sections which cool to a lower temperature than thick ones while passing the rolls. It is the case, however, that rolled beams have sometimes proved so brittle and untrustworthy that some engineers dislike to use them in railroad bridges. It is likely that the principal reason for this condition is too high heat during rolling, due to their heavy section. If the crop ends of such beams are sheared up so that a section of the web or flange can be nicked and bent in the proposed machine, the coarse structure, if it exists, will surely be exposed and the beam saved from discrediting its species when put into service.

A similar test on crop ends of rails could be made while the rails were passing the straightening press and many of those having coarse structure at center of head, open grain, lamination, pipes, sulphur flaws or other defects that one drop test in five heats does not detect, would be saved from going into the track and causing trouble for both user and manufacturer.

The above scheme of testing is intended to supplement the usual tests for physical qualities and is suggested as a means of satisfying buyers of steel that their material is sound and free from brittleness. It is cheap in installation and operation and requires the inspector's continuous attendance at the shearing end of the rolling mill where he belongs. If properly executed it should tend to allay the agitation that is now going on among users of rails and structural steel in regard to heat treatment, open grain and other rolling-mill defects. If the scheme is objectionable to manufacturers it is respectfully offered for their free criticism.

Electrolysis of Water Mains in the Boston Metropolitan District.

Electrolysis of water mains in the Boston Metropolitan District continued at a serious rate during the year 1903, according to the report recently issued by the Metropolitan Water and Sewerage Board. On 90 linear feet of 48-inch pipe in Cambridge, uncovered for examination, 525 pittings were located, varying from 1/16 to ⅝-inch in depth. Portions of two lines of 36-inch cast-iron pipes crossing under the Charles River were examined by a diver and eleven pittings from 2 to 6 inches in diameter and from ⅜ to ¾ inch in depth were found. These pipes in the river are being destroyed very rapidly. At several other river crossings the conditions have been found to be favorable for electrolytic action, and at several points damage has been discovered. In the city of Chelsea an examination of a 24-inch cast-iron pipe line disclosed 250 pittings, from 1/16 to 9/16 inch in depth, on 280 square feet of pipe surface. In Lynn at one point 387 pittings, from 1/32 to 7/16 inch in depth, were found on 175 square feet of the surface of a 12-inch pipe line, and at another place 200 pittings on an area of 44 square feet; the deepest pittings were .45 inch in depth, leaving but .24 inch of the original thickness of the pipe. It has become necessary to replace some of these pipes during the current season. In order to prevent the flow of quite a large amount of electricity from the Metropolitan pipes to the pipes in the city of Cambridge at a connection, an insulating joint, made of a rubber gasket ½ inch in thickness placed between two flanges, was used.

Notes.

FLYWHEELS CONNECTED TO MOTORS are employed in a number of electrically-driven rolling mills in Germany for the protection of the motor and equalizing the load at the power house. In the case of 1,000 horse-power motor running at 215 revolutions per minute the flywheel is 14.4 feet in diameter and its peripheral speed about 1.04 feet per second.

THE COST OF OPERATING LOFT BUILDINGS as discussed last week contained a typographical error which becomes evident if the attempt is made to verify the calculations. With regard to the cost that is imposed on the building owner when additional electric lights are installed to satisfy a tenant's increase in working force, it should have been stated that the owner is giving $68 worth of light to each tenant, or $680 altogether for the ten who were considered in the assumed illustrative example.

THE VARIATION OF ANGULAR VELOCITY in the case of prime movers can be subjected to visible measurement by apparatus invented by Dr. Berkitz and described by him in the "Zeitschrift für Elektrotechnik," of Vienna. The device consists of a heavy disk or flywheel mounted loosely on the engine shaft and driven by the latter through an elastic coupling, in which no springs are used, the connection being magnetic. An arm rigidly fixed to the shaft outside the flywheel carries two solenoids, the cores of which are fixed to the flywheel, and can vibrate in the solenoids through a limited arc. A system of levers connecting the flywheel and the arm tilts a small mirror, a ray of light reflected from which describes a curve on a screen suitably placed. When the engine runs absolutely steadily, the curve is, for instance, a circle, and any deviation from this shows the extent and the character of the variation in the speed.

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